Marta Camps
Parth R. Chauhan
Editors

Sourcebook of Paleolithic Transitions

Methods, Theories, and Interpretations

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Editors
Marta Camps
Department of Anthropology
George Washington University
2110 G Street NW.
Washington DC 20052
USA
marta.camps@gmail.com

Parth Chauhan
CRAFT Stone Age Institute
Indiana University
1392 W. Dittemore Road
Gosport IN 47433-9531
USA
parthrchauhan@gmail.com

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Thoughts on “Transitions”: A Foreword

A visitor to the Dordogne region of France in the 1960s once asked me if I could show him the place where the Cro-Magnons had wiped out the Neanderthals. I was amused, but he was quite serious. The Cro-Magnons must have had superior military capability, otherwise how did they come to dominate Europe and replace the Neanderthals? As this volume suggests, the study of prehistory has come a long way toward a more complex understanding of this and other transitions.

This is a book about Transitions in Prehistory. In other words, the focus is not on prehistoric entities in space and time, but rather about the spaces between those entities and how humans moved through those spaces from one entity to another. The book also heralds the establishment within the International Union of Pre- and Protohistoric Sciences of a “section” or interest group, which, for the first time, will focus on process in general, rather than on specific periods and sequences. Both the book and the ongoing work of the section represent a welcome shift in the research orientation of Paleolithic archaeology, and force a reexamination of our most basic concepts and assumptions.

What is a transition? The usual connotation of this term is a brief period of change between one steady state and another—for example, the existence of a “transition team” in the case of a peaceful handover of power. A transition may thus include elements of both states or be entirely independent of either. Transition also suggests that one entity morphs into or at least accommodates and responds to another. One does not speak of transitions in the case of military conquests or the French revolution, for example. This might suggest that the use of the term “transition” for any historic or prehistoric period is inconsistent with an abrupt replacement. A transition is a “frontier” in time—a zone of accommodation between two different adaptive strategies. Like a frontier, this transition zone can be of variable dimensions (width in space, length in time) and character, in which new relationships form, exchanges may take place, and either hostilities or hybrids develop. Some frontier relationships may last more than a millenium, as in the example of the “encapsulated bushmen” proposed by Sadr (2002), or the pastoralist-agriculturalist relationships of the Eurasian steppes.

For the first 100 years of European palaeolithic archaeology, the nature and causes of transitions received little consideration. Because the initial framework of palaeolithic study was the succession of epochs, defined as much by unrelated extinct mammals (mammoth, cave bear, and reindeer) as by artifactual index fossils (Lartet and Christy, 1865–1875), relationships between successive entities were not emphasized. A brief excursion into grouping the industries according to their presumed relationships based on the index fossils had disastrous results, as similarity superseded stratigraphy in the ordering of industries (de Mortillet, 1869; de Mortillet and de Mortillet, 1910). Where change was considered, 19th-century evolutionary frameworks assumed a natural progression towards more complex forms of artifacts and societies; the problem was not to explain this tendency but instead to understand why some regions appeared not to have followed the same evolutionary progression (e.g., Morgan, 1877).

By the early years of the 20th century (e.g., Breuil, 1913), the importance of stratigraphic succession had been re-established, and three subdivisions of the Palaeolithic period were recognized: Lower, Middle, and Upper. Variations within these entities, and the advent of successive stages, were often attributed to different peoples or even species, as Burkitt (1933) and later Mary Leakey (1971) suggested for the appearance of the Acheulian in their respective regions. Two different industrial "phyla" within the same region could then evolve in parallel, as Peyrony (1933) posited for the Aurignacian and Perigordian. Where these new entities came from or how, and why they displaced or interacted with the long-standing industries of the existing residents, could not be addressed, given limited knowledge and chronological controls.

By the 1950s, with the advent of chronometric dating and more detailed sequences, the tripartite division of the Palaeolithic was becoming problematic, especially in Africa, where continuous human evolution and interregional migration blurred the subdivisions between these entities or their local equivalents—leading initially to the creation of two "intermediates" (Clark, 1957) or transition zones in time. A similar problem in the Lower-to-Middle Paleolithic transition in Europe resulted in the designation of an Acheuleo–Levalloisian period, although this entity was thought by Breuil (1931–1934) to be reflex hybridization of two separate "phyla"—represented respectively by flake-dominated (Clactonian, Tayacian) and core tool industries (Chellean, Abbevillean, Acheulean). Adding extra divisions, however, did not solve the problem.

Many of the papers in this volume (e.g., Harrold, Soffer, Strauss, Gowlett, Clark, and others) explicitly address the problem of the tripartite divisions and named industries and stages inherited from the 19th century. Whether one describes industries in terms of modes, technologies, reduction intensities, *châines opératoires*, or artifact or attribute frequencies, it is clear that these outdated divisions encompass more variability within, than between each and its immediate successor. Furthermore, it is far from clear that relatively brief and well-defined "transitions" occurred between the major divisions or their industrial counterparts, or that the divisions themselves represent stages of implied stability.

From the mid-20th century onward, two alternative approaches to understanding the pattern and process of change in the Paleolithic came to dominate the literature. One was rooted in the evolving mind and the relationship of the mind to both social life and the evolutionary process, incorporating both evolutionary psychology (Tooby and Cosmides, 1989) and the more nuanced philosophical approaches to cognition underlying the concept of *châine opératoire*. (e.g., Leroi Gourhan, 1964–1965; Boëda, 1994). The other perspective focuses more directly on the role of environments and includes both evolutionary and cultural ecology (Winterhalder and Smith, 1981; Binford, 1989; Potts, 1996) in an explicitly evolutionary and adaptational framework. Increasing organizational complexity, mediated in later prehistory by symbols, was no longer seen as an inherent property of human life, or an epigenetic artifact of the evolving brain, but instead was attributed to evolutionary processes operating in response to specific conditions.

Both studies of process were informed by ethno-archaeological studies of hunter-gatherer lifeways: their economic choices (Lee, 1979; Hawkes et al., 1997; O'Connell et al., 2002), their use of networks (Wiessner, 1982, 1983, 1986), the relationship between settlement patterns and archaeological sites (e.g., Yellen, 1977, 1986, 1991; Brooks and Yellen, 1987; Binford , 1978), the intensification of symbolic behavior on hostile frontiers (Hodder, 1985), and the symbolic and psychological aspects of the shamanic experience (e.g., Lewis-Williams, 2002). Despite the problems of applying studies of these modern societies to the Paleolithic past, many models continue to be informed by them. Transition models were also influenced more recently by studies of hybrid zones among nonhuman primates (e.g., Jolly, 2001), which suggest that such zones are inherently unstable, making discovery of short-span interaction zones in prehistory unlikely.

Revolutions are a special type of transition—implying a major shift in lifeways in a short period of time, usually one to three human generations, as indicated in the following table:

Revolution	Number of Human Generations
Communications (1990s)	0.5
Political (French, Russian, American)	1
Industrial	3–5
Writing	15–50
Neolithic	50–250
"Human" (Upper Paleolithic)	250–15,000

In our emerging understanding of the long period of experimentation that preceded the end of the Pleistocene, even the Neolithic revolution may not qualify for this term, much less the "Human Revolution" often posited for the Paleolithic (McBrearty and Brooks, 2000). Just as greater knowledge of late glacial and early post-glacial lifeways suggests a slow long-term increase in human domination of environments rather than a sudden transformation, increased knowledge of the African record as well as the European one suggests that apparent discontinuity in the European record was due largely to a migration event. In Africa—especially in eastern Africa, the likely modern human area of origin—the distinction between "Middle" and "Later" Stone Age is difficult to define (Mehlman, 1979, 1989, 1991; Prendergast et al., 2007; Ambrose, 2002). The southern African "Middle Stone Age" Howiesons Poort, if found in Europe, could well have been termed "Upper Paleolithic." Within Africa, apparent discontinuities or revolutions, such as the Howiesons Poort may also relate to interregional migration. On the other hand, European industries dating to between 40 and 30 kyr, but associated with Neanderthal remains, suggest that our sister species may have possessed some of the same capabilities as ourselves for complex symbolic and technological behavior (d'Errico, 2003). In the

European Middle Pleistocene, the distinction between “Lower” and “Middle” Paleolithic is equally problematic (e.g., Monnier, 2006).

To what, then, may we attribute the apparent record of changing lifeways during the Paleolithic? The papers here and the general topic of the section suggest several fruitful avenues for future research and discussion by this section.

1. A central goal expressed by many papers in this volume seeks to refine chronologies and sequences not only for Western Europe and the Levant, but also for Africa, the Americas, and other parts of Eurasia. Part of this effort must be to refine and discover new ways of increasing the precision of our chronometric rulers.
2. A second goal, related to the first, should be to explore new ways of describing sequences that do not depend on attribution to one of the three 19th-century stages, or on use of a restrictive typology developed for western European industries (see Clark, this volume). One should even question whether the term “Acheulean”, used by de Mortillet (de Mortillet and de Mortillet, 1910) at one point to denote the *transition* between the Chellean and the Mousterian, should be applied as it is today to all industries with bifaces that predate the “Mousterian.” Indeed, this term is the last vestige of a Eurocentric terminology that has largely fallen from favor. The alternative suggested for Africa, however, of giving every site or limited region its own sequence of named industries (Kleindienst, 1967; Clark and Kleindienst, 1974), has proven far too confusing. One possibility might be to adopt the universal typology suggested by Conard et al. (2004), and to use time instead of typology to set up the entity under discussion, as the OIS3 project has done for the “Middle to Upper Palaeolithic transition.”
3. A third goal should be to work more closely with environmental scientists to refine and expand our understanding of the environments and landscapes in which prehistoric humans lived. Efforts to meld local and continental scale proxies of environmental change, and to understand why these do not always agree, would be important in reconstructing not only human economic behavior but also the potential for migration, the need for networks, and other aspects of social life.
4. Rather than assuming that inter-regional migration was a rare event and happened only twice in human prehistory, we need to follow on the implications of sites such as Gesher Benot Ya’acov in Israel (Goren-Inbar et al., 2000) and Bose in China (Hou et al., 2000), as well as on the emerging chronology of Levallois technologies, to consider whether migration may have been a more frequent event in the past—whether out-of or into Africa. Are there other proxies such as faunal migrations or environmental shifts that might indicate such migrations were more likely at certain times than at others?
5. Finally, we need to explore the potential of complex models based on better chronologies, better environmental and demographic reconstructions, innovation models based on cybernetics, and an enhanced understanding of evolutionary ecology. The study of evolutionary neuroscience may also play a role. Can these models provide testable scenarios for understanding the capacities of early humans, how innovations arise and spread through populations, or how and why human populations expand and migrate?

It is hoped that this volume and the study section it inaugurates may lead the study of transitions in prehistory in new and fruitful directions. We need to understand human change and migration as complementary processes involving factors such as cognitive capacities and their evolutionary basis, environmental stresses and opportunities for migration and expansion, demographic factors, raw material procurement, and social and symbolic networks—each of which is invoked by one or more papers in this volume.

Washington, DC Alison S. Brooks

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Following the session in Lisbon, we solicited additional papers from many colleagues to fill geographic, thematic, and temporal gaps in the planned volume and, again, received positive replies from many. Therefore, we thank all of the authors in this book for submitting very interesting and thought-provoking papers covering a range of diverse topics and themes within the Paleolithic realm. Each paper was carefully peer-reviewed by colleagues who are experts in the area/topic discussed, and therefore, special thanks go to all of them for their careful and constructive reviews, as well as for their patience, insightful comments, and suggestions, and most of all for their professional cooperation and help despite their busy teaching or fieldwork schedules. This process was done on a double anonymous basis, to avoid biases from both sides, and was determinant in the final acceptance of the papers that are included in this volume.

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Contents

Contributors

Adams, Brian Department of Anthropology, University of Illinois, Urbana, IL, USA

Adovasio, James Mercyhurst Archaeological Institute, Mercyhurst College, Erie, PA, USA

Arrizabalaga, Alvaro Área de Prehistoria, Departamento de Geografía, Prehistoria y Arqueología, Universidad del País Vasco-Euskal Herriko Unibertsitatea, Vitoria, Spain

Bednarik, Robert International Federation of Rock Art Organisations (IFRAO), Caulfield South, Australia

Belmaker, Miriam Department of Anthropology, Peabody Museum, Harvard University, Cambridge, MA, USA

Bernaldo de Quirós, Federico Departamento de Estudios Clásicos, Universidad de Leon, Leon, Spain

Blackwell, Bonnie Department of Chemistry, Williams College, Williamstown, MA, USA

Blickstein, Joel I.B. Department of Chemistry, Williams College, Williamstown, MA, USA

Brooks, Alison Department of Anthropology, George Washington University, Washington, DC, USA

Burdukiewicz, Jan Michal Institute of Archaeology, University of Wroclaw, Wroclaw, Poland

Camps, Marta Department of Anthropology, George Washington University, Washington, DC, USA

Carr, Kurt W. Pennsylvania Historical and Museum Commission, Bureau for Historic Preservation, Harrisburg, PA, USA

Chauhan, Parth R. Stone Age Institute & CRAFT Research Center, Indiana University, Gosport, IN, USA

Chazan, Michael Department of Anthropology, University of Toronto, Toronto, Ontario, Canada

Clark, Geoffrey School of Human Evolution and Social Change, Arizona State University, Tempe, AZ, USA

Close, Angela Department of Anthropology, University of Washington, Seattle, WA, USA

Dennell, Robin W. Department of Archaeology, University of Sheffield, Sheffield, UK

Doronichev, V.B. Laboratory of Prehistory, St. Petersburg, Russian Federation

Feng, Xingwu Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

Gao, Xing Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

Golovanova, L.V. Laboratory of Prehistory, St. Petersburg, Russian Federation

Gowlett, John British Academy Centenary Project, University of Liverpool, Liverpool, UK

Graf, Kelly Center for the Study of the First Americans, Texas A&M University, College Station, TX, USA

Harrold, Francis St. Cloud State University, St. Cloud, MN, USA

Housley, Rupert Department of Geography, Royal Holloway College, University of London, London, UK

Hovers, Erella The Institute of Archaeology, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem, Israel

Iriarte, Maria José Departamento de Geografía, Prehistoria y Arqueología, Universidad del País Vasco-Euskal, Vitoria, Spain

James, Hannah Leverhulme Centre for Human Evolutionary Studies, University of Cambridge, Cambridge, UK

Karavanić, Ivor Department of Archaeology, Faculty of Humanities and Social Sciences, University of Zagreb, Zagreb, Croatia

Canales Leon, Elmo Alexander von Humboldt Foundation, Institute for Ancient America and Ethnology, University of Bonn, Bonn, Germany

Lycett, Stephen Department of Anthropology, University of Kent, Canterbury, Kent, UK

Maíllo-Fernández, José Manuel Departamento de Prehistoria y Arqueología, Universidad Nacional de Educacion a Distancia (UNED), Madrid, Spain

Norton, Christopher J. Department of Anthropology, University of Hawai'i, Honolulu, HI, USA

Olszewski, Deborah Penn Museum & Department of Anthropology, University of Pennsylvania, Philadelphia, PA, USA

Oosterbeek, Luiz Instituto Politécnico de Tomar, International Union of Prehistoric and Protohistoric Sciences (UISPP), Portugal

Otte, Marcel Service de Préhistoire, Université de Liège, Liège, Belgium

Patou-Mathis, Marylène Institut de Paléontologie Humaine, Paris, France

Petraglia, Michael D. Leverhulme Centre for Human Evolutionary Studies, University of Cambridge, Cambridge, UK

Riel-Salvatore, Julien Department of Anthropology, Leacock Building, Montreal, Quebec, Canada

Rogers, Michael Department of Anthropology, Southern Connecticut State University, New Haven, CT, USA

Semaw, Sileshi Stone Age Institute and CRAFT Research Center, Indiana University, Gosport, IN, USA

Séronie-Vivien, M.R. Le Bouscat, France

Skinner, Anne R. Department of Chemistry, Williams College, Williamstown, MA, USA

Soffer, Olga Department of Anthropology, University of Illinois, Urbana, Illinois, USA

Steguweit, Leif Universität Erlangen-Nürnberg, Institut für Ur- und Frühgeschichte, Erlangen, Germany

Stout, Dietrich Institute of Archaeology, University College London, London, UK

Straus, Lawrence Department of Anthropology, University of New Mexico, Albuquerque, N.M., USA

Villa, Paola University of Colorado Museum of Natural History, Boulder, Colorado, USA

Willoughby, Pamela Department of Anthropology, University of Alberta, Edmonton, Alberta, Canada

Zilhão, Joao Department of Archaeology and Anthropology, University of Bristol, Bristol, UK

Introduction

Marta Camps and Parth R. Chauhan

This volume addresses the different transitional processes that separate the three classical periods in which the Paleolithic period (broadly understood) is divided, through the examination of the nature and extent of behavioral changes, cultural patterns, and differences that have been attributed to them. It brings together research from many regions of the world and from differing theoretical perspectives on the aforementioned transitions, not only to compare and discuss results from the various areas, but also to evaluate the contrasts between the different processes.

This book is comprised of contributions by top researchers on this topic: some of them are actively involved in field research in different geographical regions, while others are more concerned with the theoretical aspects of these events in human prehistory. Overall, the book contains the contributions of the speakers in the *International Union for Prehistoric and Protohistoric Sciences* 2006 colloquium, *Transitions in the Paleolithic*, and numerous others from scholars who were unable to attend this session as participants due to the time constraints of the session. Twenty of them presented their papers at the *International Union for Prehistoric and Protohistoric Sciences* (UISPP) meeting in Lisbon, Portugal (September 4–9, 2006).

This book not only summarizes past work, but also assesses current research strategies and the latest results, and discusses guidelines for future research, since there is no doubt that this topic will continue to engage the attention of archaeologists and researchers in several related disciplines for many decades to come. The Paleolithic period has a strikingly varied archaeological record, and the different transitional processes that took place within it contribute to create this variation in their role as the origin of the vast array of changes that characterize the end of one phase and the beginning of another—thus meriting a much closer examination and treatment than they have hitherto received. The importance of this topic was clearly seen during the aforementioned colloquium, when presenting researchers and several members of the public engaged in several lengthy and intense discussions.

During the UISPP symposium, several perspectives were addressed, such as the differences between the divisions in different parts of the world, especially in those cases when geographical areas (sometimes regions, sometimes entire continents) that have not been thoroughly studied have seen formulae used for other regions attempting to make sense of a record that does not usually fit such parameters. The question of the classic divisions into which the period is organized, established soon after this research started, and their validity at present, were two topics also discussed. Questions such as what were the crucial aspects of hominid behavior during these periods, and how they can be detected and analyzed, were weighted against the traditional interest on the typological classification of stone tool assemblages, which have turned a system to aid research on the above questions into a widely accepted end-product.

Transitional periods open to discussion in the colloquium ranged from the "gaps" in between the three major ages, to concepts as broad as the Middle Paleolithic, understood as the nexus between the Lower/Upper Paleolithic, Early/Late innovation, and "revolution"-related moments, and usually dismissed as a period characterized by technological stasis. Is such portrayal sustained by current research? Now our aim is to offer a world-wide and varied analysis of these issues, discussed in rich-data papers providing viewpoints from as many sites and regions as possible. To help keep the debate focused, presenters and new contributors were requested to address several specific questions in their papers:

- What constitutes a "transition" and how might we recognize it? Are the Lower-to-Middle and Middle-to-Upper Paleolithic transitions clearly defined in all regions? Does the Middle Paleolithic always represent a techno-chronological link between the Lower and Upper Paleolithic (e.g., the Levallois is not prominent in Asia)?
- What, if any, technological changes took place over the concerned regions and were they abrupt or gradual in nature? What are the precise timings of these regional transitions?
- How might these transitional events relate to social, demographic, ecological, or other factors? What were prime factors that invoked technological changes and/or stasis (archaeological gaps between technological stages)?
- Were many of these transitions a result of human migrations/social interactions or were they indigenous developments? If the latter, then to what degree?
- How do the transitions signify key behavioral and cognitive changes and how are they related to the dispersal of the genus *Homo* throughout the Old World?
- What current research biases exist in these studies, and in what direction should such research be heading (e.g., current marginal attention in Asia and North America)?

A key purpose of the book is to contribute to Paleolithic research, by providing the scientific community with an up-to-date publication which: (a) encompasses instrumental classic views crucial to understanding how the phenomena of transitions, in all their forms (gradual changes, abrupt changes, and crises, etc.) have been studied; (b) includes current research and the newest developments that have only been partially presented in specialized journals, usually constrained by tight word limits; and (c) incorporates a joint and debated look to the future of this research, highlighting the outcome of the balance of many years of studies, and the most promising research leads for the coming years. The different papers achieve these goals by examining the Paleolithic record in detail in a long list of regions and sites, spread throughout most regions of the world. The multidisciplinary perspective of this volume, combined with the latest information on research regarding these processes, brings a much needed modern compendium in this field to the wider scientific community involved in the study of these topics.

Transitions in the Paleolithic, as a colloquium, made one more thing very clear, and it is that this topic cannot get "final" answers in just one meeting or a volume, as thorough as they may be. This was the reason why the present book is also the first product of the newly created UISPP scientific commission, which bears the same name. Our aim is to make progress in a continued manner over a longer period of time of focused discussions at international workshops, and resulting goal-oriented and multidisciplinary research projects.

The purposes and duties of the "Transitions in the Paleolithic" scientific commission are several. First of all is the stimulation and coordination of research related to Paleolithic transitions—whether they are seen as slow and progressive, even smooth periods of change, or dramatic and abrupt episodes and even crises—within four particular themes:

- Thematic – "transitions" as broadly understood (between periods, between cultures, between lithic industries, between hominin species, to name but a few examples).
- Regional and interregional – the whole world (potential comparisons between areas far apart, as well as observation of application of typological and related terminology created for one region, and the implications of this practice).
- Chronological – The entire Paleolithic (Lower, Middle, and Upper, as well as Early, Middle, and Late Stone Age for Africa, and Paleoindian for America), including the transition into the Paleolithic period and that which closes it.
- Interdisciplinary – views and perspectives from all empirical sciences and related techniques utilized in archaeological research and field/laboratory work are considered crucial and great effort will be made to involve professionals who specialize in such disciplines.

Secondly, as a commission, the *Transitions in the Paleolithic* commission also plans to undertake the following activities: the organization of colloquia on the subject within the framework of the UISPP Congress meetings every five years, as well as intercongress symposia and meetings in different parts of the world, thus making it easier (logistically and financially) for members and interested scholars from that continent and adjacent areas to participate.

Thirdly, the commission will also work on the regular publication of the proceedings of these gatherings. This volume represents the first in an anticipated series on Paleolithic transitions. All efforts will be made to complement future session papers by also including papers from other scholars who may be unable to attend but are working on the topics chosen for the meetings—as was done in this volume—and to have not only as many perspectives, but as many geographical regions represented as possible.

We think that it is crucial to bring these phenomena into the spotlight in their own right, and not as topics that used to be treated as the end of something or the beginning of something else. To understand any given chronological period, it is imperative that we start by knowing exactly what happened right before it, and right after.

We understand this endeavor as an effort to create a strong research network in which scholars working on the Paleolithic period, broadly understood, in all regions of the globe can share their views and the results of their hard work, with the aim of working together towards solving some of the most intriguing questions and challenging topics ever.

But for now, back to the present volume, let all the contributors to this volume tell you about the Transitions in the Paleolithic through their own eyes and in their own words. . .

Part I
Methodological and Theoretical Perspectives

Has the Notion of "Transitions" in Paleolithic Prehistory Outlived Its Usefulness? The European Record in Wider Context

Lawrence Guy Straus

Abstract The archeological emphasis on "the transition" between "the" Middle Paleolithic and "the" Upper Paleolithic implies that these two putative cultural stages were real entities defined in absolute contradistinction to one another and that the passage between them was sharp and abrupt. While perhaps continuing to have value as heuristic devices when discourse demands reductionism, it is increasingly clear that each of these archeological concepts (or constructs) is characterized by great geographic and temporal variability and that many of the idealized attributes of the one are often found in the other, while others may be absent from sites of the time range in which they "should" be present. While there was cultural change in Europe between 45 and 25 kya, there had also been much during the c. 250,000-year course of the Middle Paleolithic and there would continue to be much during the remaining 15,000 years of the Upper Paleolithic—and beyond—as hominids continually (albeit at varying rates) adapted to major environmental and demographic changes. Change did not come uniformly across space or time and can be described as having been mosaic rather than monolithic in character. Of course, the situation is muddied by the parallel debate over the replacement (total or partial, fast or slow) of the Neandertals—a subject that is best left out of the purely archeological debate, at least at this time, since there is currently no actual proof for the presence of anatomically "modern" humans in Europe until 35 kya.

L.G. Straus (✉)
Department of Anthropology, University of New Mexico, Albuquerque, N.M., USA

Keywords Middle Paleolithic • Upper Paleolithic Europe • transition • continuity • change • Neandertals • early modern humans

Introduction

The point to be made by this chapter is that, although of much heuristic value in providing foci for productive research and debate, the notion of "transitions" in Paleolithic prehistory is merely an archeological construct and possibly one which has outlived much of its specific explanatory usefulness. The past third of a century has witnessed a heightening of interest in (and perhaps even "obsession" with) the Middle-Upper Paleolithic transition (instigated partly by Mellars' [1973] seminal work and further stimulated by the Cambridge symposium organized by Mellars and Stringer [1989]; Mellars [1990]), and there has also been considerable attention paid to the Pleistocene-Holocene (aka Upper Paleolithic-Mesolithic) transition (e.g., Eriksen and Straus 1998; Straus 1986; Straus et al. 1996). The Lower-Middle Paleolithic transition, with a far thinner, less precisely dated record, has been the subject of some publications in recent years, but has attracted far less controversy. It too is ripe for reconsideration, as pointed out by Brooks and Yellen (2006) in a presentation at the XV UISPP Congress in Lisbon (see also McBrearty and Tryon 2006). But, without a doubt, it is the MP-UP transition (particularly in Europe and the Near East) that has drawn the most attention, both in professional circles and among the media of mass communication. The organization of symposia and

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edited proceedings volumes, as well as the publication of authored books and articles (sometimes accompanied by press releases and Internet postings of new discoveries or—more often—"new" interpretations) on "the Transition" has become a cottage industry, guaranteeing subject matter (if not job security) for myriad paleoanthropologists across several generations. But are we deluding ourselves as to the "reality" of the phenomenon under study?

It is my perspective (quite obvious and non-controversial, I should think) that hominid adaptation is a never-ending, ongoing process. Hominid occupation of specific regions or latitude ranges was certainly interrupted (often repeatedly) because of natural phenomena (e.g., the effects of glacial cycles and other climatic fluctuations, catastrophes such as volcanic eruptions, tsunamis, or epidemic diseases). However, despite local discontinuities, the "big picture" is one of long-term evolutionary continuity for the hominids, notably Homo sapiens (sensu lato). Yet the profession wants to insist on the importance of "breaks" or "punctuation events" that are labeled "transitions." I posit that the reasons we fixate on what happened in Europe between about 40–30,000 RCYBP are (1) the "disappearance" of the Neandertals and (2) the "appearance" of "art" by the end of this period. Ironically, the Pleistocene-Holocene (Upper Paleolithic-Mesolithic) transition is easier to define, because it has to do with human adaptations to a well-studied, major, and relatively abrupt climatic "event," while the MP-UP transition took place against the backdrop of relatively benign (albeit fluctuating) climatic conditions in late Oxygen Stage 3 (van Andel and Davies 2003). Ever since the discovery of the Neandertal and Cro-Magnon type fossils in the mid-19th century, prehistorians, human paleontologists, and members of the public have been intrigued by the possibility of relationships between these two apparently different types of humans, a fascination that only grew with the discoveries of both hominids in Near Eastern sites in the early-mid 20th century. It is this (biological) question that, in my opinion, continues to color and, indeed, to drive the agenda concerning the so-called MP-UP (cultural) transition. Ultimately the issue is whether the Neandertals, long relatively isolated from the rest of (proto-)humanity in their European macro-peninsula, had drifted genetically so far as to not be able to be (or perceived to be) mates for individuals of another contemporary form of Homo sapiens, whose range had expanded once again out of Africa. This is at present an unknowable question, one not further speculated upon here.

As archeologists, I believe it is imperative that we decouple the questions of how, when, if, and/or to what extent the Neandertals and their gene pool went extinct or were genetically swamped by immigrants to Europe from the questions of what was going on in the complex world of cultural change in Europe and the Near East during late OIS 3. Why? Because I think it has been made amply clear (e.g., in the cases of Neandertal and non-Neandertal authorship of Levantine Mousterian industries, and of apparent Neandertal authorship of the Upper Paleolithic-type Châtelperronian and Olschevian industries of Franco-Cantabria and Croatia, respectively) that anatomy does not equate to artifacts. This attitude would seem all the more prudent given the fact that, during at least the first 5,000 ^{14}C years of the "transition" period, the only type of hominid for which we have physical remains in Europe is Neandertal.

More-or-less anatomically modern fossils do not appear in the record (at least at present) until about 34,000 RCYBP (in Peştera cu Oase [Romania]—with no cultural association), followed by Mladeč (Czech Republic) at about 31,000 RCYBP (Trinkaus 2005). Ironically, the Mladeč fossils—controversially argued to display a mixture of "modern" and Neandertal traits (see Frayer 1997; Smith et al. 2005) and roughly associated with Aurignacian-like artifacts—are now dated to exactly the same age as the last Neandertals at Vindija (Croatia) (associated with an Olschevian artifact assemblage that includes bone points and small lithic foliate points) (Svoboda et al. 2002; Wild et al. 2005; Karavanic 1995; Higham et al. 2006). Both before and after the period c. 34–31,000 RCYBP there are Neandertals in Western Europe: at Saint-Césaire and Arcy-sur-Cure (Charente and Yonne, respectively—both with Châtelperronian assemblages [Churchill and Smith 2000, with refs.]), at Gibraltar (to c. 28,000 RCYBP [Finlayson et al. 2006]), Zafarraya (between c. 45–30 kya [Michel et al. 2006]) and other sites in southern Spain and Portugal (associated with Mousterian materials). Cro-Magnon remains are not known in Western Europe until the later Aurignacian or early Gravettian, while there are (relatively weak) arguments for the Neandertal classification of hominid remains (deciduous teeth, a juvenile mandible, and a few cranial fragments) found in the earliest Aurignacian level (18) in El Castillo Cave (Cantabrian Spain) (Cabrera et al. 2005), as well as with Szeletian materials at a pair of sites in Central Europe (Allsworth-Jones 1986; Bar-Yosef 2006; but see Adams 2007). In contrast, the 17 human remains recently recovered from early Aurignacian levels at Brassempouy (Landes) and dating between 34 and 30 RCYBP, are judged to be undiagnostic, assigned to neither Neandertal nor AMH (Henry-Gambier et al. 2004).

In short, the current hominid panorama for Europe at the close of Oxygen Isotope Stage 3 continues to suggest the coexistence on a continental scale of Neandertals and Cro-Magnons between c. 34 and 28,000 RCYBP, with no actual physical evidence for the presence of the latter in the critical period between c. 40 and 35,000 RCYBP, when the only known fossils are of Neandertals. Both during and after the latter period, Neandertals can be associated with both Mousterian and "transitional" industries. At the regional scale, there is still no evidence of actual cohabitation by the two hominid populations, with (at the poor level of precision provided by radiocarbon dating in an era of uncertain calibrations) the possible exception of Vindija and Mladeč, which are nonetheless separated by about 650 km and the Danube River.

Can We "Think Out of the Box"?

The effect of all archeological subdivision schemes (beginning with Thomsen, Lubbock, and de Mortillet, and continuing with Breuil and the Bordes [see Sackett 1991]) has been to create and reify "steps and risers" in the course toward the modern world. The framework of Lower, Middle, and Upper Paleolithic units, each with its diagnostic trait list (anatomical and cultural), automatically creates an appearance of evolution characterized by punctuated equilibria. Each stage is seen as stable (indeed static, within a range of variability among site contents, which Bordes [1961] was among the first to systematically quantify for the Middle Paleolithic) and each is separated from the next by an abrupt, sharp break. These episodes of saltation are difficult to explain; hence the frequent recourse to such deus ex machina artifices as "immigration" and "invasion"—still used today, even when proof thereof is at best murky. Quite amazingly, we are still using the same basic culture-stratigraphic "pigeonholes" that were created when the archeological record consisted of a few "type-sites" excavated with primitive methods and analyzed in perfunctory fashion. Likewise, we sometimes "think" about the nature of cultural change in ways that hearken back to the late 19th and early 20th centuries.

I will never forget the artifact cabinet of my grandfather, Guy Magnant, in Bordeaux—made and filled by him in the early decades of the 20th century. Now on display at the Musée des Beaux Arts in Angoulême, it has a series of drawers, with the "Chelléen" at the bottom and the "Robenhausien" at the top. The "Aurignacien" (sensu lato) is in its correct place between the "Moustérien" and the "Solutréen"—de Mortillet as rectified by Breuil (Straus 1985). This cabinet typifies both the goals and the means of doing prehistoric archeology in the early decades of the discipline, pervaded as it was by an assumed progressive evolution from the simple to the complex, from the crude to the more perfect. The need to make order and therefore sense out of the record of worked stones that littered many areas of the French countryside and eroded out of rockshelters and the mouths of caves, required technological stages and cultures, and hence drawers, so that each could be in its proper place along the stairway toward modern civilization. Overlaps between the contents of one drawer and those of the next had to be overlooked in the name of creating order out of confusion, just as complex cave stratigraphies were simplified by reduction to major geo-archeological horizons whose global contents could be lumped for the purposes of characterization and intersite comparsion. Understandable in 1900 or still in 1930, to believe in 2006 that the human career jumped from one stage to the other, such that its trajectory can be summarized both practically and metaphorically as a series of separate pigeonholes, drawers, or boxes, is unrealistic. Even when different populations of hominids apparently colonized the Levant during the early-mid Upper Pleistocene, they did so with technologies that were, to all intents and purposes, identical, and with subsistence strategies at best only subtly distinct (see Bar-Yosef 2000). The lines between the Upper Acheulean and Mousterian of Europe have been utterly blurred (Monnier 2006). The makers of the Early Upper Paleolithic (aka Proto/Archaic Aurignacian and Early Aurignacian, which may be different, but partially contemporaneous technological traditions [Bon 2002; see also Teyssandier 2006]) are unknown. In light of facts like these and many others, why must we continue to be confined by the (once necessary, but now suspect) archeological constructs and biological-cultural equivalences of the 19th century (see Straus 1987a, 1991, 2007)?

Lessons from Africa

In contrast to Europe, the case of sub-Saharan Africa presents an interesting (but now generally forgotten) difference in the construction of fundamental culture-stratigraphic units; namely, the addition (in 1957) of "Intermediate" periods between the Earlier and Middle and between the Middle and Later Stone Ages of J. Goodwin and C. van Riet Lowe. The First Intermediate concept referred to a period of rapid cultural change denoted by such regional industries as the Fauresmith and Sangoan, as contrasted to the long time of cultural stasis that supposedly characterized the Acheulean (i.e., the later phase of the ESA). The Second Intermediate included such industries as the Magosian, Howiesons Poort, Umguzan, and Lupembo-Tshitolian, with artifactual harbingers of the LSA (see Clark 1971, 1982:250, 1988:236). Those "harbingers" are now known to be more diverse, widespread, and abundant in Africa (beads, works of portable art, bone projectiles, quarrying, as well as lithic artifact types such as blades and points of various types), even more completely blurring the distinction between MSA and LSA (see McBrearty and Brooks 2000). A very long, mosaic transition, rather than a sudden, abrupt break is now envisioned for the development of the LSA. While the first glimmerings of it may go as far back as the appearance of bone points and, later, portable art at Blombos Cave (Western Cape, South Africa) between about 100–80 kya (Henshilwood and Sealy 1997; Henshilwood et al. 2002), and barbed bone points from Katanda (easternmost Congo) in the same time frame (Brooks et al. 1995; Yellen et al. 1995), the transition seems to be well underway by c. 45 kya, when ostrich eggshell beads appear at Enkapune ya Muto in Kenya (Ambrose 1998). Curiously, just as in Europe, this dilated cultural transition (which, however, did not involve the disappearance of any defined hominid form) included the late survival of typologically MSA, but highly variable assemblages—sometimes after the appearance of Upper Paleolithic-like Howiesons Poort assemblages—at such sites as Rose Cottage Cave (Free State, South Africa) (Wadley 2005; Soriano et al. 2007) and Sehonghong Rockshelter (Lesotho), until around 30,000 RCYBP or even more recently (Mitchell 2002). Sites like Sibudu (KwaZulu-Natal) (Villa et al. 2005) show just how complex and nonlinear the development of MSA technologies were in southern Africa. While the "Second Intermediate" is dead, maybe such a concept would once again be of use. It certainly is mirrored in Europe by the recent rise of the category of "Transitional Industries" (e.g., Châtelperronian, Transitional Aurignacian, Uluzzian, Szeletian, Bachokirian, Olschevian) (see papers in Riel-Salvatore and Clark 2007; Conard 2006). While these were developing in some regions, in others (notably southern Iberia) the Mousterian continued to exist, seemingly uninfluenced by developments elsewhere.

Was the Mousterian Absolutely Backward?

Maybe even this view (i.e., a prolonged, mosaic transition) is myopic. In contrast to the older view of Neandertals as unchanging, inflexible, reactive, robot-like beings, who habitually made a miserable living from very simple hunting and/or scavenging with minimal technological assistance, and scant ability for anything beyond the immediate and most practical needs of survival, current research is increasingly finding evidence of Neandertal abilities and capacity for change (see for example

Clark 1997, 2007; Hovers and Belfer-Cohen 2005; Zilhão 2001, 2006). One by one, many/most of the supposed defining traits of the Upper Paleolithic are being found to have developed in the Middle Paleolithic (or earlier). Rather than being "absolutes" in the sense of being absent one day (i.e., in the MP) and present the next (i.e., in the UP), it is increasingly clear that there were frequency distribution shifts among these traits: less common, less generalized in the MP; more common, more generalized in the UP. Furthermore, some of the supposedly defining UP traits appear early in the MP (or even occasionally in the LP [Lower Paleolithic]), and others late in the MP. There are instances in the MP and LP of continuity (and spread), once certain phenomena have been developed; but many others of sporadic appearances, suggesting repeated cases of localized (re-)inventions without continuity or diffusion. Although many of the classic traits of the UP did generally become more common in that period, it must be stressed that (especially at first, in the EUP) even their appearance could be geographically and temporally spotty—either for preservation and sampling reasons, or because of genuine lack of continuity and/or diffusion. In short, in terms of cultural development in both time and space, neither is the MP uniformly "archaic," nor is the UP uniformly "advanced." This can be illustrated with a number of examples.

Prismatic blade technology is routinely stated to be a fundamental UP characteristic. Yet in recent years, study after study has shown that "true" blades (i.e., not ones produced by the recurrent Levallois technique on core surfaces, but rather by the crested blade technique applied around the volumes of prismatic or pyramidal cores) appear will before the UP in many regions. Besides appearing in Africa and the Levant, blade technology is found in Mousterian assemblages in various regions of Europe (but especially NW France, Belgium, and western Germany) as early as the Last Interglacial (OIS 5e) or the onset of the Last Glacial (OIS 5d), c. 128–75 kya (Soriano et al. 2007; Bar-Yosef and Kuhn 1999; Révillion and Tuffreau 1994; Conard 1990). There seem to have been sporadic "outbreaks" of laminar technology within the Middle Paleolithic (and Middle Stone Age) of Europe, SW Asia, and Africa, although it did not "take off" and spread ubiquitously.

Bone technology, specifically the specialized shaping of projectile points, is commonly seen as a hallmark of the UP. Many flaked bones found in LP or MP contexts remain controversial, as some simply could have been hammered for marrow extraction (see, e.g., Aguirre 2005 versus Domínguez-Rodrigo 2005), but others are incontrovertible, such as the bone bifaces at three Italian Acheulean sites (e.g., Villa 1991). Recently, Middle Paleolithic sites in the Ukraine have joined sites in Western Europe (e.g., La Quina, Cova Beneito—albeit with reservations) in having worked bones and teeth—including very convincing, deliberately sawed bone tubes found in Buran-Kaya III Rockshelter (Crimea) by A. Marks and colleagues, and some of which are interpreted as handles (Laroulandie and d'Errico 2004; see also Stepanchuk 1993). While classic polished bone, antler, or ivory projectile points are absent from Mousterian assemblages (unlike the Middle Stone Age cases of Katanda [Congo] or Blombos Cave [South Africa]), the presence of such objects in the Szeletian (sensu lato) and Olschevian technological traditions of Eastern and Central Europe raises important questions because of their possible or apparent association with Neandertals (notably in Vindija Cave, Croatia [Karavanic 1995]).

Deliberate burial by Neandertals and other forms of premodern hominins has been a much debated topic over the years (e.g., Bar-Yosef et al. 1986; Belfer-Cohen and Hovers 1992; Binford 1968; Gargett 1989 [with comments], 1999; Harrold 1980; Hovers et al. 2000; Riel-Salvatore and Clark 2001). In light of the strong suggestion that the deposition of some 30 Homo heidelbergensis individuals (mostly young adults and adolescents) together with one exceptional biface in the Sima de los Huesos at Atapuerca was a form of deliberate disposal of the dead between 500 and 600 kya (Bermúdez del Castro et al. 2004; Bischoff et al. 2006), the reality of much later, albeit sporadic and regionally spotty (notably in SW France, Belgium, Germany, and Israel) deliberate Neandertal burial seems inescapable. That MP burials were at least occasionally accompanied by some forms of symbolic expression also seems inescapable, given the presence of a peck-marked limestone slab atop one of the child tombs found by D. Peyrony in La Ferrassie in 1920 (Vandermeersch 1976). The point has been made recently by Riel-Salvatore and Clark

(2001) that human burials continued to be rare and generally quite simple in both the Middle and Early Upper Paleolithic (sensu lato). I would add that, in fact, burials became more common and were often far more elaborate in the Middle Upper Paleolithic (i.e., Gravettian, which Riel-Salvatore and Clark include within the EUP; see up-to-date MP and EUP burial lists in Zilhão 2005), at least 10–15,000 years after "the MP-UP transition," with even more increases occurring in the Terminal UP (i.e., Magdalenian and Epigravettian). Thus, as with many other things, there seems to have been more change in burial as a cultural phenomenon during the UP, rather than at its onset. Put differently, continuity in burial across the MP-UP transition can be argued in terms of various aspects.

Art is perhaps the phenomenon that provides the clearest discrimination between the MP and UP, yet even here the line is a bit fuzzy, and the differences between the situation on the respective sides of the line are not completely absolute. Of course there is a significant question as to the definition of art, particularly when the deliberate, non-utilitarian modification of certain materials results in images that are not apparently representational. Once again, such objects do appear sporadically in the pre-Upper Paleolithic record (and now quite spectacularly in the MSA of South Africa, with the discoveries of geometrically engraved pieces of worked ochre at Blombos Cave [Henshilwood et al. 2002]). Some of the earliest and more convincing material in Europe comes from Bilzingsleben in eastern Germany, rhythmically marked bones dating to c. 300–350 kya (Mania 1990).

The catalogue of Middle Paleolithic-age "art objects" from Europe (and the Near East) neither is very large nor are its constituents very spectacular, but a few researchers (e.g., A. Marshack, R. Bednarik) have long battled to gain recognition for such artifacts as deliberately crafted, non-utilitarian, possibly symbolic creations. In addition to the case of the La Ferrassie slab, some of the better known MP "art" objects are the flint nodule cortex with an engraved concentric semi-circles motif in sealed stratigraphic context from Quneitra (Golan Heights) with terminus ante quem dating of c. 54 kya (Marshack 1996) and the mammoth molar plate "plaque" from Tata (Hungary), c. 100 kya (Marshack 1988); less well known is the grooved and peck-marked pebble from the Mousterian deposit in Axlor (Spanish Basque Country), >42 kya (Barandiarán 1980), now joined by a pebble from Mousterian Level 21 in El Castillo (Cantabria), c. 70 kya, with five pecked "dots" (Cabrera et al. 2005, 2006)—neither of which looks at all like a hammerstone. Ochre was being used by early modern humans with Mousterian technology at Qafzeh (Hovers et al. 2003). Clearly, other "artistic" or "musical" objects (especially grooved teeth and perforated bones) from Mousterian deposits have more parsimonious natural explanations, while others may have been intrusive from overlying Upper Paleolithic levels. But "something symbolic" seems to have been going on within the large brains of at least some Neandertals and their contemporaries.

This is obviously true in the case of the Châtelperronian—a culture which, until the discovery of the Saint-Césaire (Charente) Neandertal in 1979, had always been included within the Upper Paleolithic stage, either under that name (sensu D. Garrod) or under the names "Lower Perigordian" (sensu D. Peyrony) or "Lower Aurignacian" (sensu H. Breuil) (see Harrold 2000). Châtelperronian levels from two sites—Quinçay (Charente) and notably La Grotte du Renne (Arcy-sur-Cure, Yonne), which also has associated Neandertal bones—have personal ornaments (mainly perforated or grooved teeth, along with worked bone items) (White 1993, 2002).

Fire, or, more precisely, the control and complex use of fire, is an exclusively human hallmark. But since when? The debate over the origins of the hominid use of fire (e.g., long versus short chronology; presence in such early sites as the Transvaal or Zhoukoudian caves) continues, but the specific question as to whether Neandertals ever built fires (like that of whether they ever buried their dead) has been resolved in the affirmative. But there has been some question as to the complexity of Mousterian use of fire and hearth-centering of activities in comparison to the Upper Paleolithic (e.g., Mellars 1996:313–14; Binford 1989:559–60). It is true that Upper Paleolithic hearths do exhibit morphological and content diversity, as has been shown since the work of Hallam Movius (1966) in the EUP site of the Abri Pataud. Especially LUP hearths commonly contain fire-cracked rocks, suggesting a sophisticated understanding of heat-banking, roasting, and possibly water-boiling (for bone grease extraction?). But what of the MP? Changes in excavation methods and the opening of larger areas of Mousterian-age surfaces have led to significant developments in our knowledge of MP hearths. Most notably, long-term excavation of the high-resolution (i.e., fast-sedimentation) site of the Abric Romaní (Catalonia), where the surviving levels all pertain to the MP, has provided a high-quality record of hearth-centered activities and hearth variability (e.g., Vaquero and Pastó 2001; Vaquero et al. 2004). There is certainly abundant evidence of Mousterian hearths in the Near East (e.g., Meignen et al. 2001). These studies and those of others such as Rigaud et al. (1995) and Backer (1993) (the latter with the Châtelperronian of Saint-Césaire) clearly blurs the line between MP and UP spatial structuring of activities in relation to constructed hearths within sites.

Subsistence has often been seen as discriminating between the MP and UP; there have been lengthy debates over the issue of scavenging versus hunting, about the meaning and reality of "specialized" hunting, and concerning the exploitation of non-ungulate resources (e.g., molluscs, fish, plants, small mammals). Space is too limited to do justice even to a limited sample of the relevant bibliography on MP-UP subsistence differences that has been generated just over the past three decades. The pendulum has fairly recently swung (back) in the direction of seeing Neandertals as active, effective hunters of medium-large game and as occasional collectors of other food items of small "package" size. When they were being characterized as heavy scavengers (mainly and influentially by Binford [e.g., 1984, 1989 and as summarized by Mellars 1996:223–224]), the contrast between them and the makers of "the" UP could not have been greater. Now the differences are far less sharp (see, for example, Grayson and Delpech [1994] for a reanalysis of Binford's [1989] putative scavenging evidence from MP Level VIII in Grotte Vaufrey).

P. Chase has long argued for active Neandertal hunting of reindeer, red deer, bovines, and horses (depending on climatic regimen) at Combe Grenal (Dordogne) and has cast doubt on the importance of scavenging in Mousterian subsistence overall (Chase 1986, 1988, 1989). Both scavenging and hunting (especially, but far from exclusively, of red deer) are attested among the Mousterian faunal assemblages of the Latium region of Italy analyzed by M. Stiner (1994), albeit with an apparent increase in hunting relative to scavenging after c. 55 kya. A series of sites with very large numbers of bovine remains associated with Mousterian-type artifacts has been excavated in recent years in France and interpreted as specialized kill sites: Mauran (Haute-Garonne) and Coudoulous (Lot) both with bison (Farizy et al. 1994; Gaudzinski 1996) and La Borde (Lot) (Jaubert et al. 1990) with aurochsen. However, the first is on the bank of the wide Garonne River near the northern edge of the Pyrenees, and the last two sites are avens, both physical settings where many natural deaths repeatedly could have occurred and been exploited by hominins without recourse to hunting. Reanalyses of old MP faunal collections from Salzgitter-Lebenstedt and Wallertheim (northern and southwestern Germany, respectively) led Gaudzinski and Roebroeks (2000) and Gaudzinski (1995) to conclude that Neandertals had, repeatedly and in specialized fashion, killed substantial numbers of reindeer and bison respectively at these two open-air sites. It must also be recalled that the famous Middle Paleolithic wooden Lehringen spear was found amidst the ribs of an elephant, clearly implying Neandertal capacity for even at least occasional mega-faunal hunting (Movius 1950). Game specialization in hunting (e.g., Orquera 1984) does not seem clearly to serve to discriminate between Middle and Upper Paleolithic subsistence strategies. Situationally, certain species (e.g., reindeer) do seem to have been repeatedly targeted and thus accumulatively contributed massively to the faunal assemblages of particular Mousterian sites.

In contrast, Stiner et al. (1999) and Stiner (2001) have recently shown that some late Neandertal groups in the eastern and central Mediterranean had begun to exploit small animal food resources (especially tortoises and marine molluscs, with traces of lagomorphs and birds/eggs), in a trend toward "broad-spectrum" subsistence that was to increase throughout the course of the Upper and Epi-Paleolithic as regional human population densities increased. If there were differences in subsistence strategies among the Qafzeh/Skhul proto-modern humans, the Neandertals and early Upper Paleolithic folk in the Near East, they were subtle and probably driven by demographic circumstances more than by inherent capacities (see e.g., Shea 2003). In other regions (e.g., Andalusia [Cortés et al. 2006] and Asturias [Straus and Clark 1986], Spain) the beginnings of a broad-spectrum subsistence strategy seem to have come in response by Solutrean groups to the environmental and regional demographic stresses of the Last Glacial Maximum, while in other regions of Europe (notably in the NW), this shift occurred at the more "traditional" time of the Pleistocene-Holocene boundary, after a period of major specialization in the hunting of reindeer and/or horses, for example, in the Magdalenian.

In a vein similar to that of Stiner et al. (1999) in Italy and the eastern Mediterranean, also demonstrating subsistence continuity across the so-called MP-UP transition are the detailed faunal analyses of sites from SW France by Grayson and Delpech (2002, 2003). Their work shows that specialized hunting was not an exclusive hallmark of the UP and that the only really significant changes in ungulate archeofaunas in the late Upper Pleistocene that are not explainable by climatic changes occurred in the LUP, not across the MP-UP transition. These changes were probably the result of human demographic pressure in the Magdalenian, a conclusion echoing earlier work in Cantabrian Spain by Freeman (1973, 1981) and Straus (e.g., 1977, 1992). In short, although Neandertals were neither incapable of hunting nor unwilling to collect small, low-yield food "packages," their numbers were usually so low as to make massive slaughters (as opposed to accumulatively redundant, single-species killing at particular loci) or descent down the food chain unnecessary under most circumstances. However, sometimes Neandertal subsistence did show hints of "modernity" (i.e., resembling Upper or even Epi-Paleolithic food-acquisition behavior) and these behaviors could also appear as needed at different times and places within the EUP, while becoming much more common (of necessity) in the LUP under the dual stresses of regional population packing and climatic severity.

So Was "the" Upper Paleolithic Always and Everywhere So Different?

The Middle Paleolithic was obviously a long period and its cultural traditions were distributed over a wide range of environments throughout Europe and beyond, as well as across the climatic vicissitudes of several glacial and interglacial cycles. To an extent that has often been minimized by many prehistorians, variety and change characterized MP adaptations and material culture, with not infrequent sparks of so-called behavioral modernity—some of which were "flashes in the pan," but others probably not. By setting up "the" Upper Paleolithic in dialectical opposition to "the" Middle Paleolithic, archeologists have tended to "sweep under the rug" the significant amounts of variation that characterize both blocks of cultural time. A more realistic picture of variation is called for in research of the 21st century. Variation should not be seen as something to be reduced, but rather a phenomenon to be studied in order to get at the complexity of hominid behavior and adaptations.

Just as the MP increasingly shows signs of "modernity," so too would a "noisier" UP come closer to reflecting the diversity of human strategies for survival during a far shorter but climatically eventful period of time—OI Stages 2 and late 3. In particular, the UP can be seen as falling into at least three big adaptive phases: an initial UP corresponding to the last millennia of OI Stage 3 (40–30,000 RCYBP—Aurignacian), a middle UP corresponding to the onset of OI Stage 2 and the depths of the Last Glacial Maximum (30–17,000 RCYBP—Gravettian, Solutrean/Early Epigravettian), and a late UP corresponding to the last part of OI Stage 2, the Tardiglacial (16–10,000 RCYBP—Magdalenian, Azilian, Late/Final Epigravettian). In reality, of course, the situation is even more complicated than this. There were major differences between oceanic (western) and continental (central and eastern) and between southern (Mediterranean) and more northerly Europe, as well as between specific climatic/vegetational phases even within OI Stage 2, particularly among the LGM, Dryas I, and the Last Glacial Interstadial (aka Bölling + Alleröd). As observed above, many of the stereotypical attributes of "the" Upper Paleolithic did not come to fruition or even appear until the middle or late UP—not at the time of the vaunted MP-UP transition. Here are some:

Art and ornamentation are far from ubiquitous in the Aurignacian; some whole regions have very little evidence thereof in the initial UP, although it is admittedly difficult to date cave art with any degree of accuracy or precision. This is true, for example, of Cantabrian Spain, where, despite some limited indications of pre-Solutrean cave art—and little of it of unambiguously Aurignacian age (e.g., El Conde, Peña de Candamo, Venta de la Perra) (González Sainz and San Miguel 2001:198–199; Fortea 2000–2001)—there are very few items of portable art or ornamentation dating to before the Gravettian/Solutrean, and indeed the vast majority are Magdalenian (Corchón 1986; Arias and Ontañón 2005). In Vasco-Cantabria, the EUP artifact assemblages are virtually devoid of works of art, and this includes some large sites such as El Castillo, El Pendo, Cueva Morín, and Labeko Koba. And this is despite a century and a quarter of excavations in the region. At the continental scale, the remarkable Grotte Chauvet is just one site and some of its rock paintings are radiocarbon dated to the very end of the Aurignacian (Clottes 2001). There are several other French caves whose art has been credibly argued to be of pre-Solutrean age, though not early Aurignacian. Likewise, the Aurignacian-age ivory figurines of SW Germany and Austria are regionally concentrated (Bahn and Vertut 1997:74), and no similar items of such early age are known from other parts of Europe. Even in LUP times, when portable art is in general most abundant, there are clearly sites with large numbers of such items and/or ornaments (several of the great Magdalenian "supersites" come to mind, such as La Madeleine, Mas d'Azil, Isturitz, La Vache, El Valle, Altamira, El Castillo, Cueto de la Mina, Gönnersdorf, Petersfels, Kesserloch), but others have very few. For example, the adjacent and culture-stratigraphically identical sites of Duruthy and Dufaure in southern Les Landes are radically different, the former being incredibly rich in major works of art and ornaments, the latter all but bereft thereof (Arambourou 1978 vs. Straus 1995). Clearly, such items were not evenly distributed throughout the universe of sites and were not ubiquitous hallmarks of even UP residential loci, even during the Magdalenian cultural "zenith."

Some regions have no UP *burials* at all. Again, this is the case of Cantabrian Spain, and indeed all of Spain—with the one Iberian exception being the Lagar Velho (Portugal) child, associated with the Gravettian and dated to 25,000 RCYBP (Zilhão 2005). If there was an "explosion" of UP burial activity, it came after about 27 kya in the Gravettian and then only mainly in certain areas (e.g., Moravia, Liguria, Périgord, the Upper Don Valley). Actual Aurignacian burials are all but absent, as are Solutrean ones. In the Magdalenian in Western Europe there are several burials, but again neither numerous nor widespread, with many regions having none. In general, only a portion of even UP burials have obvious grave goods. Thus the situation does not seem to be radically different from that of the MP with respect to burial frequencies or practices (see Riel-Salvatore and Clark 2001).

While, in general, there was increased utilization of non-local *lithic raw materials* in tool manufacture throughout the course of prehistory, culminating in the Upper Paleolithic with many cases of extremely large lithic "catchment areas" (whether by direct procurement or by trade), there are many caveats to this conclusion reached by J. Féblot-Augustins (1997). Throughout the Middle and Upper Paleolithic there were always important differences (no doubt caused by fundamental differences in relief and lithology) between Western and Central/Eastern Europe, but there was considerable continuity between the late MP and the UP. However, in specific cases the generalizations do not necessarily hold up. In Cantabrian Spain, in neither the MP nor the UP is there evidence of truly long-distance transport of lithic raw materials, with the exception of some evidence of modern circulation in the Basque Country (i.e., the use of flint sources both along the present coast and in the transcordilleran area of the Upper Ebro Valley during the Châtelperronian and Aurignacian occupations of Labeko Cave, with transport distances up to 50–70 km [Tarriño2000]). It is telling that none of the game hunted in Vasco-Cantabria (notably red deer and ibex) are long-distance migrants, unlike the reindeer, saiga antelope, or horses so prominent in the diets of Upper Paleolithic people to the north of the Pyrenees (e.g., Straus 1987b, with references).

The quintessential period of very long-distance flint (plus fossil and extant mollusc) circulation in Europe was the Magdalenian, with famous cases including Gönnersdorf and Andernach in the German Middle Rhineland, Champréveyres and Monruz on the shore of Swiss Lake Neuchâtel, or even the sites of Middle Belgium. Yet there exist sites of the same age, also with evidence of heavy subsistence dependence on the hunting of reindeer or horses, that nonetheless show no indication of much or any use of flints of very distant origin. Such is the case of Dufaure, a site in the lowlands bordering the Basque Pyrenees at a ford across the Gave d'Oloron in SW France. This site (like the adjacent Duruthy) was repeatedly used as a cold-season base camp by Magdalenian reindeer hunters who procured almost all their flint from two different but local outcrops (Straus 1995). This is in strong contrast with the situation in many Magdalenian sites in the Pyrenees themselves, with abundant evidence of non-local flints—some from quite distant sources such as the Périgord. The difference between lowland and montane sites in terms of lithic procurement patterns may have to do with seasonal factors; in winter people were less mobile, having all they needed in terms of food, shelter, fuel, and flints in the Dufaure-Duruthy area.

In terms of *lithic technology,* we have already commented upon the repeated and significant presence of true blades (once characterized as being hallmarks of "modern," UP technology) in many MP artifact assemblages. In contrast, there are many assemblages dating to the Upper Paleolithic that have few blades (or bladelets), but many flakes—and often tools that "look" frankly Mousterian (i.e., sidescrapers, denticulates, large notches, Levallois flakes, even choppers). This phenomenon is well-known in the western and central Cantabrian region and is often clearly linked to lithic raw material factors, notably the scarcity of good (or any) flints and the presence of alternate raw materials such as quartzite (e.g., Straus 1996). La Riera Cave presented a detailed case study in how UP-like and MP-like can coexist or alternate throughout a long UP stratigraphic sequence (Straus and Clark 1986). A new case is that of El Mirón Cave in the Cantabrian Cordillera. Some early Magdalenian levels (14–17 kya) have assemblages rich in backed bladelets and other retouched tools made on excellent-quality flint, probably from known sources along the present shore, about 30–45 km away; while other levels are characterized by large flakes and flake tools made on local mudstone, quartzite, and limestone. Many of the latter have an "archaic" appearance, which is probably why early 20th century reports on the site speak of a Mousterian component (presumably based on artifacts brought up to the surface by looters or fertilizer diggers, since it is very unlikely that any such non-archeological excavations actually had reached the true Mousterian deposit, given its great depth). Other equally Magdalenian levels have both flint microlithic and non-flint macrolithic artifacts (Straus and González Morales 2005).

Stone tools are not infallible hallmarks of age. Indeed, an entire cultural tradition, the so-called Badegoulian (aka Proto-Magdalenian, aka Magdalenian 0), of earliest Tardiglacial age, has been defined in large part on the presence of tools made on flakes, including *raclettes,* denticulates, notches, and splintered pieces, with rare bladelets (e.g., Trotignan et al. 1984).

The subject of *subsistence* has been commented upon above, but suffice it to say that just as most MP sites are not like Mauran or Wallertheim, most UP sites are not like Solutré, with its famous horse "magma." Many UP sites are not characterized by masses of single species, but rather by small numbers of various game. Nor do all UP sites have evidence of subsistence diversification. All possibilities are present and are dependent on both the individual site locations and the circumstances of their human occupations.

There is no such thing as "MP subsistence" versus "UP subsistence." Essentialism should be banished from characterizations of the food quest, which was certainly governed situationally by regional resource structure, human demography, and chance. There were trends in subsistence, but many of the biggest changes seem to have occurred or become more common in the latter part of the UP, during and after the LGM. It is not that MP subsistence was or was not specialized or that the UP subsistence was more intensified, but rather that hominids did what they had to do to survive under a wide variety of circumstances (or at least tried to do so). The strategies for survival were many, ranging from the deploying of various kinds and degrees of mobility and territoriality, to adaptability in diet breadth, to varying the intensity of procurement and processing of resources, etc. The lines between the MP and UP are being blurred increasingly, although, of course, if one compares the Mousterian (particularly its older phases) with the Magdalenian, a general picture of more radical difference can be made to emerge. Not so, however, if one plots what we know of subsistence across the early and late Mousterian, the so-called "transitional cultures," the Aurignacian, the mid-UP, and the LUP. Sharp distinctions disappear, yielding a picture that looks more like continuity with continual experimentation and change in hominid modi vivendi among the complex environments of late Middle and Upper Pleistocene Europe.

By Way of Conclusion

As I have argued elsewhere (e.g., Straus 1983, 1990, 1996b, 1997, 2005; Straus and Heller 1988), regardless of what was happening to the Neandertal anatomical form, cultural adaptations continued to change in Europe over a long period of time. They did so unevenly, and many of the clearest shifts came with the LGM, not before. Throughout time, changes came more in the form of mosaics rather than as monochrome canvases. Many of the changes we archeologists can dimly glimpse took the form of frequency distribution shifts: certain phenomena (behaviors, products, activities, strategies) were rare for a long time, occurring as low-level phenomena in the MP or even in the EUP, but became increasingly common especially after the climatic shock of the LGM and with the ensuing demographic packing in southern European refugia. Many of the "modern" inventions (e.g., blade technology, art, ornaments, burials) of early times may have not spread because of low population density, low intensity of social interaction among distant hominid groups, and/or the frequent demise of local groups. Certain phenomena may have become increasingly adaptive under altered regional or even continental circumstances of physical environment, resource structure, and human population density (i.e., once-neutral traits that existed as low-level "mutant-like" forms of action, could be selected for when the "playing field" changed).

There was not one Transition between MP and UP; but rather, this time range in the adaptive history of humankind in Europe was simply part of the ongoing process of adaptive change, perhaps "speeded-up" at some times and more gradual at others. There were many "transitions" at different times and place, at different rates and for different reasons. As archeologists, we must be careful not to believe too much in the reality of our constructs; units such as the MP and the UP are useful to simplify a complex series of situations, but ultimately they are arbitrary slices of cultural time that was uninterrupted. This is not to deny the importance of such genuine inventions as split-base and rhomboidal-shape bone points or representational art, but even these may have had antecedents; and their appearance—whether by independent invention, diffusion, local acculturation, migration, or some combination of the above—may not have signaled an absolute break with the past any- or everywhere in the European continent.

The truly interesting task that lies before us as prehistoric archeologists is to try to understand how and why hominids changed their behavior at some times and in some places while not others, without reducing everything to facile or almost supernatural explanations for which there may be no proof. I could be wrong in much of what I think, but this is how I see the record as it presently stands, with many fascinating parallels between Europe and Africa—where there were no Neandertals.

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Accidents of History: Conceptual Frameworks in Paleoarchaeology

Geoffrey A. Clark

Abstract A moment's reflection will show that the various analytical units commonly used by paleolithic archaeologists in western Eurasia (e.g., Aurignacian, Mousterian) are 'accidents of history,' created for the most part by French prehistorians between c. 1880 and c. 1940 in order to solve chronological problems in the years before absolute dating methods had become available. Whether or not it makes sense to continue to use them as anything other than a vague and general *lingua franca* is addressed here, along with the question of what 'transitions' between these units might mean or imply about prehistoric human behavior. Since the units themselves are 'accidents of history,' the transitions between them might not mean anything at all from the behavioral ecology perspective adopted by some American and European workers. The essay compares and contrasts the conceptual frameworks of culture history (CH) and human behavioral ecology (HBE), focusing on archaeological monitors of human adaptation and how these change, or fail to change, at analytical unit boundaries.

Keywords Epistemology • Typology • Technology • Middle-upper paleolithic transition • Culture history • Evolutionary ecology • Western Eurasia

G.A. Clark (✉)
School of Human Evolution and Social Change, Arizona State University, Tempe, AZ, USA

Some Preliminary Observations

Over the past 15 years, the literature on modern human origins (MHO) has grown to immense proportions. It is evident from even a cursory examination of that literature that there is an enormous diversity of informed opinion about the nature of the archaeological transition, much of it concerned with (1) who made what, how they made it, when they made it and where; (2) how different perceptions of cognitive capacity and chronology influence the interpretation of pattern at the level of analytical units; (3) what processes were involved in transition mechanisms like acculturation, replacement, displacement, hybridization, and genetic swamping; (4) how these mechanisms can be distinguished from one another 'on the ground;' (5) how modernity might be defined (morphologically, cognitively, behaviorally); and (6) what the impetus for the generally accepted modern human exodus from Africa might have been.

All these partly contrastive, partly consilient views are 'fuzzy sets' (Willermet and Hill 1997, 77–88) that differ from one investigator to the next. They turn on vague notions implicit in the conceptual frameworks adopted by those involved in modern human origins research. Despite nominal acknowledgment of the power and generality of evolutionary biology, and the tacit assumption that it constitutes the overarching conceptual framework for *all* MHO research, no one can claim to control all of its aspects or implications. As a consequence, we tend to become consumers of one another's research conclusions, inevitably affected by assumptions about which particular

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construals of pattern in, say, human paleontology appear to square best with our interpretations of the archaeology; which interpretations of the genetic evidence seem most credible given what we know, or think we know, about human paleontology; and so on. While it is clear that any generally accepted explanation of our origins must reconcile patterns in archaeology, human paleontology, and molecular biology, no one so far has been able to do this very successfully, and no easy solution to the problem is in sight.

There is a commonly expressed hope for the appearance of pattern so robust that it will unequivocally support a particular hypothesis, but it is a vain hope in the absence of any consensus about criteria for the definition of modernity. Although we clearly need more data, acquiring data will not, by itself, resolve MHO questions like the nature of the transition, because data are not 'neutral' or intuitively obvious in terms of the meanings we assign to them. They only acquire meaning in the context of a particular conceptual framework (be it archaeological, paleontological, or genetic), and many alternative meanings are possible under the 'big tent' of evolutionary biology. In particular, there are problems with confounding explanations proposed by the advocates of culture history (CH) and those invoked by the adherents of human behavioral ecology (HBE). Although dominant in the United States until the late 1970s (and still very influential in the most common kind of archaeology practiced here—cultural resource management, or CRM), CH is now regarded by many American scholars as a preliminary but necessary step to establish rough approximations of the time/space grids required by HBE. This is especially true of areas where chronometric assays are impossible or difficult to attain, and/or where they are scarce or absent.

I have argued (1) that the basic analytical units used in paleolithic archaeology are a legacy of the CH approach and are 'accidents of history,' created—for the most part—by French prehistorians between c. 1880 and c. 1940 in order to solve chronological problems; (2) that how these units are defined has changed over time; (3) that they are based ultimately on typological systematics; (4) that they have become essentialized or reified to some extent by subsequent workers; and (5) that there is no consensus about what they mean or represent behaviorally (e.g., Clark 1991, 411–440, 2002a, 19–26). I have also tried to show that these claims enjoy considerable empirical support in respect of the most visible of these units—the Aurignacian—taken by many to mark the appearance of modern humans in Europe (e.g., Mellars 2005, 12–27; cf. Clark and Riel-Salvatore 2005, 107–118). In my view, explicit discussion of the nature of the analytical units is (or should be) an important aspect of paleoarchaeological research, since how those units are defined cannot fail to affect perceptions of pattern over the transition interval (here taken to be the 10 millennia bracketing 40 kyr bp).

Remarks like these have sometimes been taken as unwarranted criticisms of European conceptual frameworks and, by implication, the research traditions in which they arose—especially those of the 'founders' of paleolithic archaeology, the French (e.g., Marean and Thompson 2003, 165–167). I wish to make it *crystal clear* that I am *not* criticizing the French, Latin Europeans, Europeans in general, nor, indeed, anyone at all (except perhaps strict empiricists—those who think 'the facts speak for themselves' [Clark 1993, 212, 213]). The French were only doing what all archaeologists do—creating analytical units they thought relevant and appropriate to some problem they were trying to solve (see Sackett [1981, 85–99, 1991, 109–140] for a concise history of the phylogenetic paradigm in French prehistory). It should be kept in mind that paleoarchaeology is not an experimental discipline like physics or chemistry, nor do we have 'natural' analytical units that can be discovered as the life sciences do (Clark 1982, 218–220, 1987, 30–60). We have to create them, and the only way we can do that is in terms of some problem of interest (in the case of the French, how to distinguish different paleolithic assemblages from one another in time and space). But it is more complicated than that. Problems are embedded in problem contexts, problem contexts in research traditions, and research traditions in broader intellectual *milieux* (sometimes called metaphysical paradigms) that differ from one another in respect of implicit biases, preconceptions, and assumptions about their subject matter (here, what the past was 'like') (Clark and Riel-Salvatore 2006, 49, 50). No one could deny that, if paleolithic archaeology had arisen somewhere other than where it did (e.g., Africa, instead of Europe), the analytical units would have taken on a very different character (see, e.g., the extended critique of Eurocentric bias by McBrearty and Brooks [2000]). From a philosophical point of view, of course, one paradigm is 'as good as another' (i.e., its internal logic is consistent, and its explanations coherent and 'satisfying,' given that logic). But because the assumptions underlying the metaphysic determine the character of its subordinate paradigms (which in turn determine research protocols in any problem context), conflicts often arise in respect of the nature of explanation and what kinds of explanations are regarded as plausible or not. These problems are exacerbated in transition research (in fact, paleoarchaeology generally) because it is of interest and importance to several quite different intellectual traditions. In particular, the contention that prehistory is 'history-like'—an extension of history back into deep time—is problematic because it has far-reaching implications for construals of pattern and what it might mean (Clark 1993, 217–223, 2002a, 20).

Along with some others (e.g., Straus 2003, 2007; Bicho 2002; Zilhão 2001; Zilhão and d'Errico 1999; Karavanic 1995, 2000, 2007; Kuhn 1994; Stiner 1994), it appears to me that—taken in aggregate—the conventional archaeological monitors of human adaptation (e.g., lithic industries; procurement ranges; subsistence data; site layouts, locations, characteristics; etc.) indicate a temporal and spatial mosaic over the transition, everywhere that its archaeological record is fine-grained enough to provide some indication of overarching patterns. I also suggest that, at least in some areas (e.g., northern Spain), the mosaic extends far back in time into the Middle Paleolithic, and up in time through the Upper Paleolithic and Mesolithic (Clark 1989, 589–603). Although of course arguable, this suggests to me that the west Eurasian archaeological record cannot easily be reconciled with *any* construal of an abrupt and complete biological replacement (e.g., Stringer 1992; Stringer and Gamble 1993), nor with a 'wave of advance' colonization model (e.g., Davies 1999, 2001, 195–217; Mellars 2005). Regardless of the position taken on the biological aspects of the transition, the suggestion is a relevant one, since many think transition archaeology is 'hominid specific,' that it 'maps onto' Neanderthals and modern humans respectively, and that the transition interval coincided with the biological replacement of Neanderthals by modern humans. How much empirical support is there for these arguments?

The West Eurasian Mousterian and the Transitional Industries

Let's take a look at variability *within* the Mousterian of western Eurasia, as recently summarized by Howell (1999) (Table 1). Note, first, the ever-increasing number of spatially, temporally, and/or compositionally variable kinds of west Eurasian Mousterian industries. Recognized primarily on technological and typological grounds, the 20 Mousterian facies shown in Table 1 represent a quantum increase in variability over the half-dozen or so facies recognized as recently as the early 1990s. Ignoring inevitable problems with sampling error (largely a function of the amount of work done in a particular area), the facies appear to vary among themselves according to (1) aspects of raw material (availability, package size, quality, modal production sequences, procurement range); (2) average amount of reduction and (3) utilization of particular artifact classes; (4) functional constraints related to forager mobility; and (5) the nature, (6) size, (7) duration, (8) integrity, and (9) intensity of site use or occupation. Taken together, they document a complex mosaic of adaptations that, in aggregate, persists for c. 200,000 years, overlapping extensively with both the Lower and Upper Paleolithic over the entire geographical expanse of western Eurasia. When combined with the many transitional industries now recognized in the same area (Table 2), it is possible that Mousterian formal variation, site characteristics, and faunal inventories rival (perhaps even exceed) those of the early Upper Paleolithic.

The Culture History Approach

Since its inception in the latter half of the 19th century, the European approach to paleoarchaeology has been dominated by a blend of natural and

Table 1 Mousterian spatial-temporal variants (after Howell 1999, 218–226)

- *Charentian with 2 subtypes (pan-European)*
- *Typical complex (pan-European)*
- *Levantine Mousterian with 3 subtypes (Levant)*
- Typical-Crvena Stijena type (Balkans)
- Vasconian (northeast Spain)
- *Denticulate Mousterian (pan-European)*
- Mousterian of Acheulean Tradition, 2 subtypes (western Europe)
- *Mousterian-Châtelperronian (southwest Europe)*
- Cambresian (northwest Europe)
- *Pontinian (Latium)*
- *Mousterian-Karstein type (central Europe)*
- Mousterian-Tata type (Hungary)
- Mousterian-Staroselje type (Crimea)
- Mousterian-Tsutskhvatskaya type (Crimea, western Caucasus)
- Mousterian-Kudara type (western Caucasus, Georgia)
- *Zagros Mousterian (Zagros Mountains)*
- *Micoquian with 6 subtypes (central Europe)*
- Acheulo-Yabrudian (Levant)

Facies with hominid fossils (all Neanderthals except Levantine Mousterian) are *italicized.*

Table 2 Transitional industries and sites (*) with claimed transitional levels

- Châtelperronian (southwest France, northern Spain)
- Szeletian (central Europe, especially Hungary)
- Uluzzian (south-central Italy)
- Olschewian (Croatia)
- Bachokirian (Bulgaria)
- Bohunician (central Europe)
- Aurignaco-Mousterian (Italy)
- Late Mousterian (north-central Italy)
- Uluzzo-Aurignacian (Italy)
- Zagros Aurignacian (Zagros Mountains)
- Jerzmanovician (Poland)
- Bryndyzian (Poland)
- Ahmarian (southern Levant)
- Altmuhlian (Austria)
- Lincombian (southern England, Brittany)
- Streletskayan (Crimea)
- Emiran (Levant)
- Boker Tachtit (Israel)*
- Tor Sadaf (west-central Jordan)*
- Warwasi (northwest Iran)*
- Umm el-Tlel (Syria)*

geological science, heavily reliant upon a typological systematics that emphasizes retouched stone tools (Sackett 1981, 85–99, 1988, 413–426). The cultural transition is, therefore, usually demarcated by changes in the retouched tool components of archaeological assemblages. The rationale and justification for doing this is seldom made explicit, but lurking just beneath the surface is the tacit assumption that the stone tools represent the remains of quasi-historical, stylistic microtraditions, transmitted from one generation to the next through the medium of culture. Since retouch modes and edge configurations are equated with social learning, it is assumed that the time/ space distributions of 'diagnostic' stone tools are, to a degree, 'history-like'—congruent with the boundaries of identity-conscious social units loosely analogous to the tribes, peoples and nations of history. This kind of reasoning is then extended to modes in the overall forms and frequencies of the artifacts themselves. Problems with the enormous spatial extent and temporal persistence of such hypothetical social units have often been overlooked (although cf. Bar-Yosef [1991, 371–395]).

Views of the Middle/Upper Paleolithic Transition

The transition is like a greased pig—it is very elusive, slippery, hard to grasp in its entirety, and prone to generate misunderstanding (. . . if understanding the motives of a pig is regarded as a reasonable thing to do). In my view, this is because of three interrelated aspects of *all* paleoarchaeological research: (1) no universal means of communication, (2) the ambiguity of research questions or hypotheses, and (3) an absence of an overarching conceptual framework. Paleoarchaeologists lack a metalanguage (e.g., mathematics in the physical sciences) that defines concepts and terms precisely and uses them consistently according to the parameters of a fully-axiomatized, explicit conceptual framework based on grounded theory accepted by consensus.[1] This makes it exceedingly difficult to formulate research questions precisely enough to generate test implications from them. Put another way, anthropology has no metaphysical paradigm against which the products of its 'normal science' can be measured. Although a scientific research protocol is a regulatory ideal (something to strive for—we all think we are 'doing science'), and methodological standards are very important to the 'science-like' aspirations of the discipline, many paleoarchaeological questions are rather open-ended ones, little constrained by the parameters of any recognizable paradigm. In contrast, questions in physical science are classifiable by their boundary conditions. I am indebted to James Eighmey (personal communication 1997) for the tongue-in-cheek observation that archaeological questions can be treated analogically as if they were 'gaseous,' 'liquid,' or 'solid,' according to the constraints imposed upon them by the conceptual frameworks within which they are formulated. 'Gaseous' questions are unconstrained by any discernible framework (e.g., origins of religion—essentially unbounded, expands like a gas to fill the conceptual container at equal density). 'Liquid' questions (probably the most common kind) are weakly constrained by boundary conditions (e.g., evolutionary origins of religion—bounded on one axis [it presupposes a naturalistic approach], but expands to fill the container on all other axes). 'Solid' questions are uncommon (e.g., neurophysiological and sociobiological origins of religion—bounded on most axes, with little room for expansion). He remarks that, even if they acknowledge its existence, it is exceedingly difficult for paleoanthropologists to arrive at a consensus on what shape the conceptual container should be! History, of course, is another matter altogether, which is why culture history is so problematic in 'deep time.'

These somewhat daunting obstacles to communication aside, changes in the character of retouched stone tools over the European transition have been interpreted in five or six (at least partly) contrastive ways. (1) Some workers see the transition as a largely in situ phenomenon everywhere, with clear evidence of lithic continuity between late Middle and early Upper Paleolithic (EUP) assemblages (e.g., Cabrera et al. 2001, 505–532; Clark 2002b, 50–67; Wolpoff et al. 2004, 527–546; Straus 2007, 11–18). A variant of this interpretation is the 'assimilation model' proposed by Fred Smith and colleagues on the basis of the fossil evidence (e.g., 1989, 35–68, 2005, 7–19; Churchill and Smith 2000, 61–115). It postulates that anatomically modern humans emerged first in Africa, and radiated from there to Eurasia, but that 'more than incidental' genetic exchange occurred between the expanding modern and the indigenous archaic populations (Smith et al. 2005, 15). The AM is gaining adherents, partly because it relies quite heavily on evidence for continuity in the archaeology. (2) Others argue that certain EUP industries are 'adaptive responses' by Neanderthals to the arrival of modern humans producing Aurignacian industries. Whatever that might mean, it implies that Neanderthals modified existing Mousterian technologies *because of* contact with moderns to produce assemblages with mixed Middle and Upper Paleolithic characteristics (e.g., Allsworth-Jones 1986; Valoch 1990, 115–124; Djindjian et al. 2003, 29–48; see d'Errico et al. [1998] for a critical review of acculturation). A third point of view (3) is that no such intermediate industries exist and, when contemporaneous late Middle and early Upper Paleolithic assemblages are present in the same site or region, the EUP (especially the Aurignacian) must therefore be intrusive (e.g., Adams 2007, 91–110; Hublin 1995, 931–937; Kozlowski 2000, 77–107). This scenario implies that the authorship of LMP and EUP industries is known with certainty and can be generalized; and that, in some parts of Europe, archaic and modern groups coexisted for millennia but did not interact with one another to any significant extent. There are many variants of this model, which is perhaps the most popular view of the relationship between the late Mousterian, Micoquian, Uluzzian, etc., of Neanderthal authorship, and the 'real' EUP (= Aurignacian), made by modern humans. Sometimes called 'the indigenist model' (Harrold and Otte 2001, 5), a fourth perspective (4) is that typologically discrete Châtelperronian and Aurignacian industries are 'hominid-specific,' and that Neanderthals making Châtelperronian artifacts underwent a separate and earlier Middle-Upper Paleolithic transition, independent of but fully equivalent to that involving moderns and the Aurignacian (e.g., Zilhão 2001; Zilhão and d'Errico 1999, 1–68). Finally, (5) some have remarked on the 20 or so transitional industries now known from eastern and central Europe (e.g., Howell 1999). Of unknown authorship, these industries exhibit assemblage characteristics typical of neither the Middle nor the Upper Paleolithic as defined in the west (e.g., Svoboda 2005, 69–76). In some respects the opposite of the indigenist model, this scenario uncouples assemblage types from hominid types (except—usually—in respect of the Aurignacian), and interposes a separate 'transition interval' between the Middle and the Upper Paleolithic, occupied by industries that are neither Middle nor Upper Paleolithic. (For expanded discussions of transition scenarios, see Camps [2006], for Iberia; papers in Brantingham et al. [2004], for central and eastern Europe and Asia; Olszewski [2001], for the Zagros Aurignacian; and Hovers and Kuhn [2006] and Riel-Salvatore and Clark [2007], for western Eurasia.)

Patterns Generated by Typological Systematics

Leaving aside preconceptions about authorship which tend to influence the meaning assigned to pattern, and restricting the discussion to the retouched tool components themselves, it is pretty clear that there is much more continuity across the transition than has generally been recognized. It could be the case that the different perspectives just summarized are inextricably bound up with the classifications used to compare Middle and Upper Paleolithic retouched stone tool inventories. As has often been remarked, quite distinct and largely incompatible typological systems are used to characterize these assemblages (e.g., Bisson 2000, 1–48). This also affects construals of pattern over the transition and what pattern might mean in behavioral terms. Let's take a look now at some of the patterns supposedly characteristic of the Upper Paleolithic.

Upper Paleolithic Stone Artifact Diagnostics

First, there is the issue of imposed form and standardized shape, both associated with Paul Mellars (e.g., 1989, 1994, 2000), both supposedly more evident in even the earliest Upper Paleolithic assemblages than they are in the Middle Paleolithic. Many workers have noted that, despite assertions to the contrary, UP typological variation by no means consistently displays a high degree of formal standardization, nor do the types themselves segregate neatly and unambiguously (e.g., Monnier 2006, 57–84). In fact, as Sackett has remarked (1988, 418), 'the amount of intergradation between types is sometimes so great as to frustrate even the most experienced typologist,' which suggests that the types (and perhaps even the type groups) might represent no more than modal points along a continuum of morphological variation.

A second point is that *all* paleolithic tools (not just Mousterian ones) were heavily subjected to modification over their use-lives by continual use, breakage, subsequent rejuvenation, and/or intentional reworking. This means that a continuum of formal transformation is likely the rule, rather than the exception; that there might not be much design specificity in either the Middle *or* the Upper Paleolithic; and that Dibble's arguments about formal convergence in Mousterian sidescrapers (e.g., 1995, 299–368) could apply with equal cogency to many UP tool types, including most of the *fossiles directeurs* (Sackett 1988, 419).

Finally, of the 92 types recognized by the most commonly used UP typology (i.e., de Sonneville-Bordes and Perrot 1953, 1954, 1955), most sites actually contain relatively few of them, suggesting that what are perceived to be discrete types might, more often than not, simply represent successive stages in the modification of a single generalized tool and/or minor alterations in form primarily determined by variations in blank morphology (essentially the same argument first proposed by Dibble [1984, 1987] for Mousterian sidescrapers). The implication is that many (perhaps most) Upper Paleolithic retouched tool inventories are not more complex than their Middle Paleolithic counterparts, nor do they conform to more rigorous design specifications, nor are they more functionally specific—considerations that all but erase the supposed cognitive differences between the hominids that made them (Monnier 2006; Clark 2002b).

Rather than taking their adequacy for granted, we need to directly confront the very real possibility that the existing systematics might not be up to the task of answering many questions deemed important in paleolithic research. I suggest that we do not even know what the conventional archaeological analytical units are, or mean, or represent, behaviorally. It is a facile assumption of those who have faith in the adequacy of typological systematics that we are discovering, via retouched stone artifact typology, something very like the remains of identity-conscious social units analogous to the tribes, peoples, and nations of history. To those who come to MHO research from an historical perspective (often the case in Europe, perhaps not so common in the United States), paleolithic archaeology is essentially culture history (or paleoethnography) projected back into the Pleistocene, and patterns are typically explained post hoc by invoking processes like those operating in historical or ethnographic contexts. The whole CH approach is predicated on (1) the existence of tool making 'traditions' manifest in artifact form that are detectable over hundreds of thousands (even millions) of square kilometers; (2) the idea that such 'traditions' persisted unchanged and intact over tens (or, in the case of the Lower Paleolithic, hundreds) of millennia; and (3) the conviction that they are detectable at points in space separated by thousands of kilometers and tens of thousands of years of time (e.g., Goren et al. 2000; Hou et al. 2000).

I have argued at length that this culture history paradigm, while internally consistent in respect of its logic of inference, cannot be reconciled with the human behavioral ecology perspective adopted by many American workers, and (1) that most of the paleolithic 'index fossil' tool types are ubiquitous (or nearly so), at least in western Eurasia, and carry little temporal and probably no social information whatsoever; (2) that there is only a minimal and generalized learned behavioral component to chipped stone artifact form, constrained as it is by rock mechanics; (3) that there are no universal correlations between particular kinds of hominids and particular kinds of lithic assemblages; (4) that there is much formal convergence in the (few) processes by which humans chip stone; (5) that formal convergence is conditioned by contextual factors—technology, raw material quality, size, distribution in the landscape, etc.—especially as affected by mobility; and (6) that it almost certainly overrides any hypothetical 'cultural' component. In other words, I believe it is possible to explain many (perhaps most) pattern similarities in paleolithic archaeological assemblages without recourse to typology-based tool-making traditions. I make three points specifically in regard to typological systematics (Clark 2002b):

Problems with Typological Systematics

First, there are logical problems with a significant cultural 'signal' in the form of (most) paleolithic artifacts. For one thing, the time-space distributions of prehistorian-defined analytical units *exceed by orders of magnitude* the time-space distributions of any real or imaginable social entity that might have produced and transmitted them. Unless one resorts to essentialism (e.g., there is an ineffable 'Aurignacianness' manifest in the appearance of, say, Dufour bladelets), there is simply no behavioral or cultural mechanism whereby a hypothetical tool-making tradition could have been transmitted over thousands of years and millions of square kilometers. Thus, something other than historical connectivity must account for pattern similarities.

For another, we have no guarantees that the basic analytical units themselves are discrete in time and space, are 'the same thing' whenever and wherever they are found. In fact, it is highly likely that they are not. The Aurignacian as defined in France and in the Levant is the quintessential illustration of this problem. Apart from the occasional appearance of carinated tools in a few Levantine Aurignacian levels (notably at K'sar Akil in Lebanon [Marks 1993]), and a small number of split-based bone points from the Israeli sites of Hayonim and Kebara (Bar-Yosef 2000), the only similarity between the French and the Levantine Aurignacian is the name itself, imported from France by several generations of Levantine scholars trained in the francophone tradition. Whatever the Aurignacian is, it is manifestly not a 'culture' or a 'tradition.' The same can be said of all the other prehistorian-defined analytical units used to impose order on Upper Pleistocene archaeological sites in time and space. There is, of course, a range of informed opinion as to how far back in time 'cultures' and 'traditions' might be identified empirically and whether or not it is reasonable to expect that traces of them would be found in collections of stone artifacts (e.g., Bar-Yosef 1991; Close 1977; Goring-Morris et al. 1996).

Finally, there is the question of resolution and its consequences for identifying a tradition 'on the ground.' Most workers would acknowledge that no known paleolithic site sequence, or series of site sequences, is anywhere near fine-grained enough to allow us to identify the remains of the hypothetical social units that would have been the bearers of these lithic 'traditions' (i.e., even in the best-dated sites, assemblage resolution and integrity are far too low, and traditions too fleeting in time, to be recognized). Moreover, the generally-acknowledged fluidity of forager territorial boundaries would, in short order, have impossibly confounded any stylistic patterns that might have been manifest in stone tool form in the archaeological context. So, even if there were a 'cultural' component to the form of paleolithic stone artifacts, we could not possibly detect it. It is not enough to claim, as some have done (e.g., Hou et al. 2000), that we cannot yet model 'paleoculture' adequately. In fact, we already have a relatively sophisticated model for paleoculture in the HBE approach described below. The culture history paradigm, on the other hand, is simply not up to this task. By invoking identity-conscious 'migrants' whose peregrinations are supposedly manifest in timeless, changeless tool-making traditions (e.g., Locht and Révillion 2002, 146–160), process in the remote past is treated as if it were analogous to process in recent historical contexts. While this is a perfectly reasonable thing to do from the perspective of many CH advocates *on both sides of the Atlantic,* it does not make much sense from an HBE perspective.

In sum, (1) the absence of an overarching conceptual framework specific to 'paleoarchaeology;' (2) the tendency to view paleolithic archaeology as 'history-like,' replete with processes and analytical units analogous to the tribes, nations, and peoples of history; and (3) the scarcity in university curricula of what might be called an explicit concern with the logic of inference (i.e., epistemology) are the principle factors that contribute to conflicting interpretations of pattern, both in paleolithic archaeology in general, and in 'transition archaeology' in particular. Because of the European tendency to train paleolithic archaeologists in history and natural science, it could be argued that CH approaches are more common there than they are in the US, where prehistory is considered an aspect of anthropology and is typically taught in anthropology departments. American anthropological archaeology is well-known for an emphasis on (some might say obsession with) epistemology—how we know what we think we know about the remote human past. As noted above, CH dominated American archaeology from the 1920s through the 1960s, and it was precisely because of its perceived deficiencies (e.g., purely inductive research protocols, too much post hoc accommodation, no deductive component manifest in hypotheses, no test implications, etc.) that method and theory courses became widespread there during the 1970s.

Two reviewers of this manuscript took exception to these contentions (or at least the categorical expression of them). However, in much of Continental Europe, at least, there appears to be little explicit concern with the logic of inference in university curricula dedicated to the training of prehistorians. Such courses are more common in the UK and perhaps in the Netherlands (e.g., Corbey and Roebroeks 2001), possibly because of more widespread use of English there. As noted above, in the US, CH perspectives are no longer common in academic research, although they tend to be much more prevalent in CRM.

Culture History, Transition Archaeology, and Paleoarchaeology—Problem Areas

In my opinion, there are four general problem areas that afflict transition archaeology specifically and paleoarchaeology in general. Each is more or less directly linked to the adoption of the CH approach and the implicit assumptions that underlie it. Two important ones are (1) essentialism and (2) reductionism (more accurately, the intricate tangle of essentialism and reductionism that arises from adoption of a CH perspective). A third problem is (3) over-reliance upon post hoc accommodative argument, and the failure to build a deductive component manifest in test implications into explanation candidates. Finally, and as mentioned previously, (4) the absence of a conceptual framework of sufficient scope and generality to deal with process questions related to adaptation stands in the way of more compelling explanations for pattern similarities and differences.

Essentialism

In archaeology, essentialism is most often linked to typology because typological systematics plays such an important role in the definition of stone age analytical units (so important, in fact, that typology can sometimes 'trump' patterns defined on the basis of more objective criteria like radiocarbon dates). Essentialism is a philosophical standpoint that originated in classical antiquity based on the concept of essence, and founded on the idea that metaphysical essences really exist in nature and are intuitively accessible, resident in the mind. Essentialism is often juxtaposed with realism, the philosophical doctrine that universals exist outside the human mind.

The history of classification in the CH approach can account for the importance of essentialism in its research protocols. Paleolithic archaeology on the Continent developed at about the same time as the archaeology of ancient foragers in the US (i.e., those dating to the Paleoindian, Archaic periods). On both continents, it originated in the kind of natural history that dominated much of 19th century European and American intellectual life. Until Darwin, classification in the life sciences consisted of the systematic arrangement of organisms into groups or categories according to established criteria. Linnaean species were held to be the immutable products of divine creation, and the process of classification simply involved the assignment of the proper species identification to each individual organism. A type specimen was used to define the species and served as the unique standard of comparison for identifying and categorizing other specimens.

With the realization, in the first half of the 20th century, that populations of individuals, rather than individuals themselves, are the units of classification, the concept of variation somehow had to be accommodated in biological systematics. After the 1930s, classification became a descriptive preliminary to life scientists, who began to look for explanations in genetics, ecology, and development, using principles derived ultimately from the work of Darwin, Wallace, and Mendel. Unfortunately, *many paleolithic archaeologists never made this crucial conceptual transition*. Archaeological sequences in 'key' caves and rockshelters were, and in many cases still are, seen through a typological filter as analogous to geological and paleontological type sections with time-sensitive index fossils and sequences transferred more or less directly from the earth and life sciences to the study of human culture history. Well-known examples include Mugharet et-Tabun in Israel, K'sar Akil in Lebanon, El Castillo in Spain, and Combe Grenal and Laugerie Haute in France.

Reductionism

Tangled up with essentialism is a rather naïve kind of reductionism that tends to normalize or minimize variation in the perception of pattern in paleolithic archaeology by emphasizing the kinds and frequencies of retouched stone tools. Like essentialism, reductionism has a long history. It is based on a coherent philosophical position that sees modern science as materialist, and the heir to 19th-century mechanical materialism—the basis for the development of industrial capitalism. In *Lifelines—Biology Beyond Determinism,* British biologist Steven Rose (1998) recognizes three kinds of reductionism: (1) methodological, (2) theoretical, and (3) philosophical reductionism (Rose 1998, 21–43). Methodological reductionism is fundamental to all science. Some might even say it is a cognitive necessity for all sentient organisms in order to cope with the bombardment of perception. Sometimes called parsimony, theory reduction aims for a maximally satisfying description of some aspect of the experiential world, while simultaneously minimizing the number of laws and variables. While methodological reductionism is universal in science and theory reduction desirable and attainable to some extent in the life and social sciences, philosophical reductionism is deeply problematic in all science.

Criticisms of reductionism come from many quarters (Rose 1998, 73–96). New Age philosophers argue, for example, that the human experience is uniquely multivalent and richly textured, and that reductionism drains the life out of that richness and texture. Feminist philosophers of science contend that reductionism typifies the masculine, cognitive, objectifying approach to the world taken by modern science, and that it fails to respect the validity of personal, subjective experience. Some ecologists criticize reductionism because it appears to deny the interconnectedness of the living world. Reductionism is not a unified concept, however, and there are many construals of it, depending upon context and standpoint (Rose 1998, 1–20).

How is reductionism manifest in transition archaeology? Although conceptually quite distinct, reductionism and essentialism converge on typological systematics because typology is privileged in much paleolithic research, especially on the Continent. When there is no overarching conceptual framework, when theory building is largely implicit, and when pattern in the remote past is treated as analogous to, and explicable by, pattern in recent history, it does not make much sense to talk about philosophical or theory reduction in any formal way, although the latter figures implicitly in any effort to explain observed patterns. As in science generally, most reduction takes place at the methodological level, as different workers relentlessly 'pattern search,' emphasizing different suites of variables differentially. This is evident in the use of trait lists to identify behavioral and morphological modernity (thankfully, this is going out of style—see Clark and Riel-Salvatore [2005]; Mellars [2006]; and papers in Bar-Yosef and Zilhão [2006] on problems with the definition of the Aurignacian), but remains problematic in paleoanthropology because there is no consensus about just what 'modernity' is (a philosophical question), either in the past or the present, nor how it might be detected archaeologically.

So, (1) if there is no consensus definition of 'modernity,' (2) if the appearance of 'modern' behavior (however defined) is thought to coincide with the transition interval in any particular region, (3) if 'modern' behavior is considered a 'package' with at least some empirical referents, and (4) if there is little or no explicit concern with the logic of inference, then how can we expect to arrive at a consensus about anything? Modern human origins research becomes a thing of shreds and patches, without any boundaries or rules that might constrain choice in interpretations of pattern. We cannot even come to an agreement that pattern exists, let alone whether it is 'significant' or not, what it might mean, or whether it bears any formal relationship to an hypothesis we are trying to test (Fig. 1). In essence, *theory becomes method*. In the francophone tradition, this can be traced back to the influence of André Leroi-Gourhan (1964, 1965), who emphasized a functionalist approach predicated on the conviction that concepts and theories were worthless in the absence of concrete applications demonstrating their utility. Pattern searching came first; explanation of pattern came later and was largely intuitive and inductive. Because of a general mistrust of epistemology, the origins of concepts and theories were thought to be irrelevant, and their logical coherency

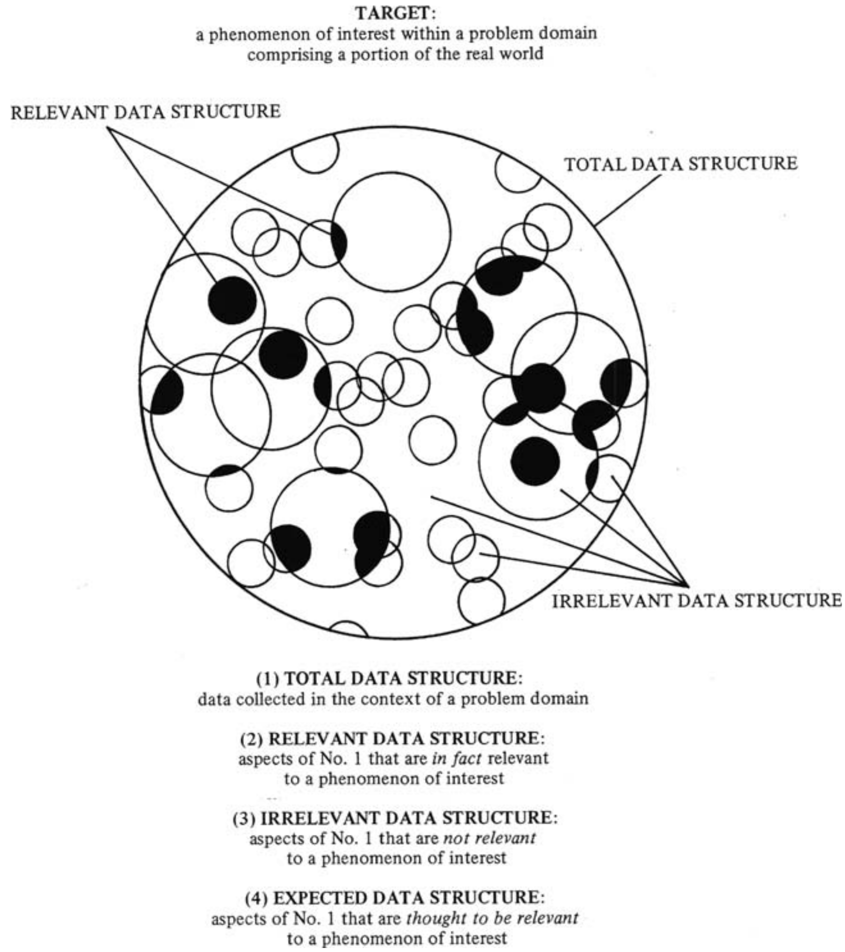

Fig. 1 A schematic representation of Carr's (1985) categories of information about the real world. The target is (2), relevant data structure. Expected data structure (not shown) may correspond poorly, well, or not at all to relevant data structure

unimportant (Audouze 1999, 167–175; Coudart 1999a, 161–167, 1999b, 653–664).

Post Hoc Accommodation

Many research designs in paleoarchaeology today are basically unconstrained or weakly constrained 'pattern search' approaches using variables selected more by convention or for convenience than for any diagnostic utility in choosing among test implications generated by null and alternative hypotheses. These pattern searches are what Binford has called post hoc *accommodative arguments*—explanations developed after data have already been collected and analyzed to explain patterns detected in them (1981, 31, 82, 83). There is a certain circularity to post hoc accommodation, and its research protocols tend to be wholly inductive. In consequence, it is only as convincing as the ingenuity of the investigator allows it to be. It can always be questioned by anyone inclined to reject the variables identified as 'significant to measure' or to disagree with how those variables are defined and measured.

Post hoc accommodative argument sets the agenda for future research; it does not constitute a genuine test of an hypothesis. It is a weak form of inference because the research designs that incorporate it typically lack a deductive component that plays off pattern in unrelated data sets (here genetics, human paleontology) against those in the primary area of inquiry (here archaeology). Paleoarchaeology has tended to rely on methods borrowed from other fields that developed in the absence of general theory as a series of conventions for assigning meaning to pattern. Human paleontologists are perhaps better off in this regard because they can invoke neo-Darwinism as an overarching paradigm. However, in both fields, these conventions exhibit a 'fad-like' quality in that they change in concert with changes in highly-visible, somewhat intangible, commonly recurring research contexts (e.g., modern human origins research [Clark 1999, 2029–2032]). A typical inductive research scenario involves a pattern search that, if at all competent, cannot fail to produce correlations among the variables examined. The question then becomes how to assign meaning to the patterns thus isolated. One's imagination is typically engaged to identify the conditions that, if they actually occurred, would account for the observed pattern. Most paleoanthropologists are sufficiently creative to be able to come up with a more-or-less plausible set of circumstances that could account for the observed 'facts.' However, it is important to keep in mind that the degree of fit between the imagined conditions and the observed properties of the data set does not constitute a test of the accuracy of that reconstructed series of events. What usually happens is that warranting arguments are marshaled to support the plausibility of the proposed explanation—to show that it is not unreasonable to suppose that it might have occurred the way the investigator suggests that it did. Plausibility is frequently supported by an 'argument from elimination' that assumes all potential causes of the pattern can be identified, enumerated (and ideally, ranked, or assigned a probability), and that all but one can be eliminated as the (proximate) cause of the phenomenon in question. However, the assertion that all possible causes were not in fact identified is sufficient to undermine the credibility of the argument (Binford 1981, 82–86). The case rests on the plausibility of the warranting arguments invoked in support of the explanation (or in some deplorable cases, by recourse to 'authority').

It must be acknowledged that there is no simple solution to this dilemma (Binford proposes more emphasis on 'middle range theory'—actualistic studies that allow us to use arguments from elimination with greater sophistication). To be fair to transition archaeologists (and to the discipline), post hoc accommodation is an aspect of all scientific research that is not purely and classically 'experimental' (whence the scorn heaped on the life and social sciences by the physical sciences). It is possible to deduce hypotheses from general theory in highly experimental fields like physics, where there is a large body of grounded theory, where theory is fully axiomatized, where argument is sustained mathematically, and where laboratory conditions are tightly controlled. None of these conditions applies to paleoanthropology.

In the absence of a strong deductive component manifest in hypothesis formulation, one can strive for what has been called consilience—the interlocking or coherence of causal explanations across multiple problem domains (Mayr 1982; Bernstein 1983; Wilson 1998). However, for consilience to work, there must be consensus about basic definitions, terms, and concepts. In my opinion, there is very little consilience in paleoarchaeology, and almost no concern with the logic of inference underlying its knowledge claims. That said, little is to be gained by ignoring these epistemological issues. If we continue to do that, we will continue to fail to confront the fundamental ambiguity of pattern in both the archaeological and paleontological records. We will fail to develop a basis for making strong inferences about the past (Clark and Lindly 1989, 661–663; Clark 2000, 851–853).

Absence of a Conceptual Framework

Clearly, the absence of a unifying conceptual framework specific to paleoarchaeology has impeded progress in arriving at a satisfactory solution to the question of our origins (in general), and the nature of the Middle-Upper Paleolithic transition (in particular). For such a conceptual framework to be viable, it must at least be consistent with the core tenets of evolutionary biology (Sober 1991, 17–38), yet flexible enough to allow for investigation of the wide range of problems associated with 'evolution and adaptive design in ecological context' (Winterhalder and Smith 1992, 4). There are a number of potential candidates (e.g., behavioral ecology, reproductive ecology, evolutionary psychology, dual inheritance theory, evolutionary genetics, community ecology, animal ethology, decision theory, etc.), all of them concerned in one way or another with the behavior of social mammals (usually primates). Sometimes lumped under the rubric of human behavioral ecology (HBE), these approaches were recently outlined, compared, and contrasted with one another by Bruce Winterhalder and Eric Aldan Smith (2000, 51–72). Although these approaches are sometimes regarded as bounded (especially by their adherents), Winterhalder and Smith (2000, 53) point out that they have increasingly come to be viewed as largely complementary fuzzy sets, overlapping with one another in problem foci, the sources of hypotheses, and some other aspects of research design (Tables 3, 4).

Human Behavioral Ecology

HBE arose out of the larger field of evolutionary ecology during the mid-1970s because of growing dissatisfaction with hunter-gatherer decision-making models (especially those concerned with resource acquisition), until then drawn largely from ethnographic accounts. Given the epistemological questions with, and limitations of, CH approaches applied to 'deep time,' it is difficult to continue to defend the position that paleoarchaeology is 'just another kind of culture history.' Over the past 15 years, there has been some recognition of this, and of the largely unrealized potential of HBE to serve as a conceptual framework for all kinds of prehistoric archaeology, from that of early hominids to that of the very recent time frames with which New World workers are concerned (Clark 2003, 51–68). These efforts, embodied now in more than a dozen books published since 1995, seek to demonstrate at the levels of 'high' and 'middle range' theory, and at the level of case studies and applications, the conviction that HBE constitutes the most promising conceptual framework within which to understand human biological and cultural evolution, 'writ large' or 'small.'

Table 3 Evolutionary anthropology—an adaptationist perspective: major approaches compared *

Aspect compared	Behavioral ecology	Evolutionary psychology	Dual Inheritance theory and evolutionary archaeology
Focuses on	Extant forager behavioral strategies	Environment of evolutionary adaptedness (EEA)	Culturally inherited variation
Approach studies	Humans	Humans, other higher primates	Humans
Temporal scale	Short-term (phenotypic)	Long-term (genetic)	Medium-term (cultural)
Emphasis on	Forager socioecology	Brain evolution (cognitive neuroscience, genetics)	Information transmission in a social context
Source of variation	Social learning (esp. as it affects subsistence, reproduction)	Cognition (esp. as it affects mating strategies, social organization)	Social learning and its material consequences
Direction of transmission	Mainly horizontal, oblique	Vertical (usually)	Horizontal, vertical, oblique
Expected current adaptedness	Highest	Lowest	Intermediate
Source of hypotheses	Formal models derived from animal ecology, ethology	Informal inferences derived from extant higher primate behavior	Formal inferences derived from social geography, demography
Hypotheses tested by	Quantified ethnographic observation, statistics	Cross-genera surveys (some laboratory analysis)	Statistical methods (usually), some use of formal models
Research protocols	Observational	Observational, experimental	Observational
Primary subfields are	Ethnography, social anthropology, oral history	Primatology, biological anthropology, linguistics	Archaeology, cultural anthropology

* Modified from Smith (2000), Winterhalder and Smith (2000), O'Brien and Lyman (2000), Steele and Shennan (1996), Barton and Clark (1997).

Table 4 Some contemporary scholars active in human behavioral ecology, evolutionary psychology and dual inheritance theory/evolutionary archaeology*

Behavioral ecology	Evolutionary psychology	Dual inheritance theory/evolutionary archaeology
M. Alvard	L. Aiello	R. Bettinger
D. Bird	S. Baron-Cohen	P. Bleed
R. L. Bliege-Bird	L. Betzig	R. Boyd
N. G. Blurton-Jones	D. Buss	R. C. Dunnell
M. Borgerhof-Mulder	L. Cosmides	J. A. J. Gowlett
K. Hawkes	F. de Waal	T. Holland
K. Hill	R. Dunbar	R. Leonard
A. M. Hurtado	H. Fisher	R. L. Lyman
H. Kaplan	R. Foley	H. Neff
R. Layton	K. Gibson	M. O'Brien
J. O'Connell	S. (Blaffer) Hrdy	P. Richardson
E. A. Smith	S. Mithen	S. Shennan
P. Wiessner	J. Plavcan	J. Steele
B. Winterhalder	M. Potts	
	M. Small	
	J. Tooby	
	C. van Schaik	
	R. Wrangham	

* The tripartite division is a 'fuzzy set;' many listed do research in more than one approach, and the approaches themselves overlap with one another.

Since its appearance in the mid-1980s, HBE has expanded to encompass multiple domains, some of them clearly applicable to paleoarchaeology (e.g., optimal foraging theory, resource transfers, dietary diversification and intensification, mating strategies, male/male competition, male/female division of labor—sexual selection in general), others less so (e.g., origins and consequences of agropastoral economies, conservation biology, demographic transitions, origins of social inequality). HBE advocates argue that natural and sexual selection, and other Darwinian mechanisms and processes, act on human behavior and more or less directly influence the material products of that behavior. HBE is often highly quantified. It adopts a hypothetico-deductive research protocol that derives testable hypotheses from mathematical models originating in a neo-Darwinian conceptual framework. Although the constituent paradigms of HBE overlap extensively with one another in terms of concepts, methods, and problem domains, all share a focus on adaptation, are explicitly reductionist, and are firmly anchored in post-synthesis evolutionary biology. In aggregate, they address research domains that, one might think, would be central to the concerns of a genuinely interdisciplinary, integrative paleoarchaeology (e.g., primate life history, demography, maturation, mating strategies, reproductive ecology, resource transfers, division of labor—indeed, all aspects of hominid sociality). HBE assumes that holistic approaches are inadequate to model complex socioecological phenomena, and that essential features of an adaptive problem must be captured and isolated first in order to understand them.[2] Despite this significant contrast with the particularism evident in much sociocultural anthropology, forager ethnographies play an important role in HBE, and there is some methodological overlap (see Winterhalder and Smith [2000, 52–54] for expanded discussion of HBE, comparisons with evolutionary psychology and dual inheritance theory). By focusing on the requirements of HBE at the theoretical and methodological levels, the approach goes some considerable distance toward creating a novel, coherent framework for explaining all kinds of variation in the archaeological record.

What is so striking about the literature of this research tradition (in addition to its 'newness'—most of it postdates 1985) is how extraordinarily fruitful it has been in terms of testability, predictive adequacy, internal coherence, external consistency, simplicity, and unifying power—epistemic qualities that should be highly prized by any archaeology that aspires to be scientific (Winterhalder and Smith 2000, 65–67). But the extent to which many paleolithic archaeologists are even aware of this literature is arguable.

The Extended Phenotype

Basic to the case for adopting HBE as the conceptual framework for paleoarchaeology is the notion of the generalized or extended phenotype—the idea that the material remains of human behavior are as much aspects of the human phenotype as are the observable features of human biology (Dawkins 1990; O'Brien and Holland 1995, 175–200). Quantitatively, the archeological record is immensely richer than that of human paleontology, and in its later manifestations, effectively holds biological macroevolution constant. Thus, it could be argued that paleoarchaeology constitutes a better basis for building hypotheses about human behavioral evolution than does the exceptionally 'coarse-grained' time-space grid of the human fossil record (even though the latter is relatively uncomplicated by 'culture'). Most of those involved in transition research will acknowledge that, regardless of the hominid involved, there is a large component of learned behavior that acts to generate phenotypic variety, manifest in the material remains Neanderthals and modern humans manufactured, modified, lost, and discarded. Evolutionary archaeologists would maintain that selection operates on the behaviors that produced this mountain of clutter, and culture—construed here as learned behavior—simply constitutes part of the human phenotype, just as it is part of the phenotype of chimpanzees and bonobos (Clark 1997, 311).

An Adaptationist Perspective

Consistent with modern evolutionary biology, an HBE perspective also entails adoption of an adaptationist view of human social behavior, conceptualized as systemic in nature. There are many definitions of adaptation (Mithen 1993, 393–398). One that is both widely used and consistent with HBE is 'any structure, physiological process, or behavioral pattern that makes an organism more fit to survive and reproduce' (Wilson 1975, 577). It could be argued that an important goal for archaeologists involved in transition research (in fact, paleoarchaeology in general) is to develop an approach to the study of the paleolithic that emphasizes changing adaptive systems. Those archaeological research traditions in which CH has a prominent place tend to overemphasize the characteristics of retouched stone tools, as if these were somehow meaningful in their own right, or to treat subsistence, paleoenvironmental, and site contextual information as if these were data categories independent of the lithics. Some have suggested that the tendency to compartmentalize aspects of the research gets in the way of the more unified approach demanded by HBE (e.g., Binford and Sabloff 1982).

Adaptation: A Local and *a Regional Problem*

For all hunter-gatherers, adaptation is both a local and a regional problem, depending on the resolution of the temporal scale that is the target of inquiry (e.g., daily, seasonal, annual range, change at the generational scale, over evolutionary time, etc.). It can be defined biologically (in terms of inclusive fitness) or, in the present context, behaviorally, by identifying particular behavioral solutions from a range of possible solutions that would allow human foraging groups to persist over time. Studies cast in a broadly ecological systems framework seek to understand the evolutionary significance of different kinds of human behavior *without making the assumption that all such behavior is necessarily adaptive* (i.e., some [probably most] behaviors are adaptively neutral, some maladaptive, some beneficial in particular places and moments in time). More important, adaptation has specific empirical referents that can be monitored using archaeological data and that can potentially inform us about the nature of change or process (i.e., whether change is directional, continuous, or not; whether change is occurring at similar or different rates; whether patterns of change are correlated with one another across different suites of variables). Analyses guided by an adaptationist perspective should be able both to identify correlated sets of variables that are changing in tandem with one another, and to isolate those that are static or exhibit a different pattern of change. Paleoclimatic fluctuations are controlled by the palynological, sedimentological, and geomorphological studies that are so fundamental to the European natural science research traditions. Time, however, is a reference variable against which to measure change attributed to other causes. Whenever possible, time is controlled by absolute dating methods and, in default of samples suited to such techniques, by dated paleoclimatic information—*never* by the supposedly time-sensitive characteristics of the retouched tool components themselves (see also Clark and Barton 1997, 309–319).

An essential aspect of HBE, the adaptationist program demands both a regional perspective and a multivariate approach to the assessment of systemic change. What this means in respect of transition research is a balanced approach that examines (1) lithic typology and technology on both sides of the transition; (2) the characteristics of raw material acquisition (source, size, quality, distribution) and transfers and how they affect lithic reduction strategies under a variety of mobility models (e.g., Kuhn 1995); (3) any evidence for organic technologies; (4) taphonomic and subsistence aspects of the archaeofaunal record; (5) site characteristics (numbers, size, artifact and faunal densities, diversity); and (6) settlement patterns in relation to paleotopography and resource distributions. As much of this pattern searching as possible should be quantified to avoid or minimize the essentialism inherent in an overemphasis on typology.

Discussion

In my opinion, it is difficult to justify continuing to search for unambiguous lithic markers of our basic analytical units, as though they were designs painted on pottery vessels. From an HBE standpoint, such a search is meaningless. Regardless of who made the late Mousterian, transitional, and EUP industries, *a temporal and spatial mosaic of different human adaptive systems* appears to be documented empirically—one that long precedes and long postdates the Middle-Upper Paleolithic transition. This, I submit, is exactly what we would expect to find, given that adaptation is—always and everywhere—historically contingent and context specific. Arguments to the contrary invoked by the CH school imply that traces of identity-conscious social units can be wrung from empirical patterns in the paleoarchaeological record, and that these patterns, manifest in lithic typology and technology, are transmitted over time and space by traditions (i.e., social learning). The CH approach has been used successfully for several generations with regard to ceramic decoration in the recent prehistory of the American southwest, where humans are unequivocally 'modern,' temporal resolution is measured in decades, and where a rich ethnographic record allows us to monitor social learning in 'living' societies not very different from their pre-contact antecedents. Whether it is justifiable or warranted to treat paleolithic stone artifacts in a similar fashion, as culture historians would maintain, is, in my view, problematic (Clark 1989, 1993, 1994, 2005).

Leaving aside the important issue of what they might mean, the commonly invoked criteria for modern behavior (e.g., Mellars 2006, 167–182) show *no correlation whatsoever* with the appearance of morphological moderns anywhere, including their alleged homeland, Africa (McBrearty and Brooks 2000). Some of the criteria originated long before the appearance of Neanderthals, became elaborated in Neanderthal contexts, and were either lost or became still more marked features of the human condition during and after the Upper Paleolithic. Preconceptions about the authorship of the transitional industries, and typological myopia, have caused some to overlook the ecosystemic contexts in which Upper Pleistocene hominids, as social animals, evolved. Modern humans are not, of course, the 'end product' of that evolution, and are only unique in the sense that any species is unique—by virtue of possessing a unique evolutionary history. The point is that we can no longer afford to approach the problem of the transition in the purely inductive, piecemeal, atheoretical fashion that has been the practice of the CH approach for more than a century.

A New World Example—Clovis Origins

Contrasts between CH and HBE are not confined to the paleolithic, nor to the Middle-Upper Paleolithic transition. They are also manifest in different interpretations of models for the initial human colonization of the Americas. In a recent essay 'deconstructing' the North Atlantic Model of Clovis origins (Stanford and Bradley 2002; Bradley and Stanford 2004), I suggested that, although we can plausibly explain *some* pattern continuities (i.e., those free to vary independently from functional constraints) by invoking social learning (i.e., traditions) in contexts like recent southwestern prehistory, to do so in 'deep time' is likely to be difficult (if not impossible) because of the factors noted above: (1) the low resolution of the Pleistocene archaeological record does not allow us to identify identity-conscious social units; (2) identity-consciousness is, always and everywhere, a 'fuzzy set' with permeable boundaries (Owen 1965, 675–690); (3) ethnohistoric traditions have limited 'life-spans,' much shorter than those implied by CH advocates for their paleolithic counterparts; (4) paleolithic traditions have an enormous geographical extent, exceeding that of any real or imaginable identity-conscious social unit that might have transmitted them; and (5) even if we could detect the material residues of lithic traditions in 'deep time,' the mobility characteristic of all foragers would, in short order, have impossibly confounded any pattern that might have allowed us to identify them (Clark 2004, 103–112).

Bruce Bradley (2006, 212–217), who is widely known for his lithic expertise, reviewed the book in which this paper appeared (Barton et al. 2004). In regard to traditions, he makes a distinction between those he calls 'situational determinists' (e.g., Straus, Meltzer, Goebel, Clark) and those he calls 'independent inventionists' (e.g., Stanford, Bradley, many Old World prehistorians on both sides of the Atlantic), arguing that the former overemphasize independent invention and formal convergence, and deny a significant role to social learning, whereas the latter—while acknowledging the importance of formal convergence—also take social learning into account. Both perspectives seek to explain pattern in lithic technology, but emphasize different causal factors differently. Bradley takes issue with the situational determinists for oversimplification:

> . . . if the contexts are similar, the technologies will inevitably be similar. [pg. 216]

and for trying to explain pattern at too gross a scale:

> The challenge for (both) the situational determinists and the independent inventionists is to demonstrate their conclusions with *detailed* technological and situational analyses. [pg. 216, emphasis in original]

Although this is a perfectly reasonable suggestion, it encounters difficulties because of the physical properties of the cryptocrystalline rocks usually selected for knapping. Chipped stone is not a '-plastic' medium like metal or clay, nor is it as malleable as ground stone or bone worked by cutting, grinding, and polishing. This 'convergence of form' is characteristic of *all* lithic reduction, regardless of where it occurs in space and time. Separate species or not, it is clearly important to ask whether we can detect significant behavioral differences encoded in the material remains attributed to Neanderthals and moderns. The resolution and sophistication of our analytical methods *are* important, and we should continue to strive to improve them. That said, I simply do not believe (for the reasons just noted) that there is likely to be much of a social transmission 'signature' in the form of most chipped stone artifacts, or that more refined analysis is likely to be fruitful if the medium involved (cryptocrystalline rocks) is relatively intractable to stylistic imprint, and the time-space resolution so coarse-grained as to preclude the identification of the makers of the stylistic microtraditions implied by the CH conceptual framework.

Concluding Remarks

It has been my intention here to compare and contrast the logic of inference that underlies the research conclusions of two intellectual traditions—that of culture history (CH) and that of human behavioral ecology (HBE). I am not claiming that one is better than the other. I am claiming that the implicit biases, premises, preconceptions, and assumptions each one of us brings to the geographical areas and problem domains in which we work can have a significant effect on how we explain things. I submit that these nebulous, but no less real entities structure archaeological research in complex and subtle ways, and offer broadly defined conventions by which we attempt to give meaning to pattern. I also think that paradigmatic biases exhibit a fuzzy but modal character, manifest geographically and temporally, that is essentially the product of the scholarly traditions in which workers have received their training, combined with the compromises they must make in order to come to grips with archaeological evidence in actual, 'real-world' situations. There are differences of opinion as to whether or not it is possible to identify the parameters of national or regional research traditions, whether all bias is idiosyncratic, and even whether such things as research traditions exist (Knüsel 1992, 981–986). If they do exist, differences amongst them should be most apparent at the level of the metaphysic—the overarching conceptual framework that governs the entire research enterprise—since there is clearly much overlap in lower-order sociological and methodological paradigms (Masterman 1970, 59–90).

Readers should keep in mind that paleolithic archaeology is, for the most part, a nonexperimental field that is poorly developed conceptually and in which epistemological concerns are shared by only a small number of practitioners (let alone accorded any importance). That tends to leave 'high theory' (explanation) as something to be built 'from the bottom up.' Although the now-venerable and wholly commendable concern with middle-range theory (e.g., Binford 1981) has led to important new insights about the natural and cultural processes that combine to create pattern in an archaeological record, there are no guarantees that anything will cohere at higher levels of abstraction. If there is any coherence, it will come from a shared metaphysic that is essentially the product of a research tradition. For an increasing number of American paleoarchaeologists originally trained in anthropology, the metaphysic is that of human behavioral ecology. For many European scholars trained in ancient history and natural science, the metaphysic is that of history.

Notes

1. I am indebted to two anonymous reviewers for pointing out that there is more explicit concern with inferential logic in the European research traditions than I had originally given them credit for. Since the mid-1980s (and largely due to criticisms of typology), much of this literature is concerned with technological systematics (especially, although by no means confined to, *chaînes opératoires* [which by their very nature focus on technology and raw material transfers]). There is a large body of literature devoted to technological systematics, and to cite even a sample of it here would make an overlong paper even longer. Some of the more important workers are Boëda (2005), Geneste (1990), Geneste et al. (1997), Laville and Marambat (1993), and Meignen (1988). Then there are a series of books and papers that focus on explanatory frameworks at the highest level, e.g., Leroi-Gourhan (1964, 1965), Gardin (1980), Gallay (1989), Stoczkowski (1994), Coudart (1999a, 1999b), Cleuziou et al. (1991), Audouze (1999), Bicho (2002), Rigaud (1997), Delagnes and Meignen (2006), Vega (1993), papers in Scarre and Stoddart (1999), and an Ucko-edited volume (1995), to name just a few. Except for the works of André Leroi-Gourhan, however, much of this literature has had relatively little impact on paleolithic archaeology. Whether or not the shift in emphasis from typology to technology has had an impact on explanation is more difficult to ascertain. As mentioned previously, a case could be made that many European explanations for pattern (especially those in the Franco-Cantabrian 'heartland') are largely uninformed by theory, are 'history-like,' and are based on artifact-making traditions that persist for, in some cases, tens of millennia. I would submit that the contention that they are technocomplexes begs the question of transmission as much as the contention that they map onto identity-conscious social units of some kind. A good example is the conclusion

that the (presumably Neanderthal) makers of the Mousterian at Bettencourt exemplify a tool-making tradition that persisted in the Somme valley for c. 40,000 years (Locht and Révillion 2002, 167; cf. Clark 2005).

2. The idea that the undifferentiated cultural system cannot be analyzed and understood holistically was first articulated by Binford more than 45 years ago (1962, 217–225).

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Defining Modernity, Establishing Rubicons, Imagining the Other—and the Neanderthal Enigma

Olga Soffer

Abstract This chapter begins with the assumption that the analytical categories we impose on the world—including the deep past—are arbitrary constructs invented for heuristic purposes rather than discovered innate properties. I argue that such partitioning is and always was affected by political realities—extant or envisioned—which clearly demonstrate the "virtual" rather than intrinsic reality of such "Rubicons." I further argue that when we fail to acknowledge this, we assign unwarranted significance to our constructs and waste precious research resources analyzing them. I illustrate these points by discussing the "Modernity" conundrum—the Middle to Upper Paleolithic Transition—that has been the subject of innumerable muddled and ultimately largely sterile debates over the last 25 years or so.

Keywords Modernity • Neanderthals • Early Anatomically Modern Humans • Middle Paleolithic • Latter/Upper Paleolithic lifeways

I suggest that the current "modernity muddle" is with us largely because of the dual heritage that our evolutionary theories have, once we get beyond pure biology. These two roots differed significantly in how change was envisioned. The progressive directionality of social philosophy, while broadly congruent with Lamarckian thought, was in an ongoing tension with the innate opportunism of Darwinian biology. The net result of this 19th century syncretism was to envision human prehistory as a series of universal progressive stages, each featuring specific technologies, subsistence practices, and social organization—something clearly exemplified by Henry L. Morgan's grand scheme, for example.

By the end of that century the depth of human antiquity was recognized, the archaeological record augmented with hominid remains, and the Paleolithic subdivided within the Stone Age. The social-political realities in the first half of the 20th century led to a divergence in what Euro-American scholars focused on in Paleolithic research. Scholars in continental Western Europe, after initial paleontological criteria to subdivide the Paleolithic (e.g., the Age of the Reindeer, the Age of the Mammoth and Wooly Rhino), settled on stratigraphy and changes in tool typologies. Anglophone scholars, on the other hand, conjoined earlier Scandinavian interests in the natural environment with Thomsen's effective sorting scheme and focused on technological progress through time (e.g., the Three Ages, dividing the Stone age into the Old and New Stone Ages).

Researchers in the East, on the other hand, more influenced by German ethnology as well by Marx, Engels, and Morgan, emphasized changes in social relationships through time. These diverse vantage points necessarily led to different ways of segmenting the continuous Paleolithic record: into the Lower, Middle, and Upper in the West and into the Ancient endogamous horde and Late kin-based exogamous clan societies in the East. In spite of these overt differences however, West, Central, and East European scholars all envisioned human prehistory as a series of universal linear evolutionary stages where the global was reflected in the local.

O. Soffer (✉)
Department of Anthropology, University of Illinois, Urbana, Illinois, USA

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By the second half of the 20th century, the Paleolithic “when” and “what” having been more or less established, research focus shifted to the “why”—giving rise to questions about ancestral behavior. Political events at the end of the century coalesced the East and West research agendas. Although these newly globalized “why” questions were informed by ecological insights, they still carried with them many old and problematic assumptions: specifically, that the chronological and conceptual boundaries created by our predecessors had innate eternal reality as well as that the limited technological repertoire recovered from the sites mirrored not only past “performance” but also past “capacity.” Furthermore, the local and arbitrary nature of techno-typological constructs was naturalized and globalized, and technological progress continued to be seen as a self-generating product arising from the intersection of hominid genius and need. This accompanied a normative stereotypical approach to behavior—one which was conceptualized on the group level only.

Introduction—The Perils of Mixed Heritage

The “Neanderthal Enigma,” a range of questions about what happened to the Neanderthals and Middle Paleolithic lifeways in Eurasia some 50–27,000 years ago, has been a perennial academic “hot topic” for the last two decades. Despite numerous conferences and ensuing edited volumes on the subject, today we are no closer to agreement on whether the advent of Upper/Late Paleolithic/LSA lifeways resulted from “evolution” or “revolution.” In this chapter, I argue that this muddled state of affairs is with us largely because of the dual heritage that our evolutionary theories have, once we get beyond pure biology. This theoretical amalgam is a 19th-century unilineal evolutionary construct that conjoined biological insights about how change through time came about with those of social philosophers. These two roots differed significantly in how change was envisioned. The progressive directionality of social philosophy, while broadly congruent with Lamarckian thought, was in an ongoing tension with the innate opportunism of Darwinian biology (Trigger 1989). Added to this were the bifurcated ideas about the pace of change—Marxist qualitative revolution vs. Darwinian slow additive evolution. The net result of this syncretism was to envision human prehistory as a series of universal progressive stages, each featuring specific technologies, subsistence practices, and social organization—something clearly exemplified by Henry L. Morgan’s grand scheme, for example (for a related critique but from a different starting point of post-colonial theory, see Gamble [2007]).

By the end of that century the depth of human antiquity was recognized, the archaeological record augmented with hominid remains, and the Paleolithic subdivided within the Stone Age. The social-political realities in the first half of the 20th century led to a divergence in what Euro-American scholars focused on in Paleolithic research. Scholars in continental Western Europe, after Lartet’s initial biostratigraphic criteria to subdivide the Paleolithic (e.g., the Age of the Reindeer, the Age of the Mammoth and Wooly Rhino), settled on de Mortillet’s archaeostratigraphy and tool fossil indexes (Sacket 2000). Anglophone scholars, on the other hand, while incorporating earlier Scandinavian interests in the natural environment, focused on technological progress through the Stone Age as illustrated by various contemporary groups such as the Australian aborigines, the Bushmen, and the Eskimo. The resulting constructs, although using different criteria to characterize the Middle and the Upper Paleolithic inventories, centered on one component of past technologies: tools made of durable media, specifically of stone. Both also treated technology as *sui generis*—as well as assumed a progressive relationship between the two.

Researchers in the East, on the other hand, although initially trained by French scholars, from the 1920s onward were more influenced by German ethnology as well as by Marx, Engels, and Morgan, and by privileged changes in social relationships through time (Boriskovskij 1984; Efimenko 1938; Klejn 1977; Trigger 1989). These diverse vantage points necessarily led to different ways of segmenting the continuous Paleolithic record—into the Lower, Middle, and Upper in the West and into the Ancient endogamous horde and Late–kin-based exogamous clan societies in the East (Bordes

1968; Gamble and Roebroeks 1999; Grigor'ev 1968; Klejn 1977, 2001). In spite of these overt differences however, West, Central, and East European scholars all envisioned human prehistory as a series of universal linear evolutionary stages where the global was reflected in the local.

By the second half of the 20th century, the Paleolithic "when" and "what" having been more or less established, research focus shifted to the "why"—giving rise to questions about ancestral behavior. Political events at the end of the century coalesced the East and West research agendas. Although these newly globalized questions about ancestral behavior were informed by ecological insights, they still carried with them many old problematic assumptions. Specifically, the limited technological repertoire recovered from the sites was taken as a mirror of not only past performance but also of past capacity; the local and arbitrary nature of techno-typological constructs was naturalized and globalized; and technological progress continued to be seen as a self-generating product arising from the intersection of hominid genius and need. This accompanied a normative stereotypical approach to behavior—one that was conceptualized on the group level only.

Defining "Modernity"

This complex theoretical heritage, together with the accumulated research results, has produced the problematic contested criteria we use today to investigate the "Neanderthal enigma" and to characterize the transition from the Middle to the Upper Paleolithic. The central operating concept appears to be "modernity"—biological and behavioral—yet no agreement is on hand about its definition. While in more innocent days the two were equated, in light of the Near East record as well as of St. Cesaire, Arcy (Hublin et al. 1996; Julien and Connet 2005), and Vindija (Higham et al. 2006, with references), today we know that morphology and genetics are best decoupled from archaeology. Debates about "modernity" are ongoing among paleoanthropologists, with the significance of particular character sets and DNA sequences in contention (Stringer 2006; Trinkaus 2006; Wolpoff et al. 2004; Zilhao 2006).

Debates are also evident in archaeology with discourse increasingly challenging the idea that there are discrete universal signposts or "fossil indices" of modernity diagnostic for all times and all places. In archaeology the "modernity" kitchen list is techno-centered and includes blades vs flakes; ivory, bone, and antler technologies vs. just lithic or lithic plus wood ones; personal adornments vs. the unembellished body; and "art" and "decoration" vs. utilitarian minimalism (e.g., Klein 1999; Mellars 1996, 2005, 2006; Bar-Yosef 2000, 2002). These criteria are more than slippery because they are neither universal nor eternal (Henshilwood and Marean 2003; Hovers and Belfer-Cohen 2006; McBrearty and Brooks 2000; Soffer 1995; Zilhao 2001; Zilhao and d'Errico 2003). The classificatory significance of flake vs. blade tools was a quantitative one for Bordes (1968) to begin with—38% of tools made on flakes meant Middle Paleolithic inventories, 41%—Upper Paleolithic. Such a classification system not only rested on essentialist assumptions that the patterns in retouched stone tools are objectively real and meaningful, but also used very different typologies for each time period to begin with (Clark 1997a). No wonder a pattern was observed—the typological filter insured it! Although blade tools were locally important in Southwestern France some 30,000 years ago, they were irrelevant in Australia and the New World until at least the mid-Holocene (Bar-Yosef and Kuhn 1999; Mulvaney and Kaminga 1999). Even in France itself, pre-Upper Paleolithic blade industries are noted at early Middle Paleolithic sites, as is the case in the Caucasus, in the Near East, and in Africa (Bar-Yosef and Kuhn 1999; McBrearty and Brooks 2000; Kozlowski 1998). Such a waxing and waning blade record clearly indicates that blade tools are not valid markers of "modernity." A similar observation can be extended to all other tool types, be they bladelets, microliths, or grinding stones (*contra* Bar Yosef 2000, 2002).

More recent technological criteria of core treatment in the different *chaînes opératoires*—two dimensional or volumetric—are also not universally diagnostic. While Upper Paleolithic Perigord saw volumetric crested cores used, many coeval and equally modern Late Paleolithic Central Asians (Shafer and Ranov 1998) and Siberians used bifaces and Levallois flake tools (Brantingham et al. 2001; Derevianko 1997; Vasil'ev 2001).

The appearance of bone, ivory, and antler implements also is a local weathervane and not a global one. First, they are found, admittedly sparsely, not only in Middle Paleolithic/Middle Stone Age assemblages, such as at Blombos in South Africa (Henshilwood et al. 2002; Henshilwood and Marean 2003) and Salzgitter-Lebenstedt in Germany (Gaudzinski 1999a) but also in Middle Pleistocene Lehringen and Swanscombe, for example. Furthermore, the 400,000-year-old Shoeningen wood spears remind us of the ubiquitous preservational bias which our focus on durable media ignore (Thieme et al. 1993). The proliferation of osseous implements in northern Eurasia at one point in Late Pleistocene time and their paucity or absence from the Near East, Australia, or the New World, I would suggest, has more to do with the thermal tolerance and plasticity of antler and bone in northern latitudes—something especially important there in stadial times—than with human cognition.

The same critique can be extended to all other items of technology, and led McBrearty and Brooks (2000) to argue that the "modernity revolution" never happened as such, but represents a compendium of cumulative innovations first seen in Africa. While we may challenge some of their evidence, their point about the asynchrony and locality are most important.

The same observations are true for "art," for jewelry, engravings, and all other symbolically meaningful inventories. Durable personal adornments are equally local in time and across space, and so are painted cave walls and carved figurines. While these inventories proliferate in Upper Paleolithic Eurasia, they are patchily distributed across it (Soffer 1994, 1995). They are sparse indeed on continents such as Australia or North America, which were peopled by equally modern humans. These inventories also all but disappear from the locales of their prior proliferation—for example, from Europe at the close of the Pleistocene—only to appear where they were sparse before: the Natufian Levant, for example. Such a mosaic record clearly suggests that neither "the climate" nor unique capacities (i.e., "vitalism") are adequate explanations for these categories of artifacts or for the more mundane ones.

Bar Yosef and Kuhn (1999) have noted that evolutionary trends in Pleistocene Eurasia were historically contingent and not universal. This negates the value of seeing the Middle to Upper Paleolithic transition as a "Revolution" and seeking a core area where it began (*contra* Sherratt 1997; Bar Yosef 2000, 2002). To do so not only equates a contingent change in human behavior to speciation, but invokes the centuries-old "*ex Oriente lux*" explanation to boot.

Implicating Technology—Inventions and Innovations

We know that the Upper Paleolithic/LSA archaeological records in various, but not all, regions of the occupied world do show a proliferation of blades and bladelets. These likely are related to changes in the desired supports and the use of complex composite tools. In northern latitudes these supports involved ivory, antler, and bone, and signal a proliferation in the diversity and complexity of multicomponent composite tools and a greater reliance on them (Bar Yosef and Kuhn 1999). Since this multicomponent weaponry was likely used in hunting, what we are seeing, in fact, is a veritable "arms race," where it was, as Kuhn and Steiner (1998) put it, important either to be a better hunter or, perhaps, to just look like one.

Exploring why this may have happened places us before a reality that technology, just like the symbolic marking of the self via jewelry or of cave walls, is a social phenomenon. As Kranzberg (1989) has pointed out, technology is a very human activity, and so is the history of technology. Furthermore, since technology solves problems, to understand both invention and its development we need to embed technology within the human decision making from which it emanates (Dobres 2000; Lemmonier 1986, 1992, 1993). It follows from this that seeing technology as a solution to problems, calls for specifying the types of problems that it addresses (Torrence 1989; Kuhn and Stiner 1998). For the purposes of this discussion I wish to stress Balala's (1988) seminal point that technology is cultivated to meet perceived needs, and that these needs are defined by a particular social matrix. The social matrix, in turn, is constrained by a number of variables that may be discernible in the archaeological record. Specifically, if we combine the economic insight that in pre-market societies it is consumption that stimulates production (Gregory 1982) with the understanding that technology is a component of production, we can hypothesize that technological changes in the past likely signal changed wants; more specifically, increased consumption demands. Such changes in demands, as Minnegal (1997) has pointed out, may have resulted from changes in social organization alone—in other words, without requiring an increase in population or in group size.

Our past studies of prehistoric technologies have followed adaptationist paradigms which favor seeing ecological/economic concerns as primary in human decision making. More resent research also points to the importance of the social and political concerns of the decision makers. Seeing technology as meeting perceived needs defined by a particular social matrix allows for new questions and insights. Why does the Upper Paleolithic/LSA initiate what Straus (1997) has called the "Upper Paleolithic arms race"—refinement and rapid change in support and insert types? Kuhn and Stiner (1998), as noted above, have suggested that it reflected a desire to be a better hunter or, at least, to look like one. Why want this? Why hunt more or better? What is the payoff? These are questions of performance, real or perceived, and ones that lie squarely in the domain of the social. The beads, the painted animals, and the carved figurines proliferating in some parts of Eurasia point in the same social direction—to the domain of defining the self and the "other" and negotiating the boundaries.

Being Modern—Being Human

Since I have argued that modern behavior is not about specific artifacts or media, what is it then that we can identify as universal features common to all modern humans whom we know through history and ethnography? For me the essence of "modernity" is institutionalized interdependence—the various social ties that create permanent intersex bonds between adult individuals through such grouping principles as marriage, kinship, and descent ideologies (Graves-Brown 1996; Strum and Latour 1987; Thomas 1998). This interdependence, evidenced in social obligations, is grounded in sharing and protecting beyond the mother and child dyad ubiquitous in all primate societies (Hawkes et al. 2001; Ingold 1987; Riches 1982). It is this social construction that permits the division and separation of labor along many possible lines and can be understood as the first manifestation of specialization in production. The tie between interdependence and the sexual division of labor was highlighted by Collier and Rosaldo (1981) more than 25 years ago, while Hartmann added gendering to it by noting that "From an economic perspective, the creation of gender can be thought of as the creation of the division of labor between the sexes, the creation of two categories of workers who need each other" (Hartmann 1981, 371).

Gamble (1999), arguing along similar lines, has suggested that "modernity" lies in extra-local ego-centered networks vs. the mere co-presence that preceded it. Recent research on primates, however, has shown that ego-centered networks are an important feature of their social organization as well, making such networks not diagnostic of human modernity. Rather, I argue, it is the invented social categories that distinguish us from all our hominoid relatives and hominid ancestors. The interdependence underwriting such categories can be and is performed through a variety of actions that leave behind a material record, which ranges from minimal and ephemeral, as in Tasmania for example, to permanent, as in Lascaux or Mezhirich. It is this interdependence that underlies the symbolically organized behavior that Stringer and Gamble (1993, 207) have argued is "the main structural difference that distinguishes moderns from the ancients." This insight is echoed by Henshilwood and Marean (2003) as well as by Wadley, who underscores that: "Modern behavior is, then, about social organization and relationships that are expressed and transmitted through symbols" (Wadley 2003, 248). While all these authors see "modernity" in symbolically mediated social relationships, they do not problematize how such a uniquely human state of affairs came to be—a question I address below.

Agency, Geography, and Motherhood

Having outlined my criteria for modernity, I next turn to the Eurasian paleoanthropological record to consider the possible differences between archaic and modern lifeways. I use demographic history as my entrée—focusing on the distribution of the youngest evidence for archaic lifeways.

Demographic Histories

Change, be it evolution or extinction, does not happen to individuals—it happens to populations. All populations have histories that show successful periods when they expand into new habitats, as well as periods of stress when they contract into refugia. Sometimes refuging is temporary and populations rebound; while with no rebound, local extinctions follow. Research on the extinction of mammoths has shown that it is serial local extinctions that ultimately bring about the extinction of the taxon (Soffer 1993, 2000, with references). The young dates for the last mammoths clearly show just how slow a sequence of serial local population extinctions can be before the demise of the last representatives of the taxon occurs. These Holocene mammoths also inform us about the relationship between refugia and lifeways by showing that refugia are locations that provide a species with a suitable niche, offering stable environmental conditions for its way of life, which permits demes to survive and compete successfully.

Research on prehistoric human populations before food production documents that they were not stable in space or through time. Instead, from initial colonization of extratropical landscapes onward, all continents witnessed settlement discontinuities, including local population extinctions (Finlayson 2004; Lahr 1996, 1997; Rochman and Steele 2003, with references). During the Last Glacial Maximum (LGM) some 20,000–18,000 years ago, for example, southwestern France and the East European Plain served as refugia for European populations (Soffer and Gamble 1990). Similar range contractions are documented for Africa and Australia also (Butzer 1991; Lahr 1997).

We see the same refuging phenomenon when we look at the youngest Neanderthals and the last of Middle Paleolithic lifeways. Specifically, I argue that the adaptations developed by these archaic hominids over many millennia gave them competitive advantages in very specific regions of Eurasia where they persisted until as late as some 27,000 years ago. I underscore that in this discussion I do not assume a 1:1 relationship between a taxon and a particular technological repertoire. Nor do I assume that in the last Neanderthals we see a species before extinction. These were not Wrangel mammoths but hominids with behavioral flexibility that could allow for significant changes—for new lifeways. Thus, rather than discussing species extinction, I only deal with an end to a particular way of life.

The Distribution of the Sites and Fossils

Figure 1 plots the distribution of regions with the last chronometrically dated Neanderthals and Middle Paleolithic sites in Eurasia. All radiocarbon date between some 35,000 and 27,000 years ago. These dates, as well as all others discussed or cited in this chapter, are uncalibrated. Beginning in the west,

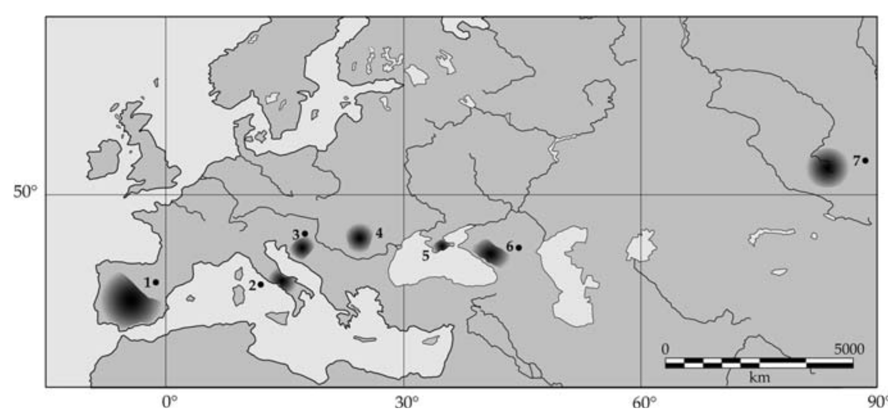

Fig. 1 The distribution of the "last" Neanderthals and the youngest Middle Paleolithic sites—dating <35,000 BP (uncalibrated). 1. Spain and Portugal; 2. Central Italy; 3. Croatia; 4. Romania; 5. Crimea and adjacent areas; 6. The Caucasus; 7. Southern Siberia. *Shaded areas*: Middle Paleolithic inventories; *dots*: hominid remains

they include sites in Iberia (Barton et al. 1999; D'Errico et al. 1998; Finlayson 2004; Straus 1997), possibly Italy (Bietti 1997; Pettitt 1999), the southwestern Balkans (Higham et al. 2006; Kozlowski 1998, 2000; Smith et al. 1999; Trinkaus 2005; Wolpoff 1996), the southern Carpatians (Cârciumaru 1998), Southern Russia and Crimea (Chabai and Monigal 1999; Marks and Chabai 1998), and the Caucasus (Adler et al. 2006; Bar-Yosef et al. 2002, 2006; Boriskovskij 1984, 1989; Golovanova et al. 1999; Meshviliani et al. 2004). Moving southeast from the Mediterranean, the sites may include Syria (Boëda et al. 1998), as well as southern Siberia in the regions of the Altai and Sayan mountains and Kuznetsky Altau (Brantingham et al. 2001; Derevianko 1997; Derevianko et al. 1998; Krause et al. 2007; Kuzmin and Orlova 1998; Vasil'ev 2001).

Last Glacial Environments

The period in question falls in the second half of Oxygen Isotope Stage (OIS) 3—a stage characterized by numerous very brief sharp climatic oscillations, including a well marked warm episode a bit prior to some 40,000 years ago and a cold one at 30,000 years ago in the calendar year chronology of ice and deep sea core data (Van Andel and Davis 2004, with references; Soffer 2000). Reconstructions of biotic zones during both the warmer and colder periods show that regions occupied by late Middle Paleolithic populations were covered by a mix of broadleaf and coniferous arboreal growth which remained in these areas, although somewhat reduced in extent, throughout the cold stadials, including the maximal cold and arid times of the LGM (Grichuk 1992). It is these regions that served as refuges for both deciduous and coniferous species, as well as for some Mediterranean evergreens.

While these reconstructions focused on western and central Europe, research on Late Pleistocene Eurasian faunal communities—specifically measures of taxa richness—repeatedly shows that all the regions with the youngest Middle Paleolithic sites, the circum-Mediterranean ones as well as southern Siberia, featured the mildest climates during the last interglacial (Fig. 2a). The same was true during OIS 4 and the early part of OIS 3 (Fig. 2b), as well as during the last part of OIS 3 some 35,000–24,000 years ago, when these regions served as refuges for a number of relict species (Fig. 2c) (Agadzhanian 2001; Lordkipanidze 1997; Markova et al. 1995; Musil 1985).

Thus, while it is tempting to correlate the distribution of the Last Neanderthals with warm Mediterranean climates, their near absence from the Levant in southwestern Asia and presence in the Altai and Sayan suggest a more complex scenario. To understand this distribution pattern we need to consider pertinent demographic, physiogeographic, morphological, and archaeological data. When looking at these data, however, it is crucial to remember that while changes indeed happen to populations, such populations are not made of

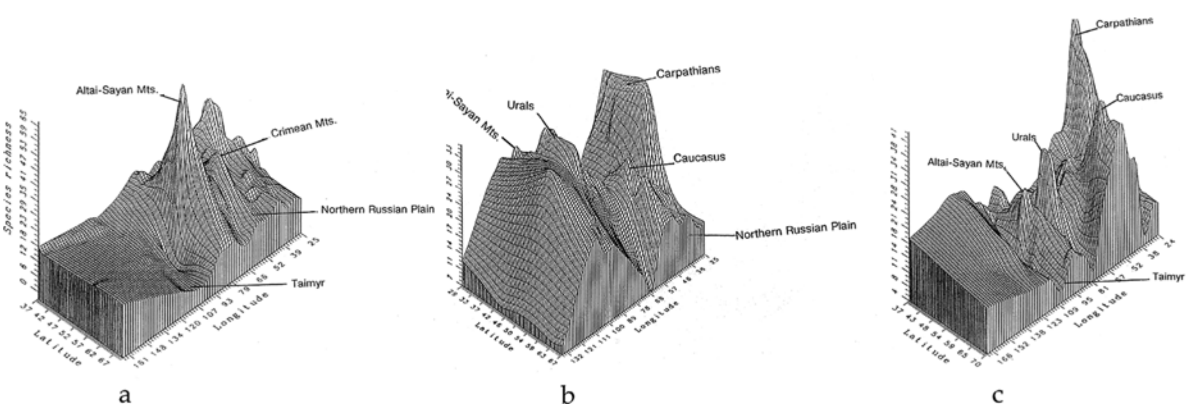

Fig. 2 Mammal species richness in Central and Eastern Eurasia throughout the late Pleistocene (after Markova 1995: Figs. 5.3, 5.4, 5.5). a. 100,000–35,000 BP; b. 35,000–24,000 BP; c. 24,000–15,000 BP

identical clones but consist of a myriad of individuals with diverse interests, which, by and large, we have not considered when addressing the deep past. While we cannot recover specific individual motivations from prehistory, we certainly can obtain new insights through an agentic approach that distinguishes groups along the natural cleavage lines such as sex and age, extant in any population.

Eurasian Demographic History

Research on the distribution of Middle Paleolithic sites across Eurasia suggests regional differences in the intensity of occupation, with the southern warmer provinces witnessing a continuous human presence throughout the late Pleistocene while the northern areas were not permanently occupied before the Upper Paleolithic (Finlayson 2004; Gamble 1986, 1994; Derevianko 1997; Goebel 1999; Klein 1999). These differences were not about latitude, however, but about the distribution of resources. Specifically, I have argued elsewhere that Middle Paleolithic groups occupied permanently only those regions where the proximity of the plains, foothills, and mountain ranges created a number of ecotones with more complex, diverse, and productive biotic communities during both stadial and interstadial times (Geist 1978; Soffer 1994, 2000). Such areas featured the greatest proximal biotic diversification, and it is they that saw more continuous occupation while the more homogeneous open landscapes of Eurasia underwent sporadic colonization and abandonment. This is well illustrated on the East European Plain and its periphery, for example. The plain is a vast flat expanse of land rimmed by north-south running mountain chains that restrict vertical biotic differentiation to its western, southeastern, and eastern margins. During warmer Pleistocene times this region was covered by nemoral forests (Grichuk 1992; Markova et al. 1995). At stadial times it changed to open landscapes covered by a periglacial steppe—one with a dramatic reduction in latitudinal biotic differentiation and diversification and an increase in the spatial and temporal unpredictability of biotic resources. The only exceptions to this were found in the Dnestr-Prut region in the west, in the Crimea in the southeast, as well as in the nearby Caucasus. The archaeological record here is highly informative about landscapes favored by late Pleistocene groups (Soffer 1989). We find early Middle Paleolithic sites in the western, central, and southern parts here. Late Middle Paleolithic sites, on the other hand, are restricted to the western Dnestr-Prut region and to the southern Crimea. Early Upper Paleolithic sites are found in both these regions as well as in the Kostenki-Borshchevo region of the middle Don. Using stratification as a rough gauge of successful occupation (i.e., single vs. multilayered sites), we see that it is precisely those regions with the greatest vertical and biotic diversification that hold evidence for human occupation throughout the last Interglacial-Glacial cycle, while the more homogeneous areas were sampled by archaic populations on a one-time basis only. A similar pattern, in fact, can be observed throughout Europe, with regions containing the greatest vertical and biotic diversification showing a more continuous archaic presence, while the more homogeneous parts of Europe witnessed a pattern of waxing and waning of occupation.

The human occupation record of eastern Eurasia mirrors this pattern also. The heterogeneous landscapes of the western and northwestern Caucasus have numerous stratified Middle Paleolithic sites (Bar-Yosef et al. 2002, 2006; Golovanova et al. 1999; Liubin 1993; Lordkipanidze 1997; Meshviliani et al. 2004). In fact, as in Crimea (Chabai and Monigal 1999; Marks and Chabai 1998), there are considerably more Middle than Upper Paleolithic sites here. The same regionalization is in evidence in Siberia, with multilayered Middle Paleolithic sites clustering in the southern most diversified landscapes around the Altai and Sayan ranges (Derevianko 1997; Derevianko and Rybin 2003; Derevianko et al. 1998, with references; Goebel 1999; Kuzmin and Orlova 1998).

In sum, data from across Eurasia indicate that Middle Paleolithic groups were localized in discrete regional patches and continuously present only in regions with the greatest resource diversification. This patterning shows us that the areas where we find the last Neanderthals and Middle Paleolithic lifeways are not cul-de-sacs to which they were pushed by encroaching “moderns,” but rather their landscapes of habit.

The Neanderthal Body

I next turn to the Neanderthal bodies, which contain many clues about just why these regions were their landscapes of habit.

The Neanderthal morphology indicates that they were much more robust than anatomically modern humans, adapted to significantly greater physical exertion (e.g., Berger and Trinkaus 1995; Churchill 1998; Trinkaus 1981, 1984; Wolpoff 1996). Interpopulation comparisons note a greater gracility of Near Eastern Neanderthals inhabiting lower latitudes when compared to European populations in higher ones, with the more robust Neanderthal bodies reflecting morphological adaptations to life in more stressed northern environments. These observations hold true for both male and female Neanderthals (Frayer 1986). Although common wisdom holds Neanderthal morphology to reflect adaptations to glacial cold in highly physical ways, little relaxed by culture (Holiday 1997; Hublin 1998; Klein 1999; Wood and Richmond 2000), dissenting views question this (e.g., Finlayson 1999). One problem with the "hyperpolar" thesis is that progressively attenuated Neanderthal traits are seen from some 450,000 BP onwards (Condemi 2000; Hublin 1998; Wood and Richmond 2000). This appears to be an extraordinarily long-lasting adaptation to climate, one that persists through warm interglacial as well as cold glacial cycles, while we know that significant morphological differences can occur in < 20,000 years (Brace 1997; Hublin 1998). This has led some scholars to argue that demographic histories—small population size and isolation—rather than climate offer more satisfactory explanations for Neanderthal morphology. Others have suggested that the Neanderthal bodies, in addition to reflecting greater physical exertion, may also reflect greater body weight (Alekseev 1993), a point I will return to later.

While very little attention has been paid to intrapopulation differences, Frayer (1986) has suggested intersexual differential gracilization rates in early anatomically modern humans (EAMH)—with females gracilizing earlier than males. Although Neanderthals exhibit about the same degree of sexual dimorphism as do anatomically modern humans, it is important to underscore that both male and female Neanderthals are equally robust and that it is the Neanderthal children who show the most dramatic differences from modern children in much greater robusticity and accelerated development (Trinkaus et al. 1998).

Furthermore, Neanderthal remains show greater incidence of stress, both in terms of trauma (Berger and Trinkaus 1995; Richards et al. 2000) and in less diagnostic indicators such as hypoplasia , juvenile dental attrition, and Harris lines (Soffer 1994, with references). Since dental hypoplasia develops in children between the ages of 2 and 5, these data, together with the evidence for accelerated development and robusticity, suggest considerably greater stress on Neanderthal children than on their anatomically modern equivalents.

Research on patterns of longevity in Neanderthal and modern populations indicates shorter lifespans for Neanderthals, most of whom died prior to their 45th birthdays (Caspari and Sang-Hee 2004; Trinkaus 1995). In addition to this, a significant drop in infant and juvenile mortality can be observed in Pleistocene moderns (Soffer 1994, with references, *contra* Trinkaus 1995).

Bone chemistry studies of Neanderthal and EAMH diets suggest that the Neanderthals were hyper-carnivorous (Bocherens et al. 1999, 2005; Bocherens and Drucker 2003; Fizet et al. 1995; Toussaint et al. 1998; Richards et al. 2000, 2001). This in turn implies that to survive, like all other carnivores in northern latitudes, they needed to exploit either very large day ranges and/or highly diverse environments. In northern latitudes, the inescapable reality of seasonal resource fluctuation dictates that omnivores hibernate (e.g., bears), while carnivores both range widely and store food in their bodies by gorging in periods of abundance and living off body reserves during the leaner seasons (Geist 1978; Stiner 2002). This suggests that Neanderthals may also have undergone dramatic fluctuations in body weight between seasons—something that needs to be considered when evaluating their anatomy. In light of the ties between female fertility and fat storage summarized by Lancaster (1986), we can hypothesize that if "storing in the self" was a part of the Neanderthal behavioral repertoire, then we can expect greater fertility among Neanderthal females. We can also envision the consequences that were likely to ensue from this, including more children, possible earlier weaning of the children, greater stress on the newly weaned children, and so on.

Finally, questions of language use among Neanderthals have generated much heated debate (e.g., Mithen 1996; Noble and David 1996; Wolpoff et al. 2004—all with references). I find these debates not only inconclusive but sterile as well. Since language does not fossilize, we need to consider just what the proxy measures used for it—from undiagnostic anatomical hardware to material correlates of symbolic behavior—reflect. The working assumption has been "capacity." As I have argued at length elsewhere, however, this focus on "capacity" totally ignores the fact that any behavior involves not only the capacity for it but also the habitual exercise of this capacity—namely, "performance" (Soffer 1994, with references; see also Chase 2001; Donald 1998; Hovers and Belfer-Cohen 2006 for similar points). Questions of performance, in turn, take us into the social realm and into the domain of archaeology (Thomas 1998).

Middle Paleolithic Sites and Inventories

When we focus on regions occupied by Middle Paleolithic groups rather than on specific sites—something clearly warranted, because there is neither the evidence for year-round sedentism at specific sites nor can hypercarnivory be accommodated by sedentary predators—the recovered faunal remains point to regionally circumscribed opportunistic subsistence strategies (for a detailed discussion, see Soffer [1994]). Such a focus obviates the need to see such monofaunal sites as Starosel'e, Mauran, Salzgitter-Lebenstadt, or Sukhaia Mechetka (Volgogradskaia) as evidence for specialized hunting in the Middle Paleolithic (e.g., Gaudzinski 1999b). From a regional perspective such sites just reflect repeated returns to particular locations with particular abundant resources—something seen time and again among nonhuman primates (see, for example, Garber [1987]).

This kind of locational fidelity is reflected in the evidence for the procurement and use of raw materials. The lithic inventories show a redundant use of local raw materials regardless of their quality, suggesting a very localized provisioning system that featured large daily home ranges but relatively small core areas (Soffer 1994; Gamble and Steele 1999). The sizes of these core areas were not uniform across Eurasia, being smaller in more heterogeneous areas such as southwestern France and larger in the more homogeneous terrains of Central Europe (Roebroeks et al. 1988; Féblot-Augustins 1993; Gamble 1999). While archaeologists have used data about distances involved in the procurement of raw materials as a gauge of the size of the territories exploited by Paleolithic people, they did so assuming that the record mirrors mean/modal group behavior. Such an assumption, however, may not be warranted. There is also a possibility that locally obtained lithic materials found at Middle Paleolithic sites reflect female technologies. Specifically, Brumbach and Jarvenpa's (1997) ethnographic work on hunting shows that since male day ranges are larger than those of females, a disproportionately large number of tools found at or near residential sites are those used by females. It is therefore possible that a change from local to extralocal raw material procurement may reflect not only changes in the settlement system but also in social relationships. The exploration of this possibility, unfortunately, lies beyond the scope of this paper.

As I have noted elsewhere, Eurasian Middle Paleolithic sites, both open and cave ones, consist of relatively small concentrations of cultural remains which often at least partially overlap one another, suggesting palimpsest occupations (Soffer 1994, with references). Kolen's (1999) studies of features at these sites led him to conclude that the patterning of material remains around such features suggests aggregate individual rather than group-based utilization of space.

Lastly, there is the issue of symbolism in the archaeological record and its significance for interpreting behavioral modernity. Although red ocher is present at a number of both Middle Paleolithic and Middle Stone Age sites, and some scholars have claimed that this presence is indicative of symbol-mediated behavior and thus of "modernity," Wadley (2003) has cogently underscored that its possible use for utilitarian purposes makes the mere presence of colorants dubious proxies for symbolic behavior. The issue is more complex with body ornamentation, imagery, and other symbolic paraphernalia. I have argued that the recovery of some, albeit incredibly few, suggestive items of this kind, such as the Tata plaque or the Berekhat Ram piece, from pre-

Upper Paleolithic sites, indicates that the capacity to make such items was there, but that their non-patterned nature through time and across space is best understood as idiosyncratic manifestation of such capacity rather than as habitual performance (Soffer 1994). The same caveat can be extended to the significance of the Blombos "engraving" (Cain 2006; Zilhao 2007). Symbols, whether verbal or visual, are a social phenomenon. The use of symbols, as Geertz (1973) has pointed out, is the essence of human culture where they are incredibly ubiquitous and redundant. Their Upper Paleolithic proxies are such; earlier ones are not.

Imagining the "Other" in Time

Conceiving Differences

The sum of these data suggest that Middle Paleolithic lives were indeed lived differently than modern ones. How to envision this "other" way, however, is another matter. While we have centuries of experience in value-laden classification of "the them" as evidenced in our unilineal evolutionary schemes, such classifications are and always were Eurocentric and judgmental (Gamble 2007; Trigger 1989). During the last two centuries our predecessors saw the Tasmanians as living fossils of the Lower Paleolithic, while Australian aborigines were Neanderthals incarnate. By the middle of the last century in the Anglo-American world ecology replaced conjectural prehistory and the !Kung became Pleistocene "everymen"—albeit shortly thereafter they had to time-share the epoch with the Nunamiut. Of course both groups had to be divested of some things, such as Herero neighbors or snowmobiles, respectively—their histories in other words—but their subsistence practices and social organization were seen as essential, eternal, and thus transposable in time (e.g., Lee and De Vore 1968). Such use of assumed "eternal features" led to identifying "logistically organized" hunter-gatherers in the Upper Paleolithic, without problematizing the question of transport technologies that necessarily must underwrite bringing food back in bulk to consumers. Another example, closer to home, was extending sharing, interpersonal dependence, division of labor—in other words—the nuclear family, back into not only the Pleistocene and the Pliocene, but even the Miocene (e.g., Lovejoy 1981; Clark 1997b). Doing this did not permit us to learn about the past; it just naturalized the present and made the past its faded copy.

Some recent attempts to pinpoint the origins of biparent provisioning of the young, and thus of the division of labor and of food sharing, have argued that the mid-Pleistocene brain expansion is somehow an adequate gauge of such new forms of sociality (e.g., Aiello and Dunbar 1993). Others, interrogating the origins of the division of labor, focused on the resource base and posited its advantages, and therefore likely origins, in diverse southern habitats in Late Pleistocene times (Kuhn and Stiner 2006). These attempts are neither convincing nor satisfactory—first, because they treat hominids as ecological beings reacting only to natural environments; and second, because the global archaeological data do not support their constructs.

Given that humans are simultaneously involved in both ecological and social relationships (Ingold 1987), we clearly need extremely broad interdisciplinary insights to investigate the origins of this uniquely human essential. While we need insights from biogeography and ecology, they are not enough, because there is no mean or modal species-specific behavior. Recent primatological research, as well as research in behavioral ecology, have clearly shown that significant new understanding arises from the realization that different interests exist in all populations of primates, including humans, and that different strategies are available to cope with their environments, both natural and social (Hawkes 1996; Hrdy 1999; Smuts 1999; Zeller 1987). This new focus both introduces contingency, and thus history, into ecological studies; and converges with various social theories that stress the primacy of agency in understanding the human present and hominid past. Together these disparate theoretical domains tell us that neither the Neanderthals nor the EAMHs were all the same. Rather, those populations, just like their present day descendents, consisted of diverse interests, some of which likely patterned along the apparently universal "fault lines" of age and sex (Hawkes 1996; Ingold 1987, 1994, 1999), regardless how these may have been understood, constructed, or enacted.

Keeping these potential disparities in interests in mind, what can we hypothesize about the lifeways led by Late Pleistocene people?

I have argued elsewhere that the demographic and archaeological data, together with the evidence for muscle hypertrophy in both sexes, an inherited pattern of dimorphic feeding ranges for the sexes, and the very equivocal evidence for the divisions of labor and extensive food sharing beyond the mother-child dyad, suggest that adult members of these small-sized co-residential units provisioned themselves (Soffer 1994, 2000; see also O'Connell et al. 2002). Given that all primate females do provision their young, while very few if any males do (Hrdy 1999; Smuts 1999), Neanderthal females most likely did the same. The robustness and hypertrophy of the Neanderthal children, when compared to EAM ones, not only suggest that their provisioning was inconsistent but also that they might have provisioned themselves at an earlier age than modern children do. Such early weaning could have been one solution to the high costs of birthing large-brained infants, because such a transfer of feeding costs to the children themselves would have permitted mothers to have more children (for a discussion of female reproductive costs and possible solutions see Leigh [2004]). This solution would have presented one option if, as I have hypothesized above, the Neanderthals overwintered by storing energy in their own bodies via large seasonal weight gains. Such increases in body fat may have impacted female fertility and resulted in more conceptions and more big-brained newborns. I believe that this might be what we are seeing in the significantly higher mortality noted for Neanderthal when compared to EAM ones (Skinner 1996; Soffer 1994).

Finally, I also suggest that the shorter Neanderthal lifespans resulted in two-generational groups at best, leaving few viable candidates such as grandmothers to help mothers feed their young; although I do admit that the "grandmother hypothesis," which suggests that grandmothers likely provided a significant amount of food for their immature kin, is a contested one (Hawkes 1996; Kaplan et al. 2000) (Fig. 3). Since Hrdy (1999) has demonstrated that "allomothering," meaning helping mothers with the care and feeding of their young, appears to be a widespread pattern among both humans and their nearest primate relatives, this contestation is not about help with provisioning of the young, however, but just about the specificity of the personnel involved. The crux of the matter is that increased longevity among the EAMs enlarged the pool of personnel from which such help could be and likely was sought. Such help with the young represents another solution to the problems of having large-brained children which hominids both past and present face. I argue here that this second

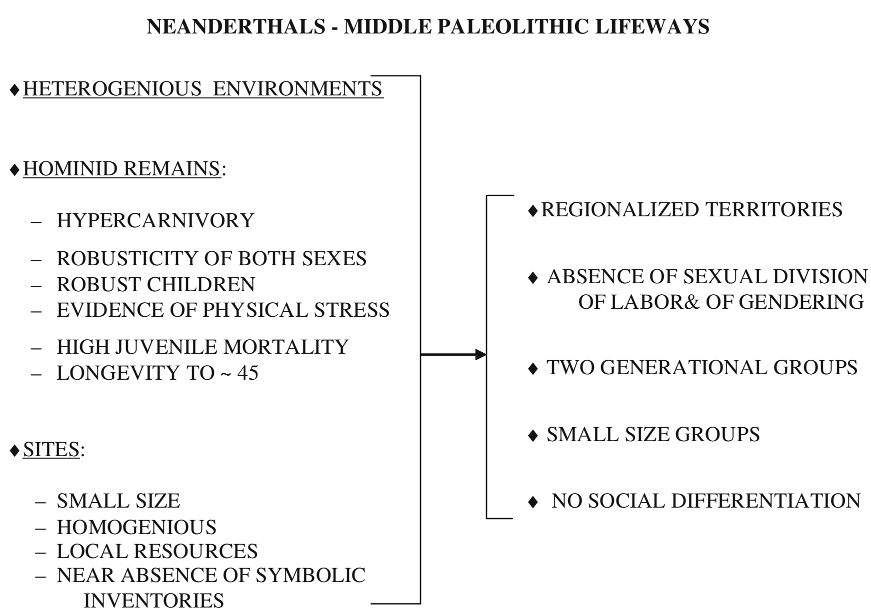

Fig. 3 Neanderthals—Middle Paleolithic lifeways

solution augmented the problematic Neanderthal solution of early weaning and led to the notable decrease in childhood mortality seen when we compare EAMs with their Neanderthal predecessors (Soffer 1994, 2000, both with references).

The small size of the groups that the Neanderthals lived in, together with their restricted territories, necessarily raises questions about group composition and mating. Among social carnivores the pattern is mixed. The lion pride core consists of related females and their young. Among wolves, on the other hand, there is evidence for mating of relatives across generations and thus pack endogamy, but also for emigration of both young males and females (Mech 1970). Most African primates, however, with the exception of chimpanzees, have core groups composed of related females with males emigrating at maturity (Smuts 1999). Hunter-gatherer data, on the other hand, show core groups of related males (Hawkes 1996). Hawkes has suggested that this hunter-gatherer pattern, one not verified by genetic tests, may have been a relatively recent and historically specific development, and thus not a suitable universal gauge of past arrangements. "Common wisdom" has all ancestral hominids after the advent of hunting organized around a core of related males (e.g., Noble and David 1996; Foley and Lee 1996). The arguments offered for this, namely cooperative hunting as a "males-only" kind of thing, is less than a "just so story." Both lions and wolves hunt cooperatively without the need for male genetic bonding. Given the overall primate pattern, we are on safer grounds, I suggest, assuming that the Neanderthals may have followed the generic primate social pattern as well: namely, one centered around a core of related females and their young.

The Upper Paleolithic way of life in Eurasia differed from this (Soffer 1994) (Fig. 4). Since I have discussed the bases for this conclusion elsewhere, I only summarize them here (Soffer 1994, 2000). I suggest that the UP/LSA featured life in both small and large groups, as well as seasonal group mobility. At the core of these modern lifeways lay social awareness of the self and dependence on others, and it was lived through the divisions of labor, sharing, and biparental provisioning of the young. It is during this time that interdependence was institutionalized through the invention of social categories of kinship and descent ideologies and the cleavage lines along age and sex categories, underscored and imprinted through symbolic paraphernalia such as art, jewelry, engravings, etc. It is this interdependence that also permitted permanent occupation of more challenging homogeneous northern landscapes. Writing about people living in challenging Australian environments, McBryde (1987) has observed that social interdependence is ultimately more important than

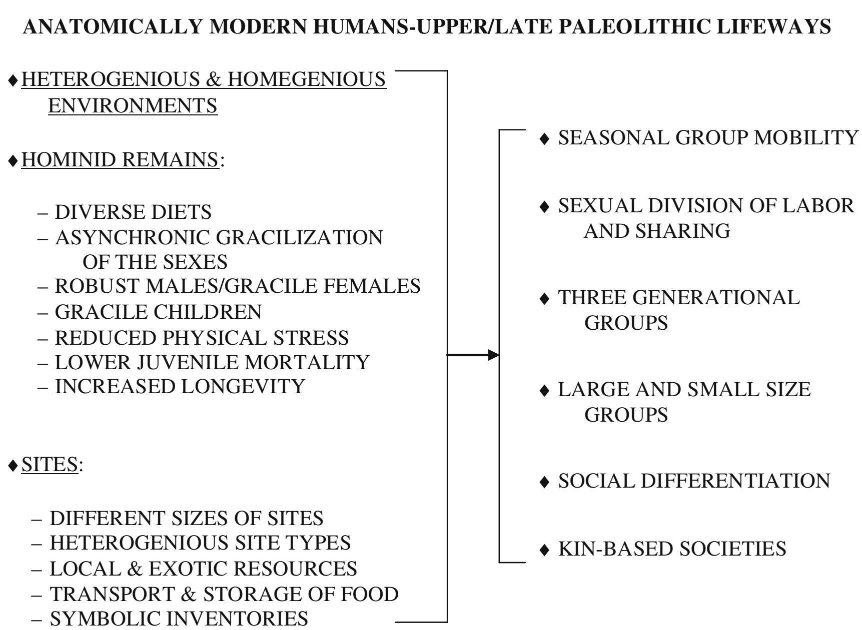

Fig. 4 Anatomically modern humans—Upper/Late Paleolithic lifeways

economic independence. The same is true for hunter-gatherers in northern latitudes. This is because the specificity of factors leading to resource unpredictability found in Holocene deserts vs. Pleistocene periglacial steppes are secondary in importance. The primary factor—namely, very low resource predictability—is common to both areas, and this is seminal. Interpersonal dependence also permitted larger group sizes (Binford 2001), as well as initiated the "arms race" noted earlier. There were now indeed not only more mouths to feed but also more minds to control. I have argued that this uniquely human invention also facilitated the colonization of new continents.

This newly invented interdependence had both its bright and dark sides, however. The division of labor and food sharing did facilitate longer lifespans (Geist 1978; Caspari and Sang-Hee 2004), permitted permanent occupation of open northern landscapes (Ingold 1987), and, perhaps, even made colonization of new continents possible (Balme and Bowdler 2006). Post-reproductive and post-prime people were now around, able to provide not only help with the young but also longer-term knowledge beyond one's memory. On the other hand, it also led to the invention of "the other"—the "them"—with all of the ensuing consequences. The social differentiation we see congealed in such things as Upper Paleolithic body ornamentation and "Venus-wear" is a clear testament to the existence of institutionalized social differentiation. Following La Fontaine (1981), I suggest that such material acts of differentiation are signs that the "social glue" is working—binding the different actors into newly created multi-actor social entities. Social differentiation also is a necessary prerequisite for the creation of sex and age hierarchies and inequality. These negative consequences, ones that may have begun in Upper Paleolithic times, were likely unintended; for, as Brightman (1996, 722) points out: "Cultural forms are more commonly conceived as the cumulative unwilled byproducts of human agency than as the latter's deliberate products."

Neanderthal Niches and "Last Stands"

The structure of the resource base in Eurasian northern environments presented hominids there with a set of specific problems solved one way by the archaic populations and another by modern ones (Soffer 1994). These different solutions were not about different capacities but rather about performance—meaning contingent outcome of social patterns, new decisions, and their intended and unintended consequences.

The latitudinal increase in the patchiness and unpredictability of the food resources—their season-specific availability—as well as a decrease in vegetal resources, confronted hominid omnivores with the need to exploit much larger territories than in lower latitudes. Some Eurasian regions—those with more predictable and diverse resources in smaller areas, which happened to be relegated to the southern parts of Eurasia—did so in contrast to more homogeneous plains further north and east. One Middle Paleolithic solution to these realities of northern lands may have been to considerably increase carnivory. Ecological realities in inland Eurasia made terrestrial animal resources more predictable, yet the hypercarnivory apparently adopted exacerbated the need for even greater territories. The positive relationship between carnivory and large territories can be seen even in the ethnographic present, where hunter-gatherers who rely on terrestrial animals annually exploit much larger territories than do groups who subsist on aquatic or vegetal resources (Binford 2001). In addition, given the inefficiency of the hominid body to convert food into body fat, where roughly 2 calories of intake are needed for 1 stored (Geist 1978, 272), northern hominid carnivores needed to consume more animal protein than their southern equivalents. The structural need for carnivores to exploit very large territories and be residentially highly mobile, as well as the need for considerably more animal protein by hominid carnivores, would have been extraordinarily costly and stressful to the females, especially pregnant and lactating ones, as well as to their young. The Neanderthal solution was to permanently occupy those regions where female day ranges as well as those of the children could be minimized, while the physiogeographic realities of Eurasia relegated these to just some regions.

These insights help us understand the patchy spatial distribution of the last Neanderthals. These areas were just such optimal habitats where their way of life was successful, and permitted them, for a time, to continue living there (Soffer 2000). These were, as I have argued elsewhere, ecological rather than geographic refugia, where archaic lifeways permitted relict populations with well-honed adaptations to occupy stable niches and remain competitive. They were there not because these areas were forested rather than covered by grasslands (*contra* D'Errico et al. 1998); Middle Paleolithic lifeways persisted in these refugia for so long because of the highly specific ways in which archaic hominids exploited the Eurasian environments (Soffer 1994, 2000). Since by some 25,000 years ago we have no Middle Paleolithic sites left in Eurasia, apparently this time there was no rebound for this way of life, and it faded into oblivion.

Conclusions and Implications

A global perspective on the Middle Paleolithic "last stands" shows us that environmental determinism is an insufficient explanation. It is unsatisfactory both because of the disjunction between anatomy and culture, and because of growing evidence for some changes in Eurasian lifeways by the middle Würm (d'Errico et al. 2003; Gamble 1999; Soffer 1994; Stiner 1994; Stiner et al. 1999). Data from the East European Plain, on the other hand, show the probable coterminous presence of different lifeways during the Early Upper Paleolithic: one more Middle and the other more Upper Paleolithic in organization (Soffer 1989, 1994). I have noted that the sum of this evidence indicates that we are not dealing with innate differences in the capacity for particular behavior between the archaics and their successors, but rather just with the habitual practices of behavior. In sum, what became extinct by some 25,000 BP was not a taxon, but a way of living and relating to others.

A Darwinian perspective informs us that adaptation and selection are not about mean/modal behavior of a generic animal, but about how various interests of diverse constituencies are played out. This is why agency is important and why concerns with the social need to be a part of our research agendas. An evolutionary perspective on our closest living relatives shows the presence of male-female bonds of friendship and suggests that these were in place before sharing, divisions of labor, and biparental provisioning of the young came about (Smuts 1999; Strum and Latour 1987). The sequence of what our ancestors came up with next can be teased out from the paleoanthropological record, and the crippled old man from Shanidar and other maimed late Neanderthals may indeed imply that next came sharing of food and the dawn of economic interdependence. Since no individual of any social species acts in a social vacuum, Strum and Latour (1987, 795) argue that for our ancestors "Acquiring the skills to create society and hold it together is then a *secondary* adaptation to an environment made up, in large part, of conspecifics." I suggest that it is precisely this that we are seeing in the transition record. For Gamble (1999) it's about extending ego-centered networks beyond immediate locality. Since ego-centered networks involve only the contractual players themselves, among modern humans they are ancillary to more permanent obligations institutionalized through kinship ties, in the broad sense of the term, linking individuals across space as well as through time (Ingold 1999; Riches 1982).

For me, as noted before, the archaeological and paleoanthropological records of "modernity" show more permanent institutionalized intersubjectivity. While we can outline a number of reasons why it was in the interest of archaic females to impose such permanent obligations on themselves, we need to understand better the benefits for such "domestication" for the males—to use La Fontaine's (1981) fortuitous term. Since among our closest living relatives it is the tactics of females that shape those of males, the environmental realities of northern latitudes may have been one such proximate cause. Another, as Kuhn and Stiner (2006) have argued, may have been highly diverse tropical and subtropical ecosystems. Stringer (2006), among others, has highlighted the apparently unique rapid climatic fluctuations between stadial and interstadial times evident in the European record during OIS 3 and argued that such instability significantly stressed the resident hominid populations there between some 45,000 and 20,000 years ago. He goes on to suggest that such stress would have been magnified by the arrival of even a small number of immigrants and that it likely affected both groups. These and other proximate causes are possible and need to be explored in order to fully understand why "modern" social arrangements prevailed.

A social perspective on technology shows not only that, like language, it is yet another means to create intersubjective bonds (Strum and Latour 1987), but also that it does not drive social evolution but is driven by it. Upper Paleolithic lifeways, *contra* Gilman (1996), did not arise from improved technology but vice versa. Technology has no volition of its own; it functions in the domain of production, with production wants being socially determined and socially performed. The Upper Paleolithic "arms race," as well as the broadening of the resource base around the Mediterranean during late Middle Paleolithic, may both indicate increased demands on production. Such signs of intensification need not only signal population increase (*contra* Stiner et al. 1999), they may be signaling social reorganization—specifically, divisions of labor and ideologically and symbolically structured sharing.

In light of all these observations, and given evidence for the complex, albeit somatic, sociality of our closest living relatives (Strum and Latour 1987), the Upper Paleolithic "Creative Explosion" then just signals the use of material culture to do so (Gamble 1999). The symbolic organization of human interactions that we see reflected in this "Explosion" requires no genetic mutation, point or otherwise (*contra* Klein 1999). Rather, as Gamble (1999) has pointed out, such novel uses of material culture are best understood as "exaptations."

Using insights from primatology, evolutionary biology, and social theories, I have suggested that the Eurasian archaeological record can best be understood by juxtaposing our primate heritage, the environmental realities of northern Eurasia, and agentic interests. The various material expressions of the social solutions that our ancestors chose were likely incremental and date back to Middle Paleolithic/MSA times. They were also local; and my scenario just addresses the proximate causes in one region of the occupied world. Furthermore, we need also to keep in mind that the solutions chosen, like all decisions, have not only intended and unintended consequences, but also varying degrees of reversibility. Thus, as McBrearty and Brooks (2000) have argued, there was no "Upper Paleolithic Revolution"—and there is no point to looking for its core or ancestral core area (*contra* Bar Yosef 2000, 2002; Mellars 2005, 2006; Sherratt 1997). To do so is to fall back on a Eurocentric bias and a contingent package of purportedly diagnostic traits.

The Pleistocene saw a very long-term creation of deep mutual involvement of people with each other and with the world—one that gave rise to modern intersubjectivity (Gosden 1994). If we are to fully document and understand it, we cannot use the record from just one part of the world and assume that it is a necessary and sufficient proxy for the rest. After all, understanding how and why food production arose in the Near East does not explain how or why it happened in Mesoamerica or South America. History does not work that way, and universal processes are a sum total of all local expressions. While the basic biological constraints were constant, the environments, both natural and social, differed in time and space. Thus, the proximate causes were necessarily local, the ultimate consequences global.

In sum, then, it is not only Neolithic or Bronze Age "man" that made "himself," but so did "his and her" Middle and Upper Paleolithic predecessors—creating both their cultures and biologies through day to day decisions and their intended and unintended consequences.

Acknowledgments This contribution is an ongoing project, one that I have been writing and revising for at least ten years. It is also one that I will, most likely, continue to revise and "evolve" in the next decade as well. An earlier version was published in 2000, and a revised version of that paper was presented at the 2001 CALPE conference in Gibraltar. I presented an updated version at the 2006 UISPP Congress in Lisbon. In working through the topic of "modernity," I have benefited greatly from discussions with many colleagues, four of whom deserve special gratitude: Meg Conkey, Alma Gottlieb, Steve Leigh, and Milford Wolpoff. I also thank my anonymous reviewers for pressing me to think more deeply.

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The Longest Transition or Multiple Revolutions?

Curves and Steps in the Record of Human Origins

John A.J. Gowlett

Abstract Preservation and the history of archaeology have led to classification of a Stone Age in stone, in which there are naturally phases and transitions. A major issue is whether the phases have an overriding reality, and whether they give a good fit between biological and cultural evolution. In the evidence of biological evolution there is a surprisingly smooth curve documenting the rise in brain size through the Pleistocene. Models of social competition and the managing requirements of a 'social brain' have claims to explain much of the change without reference to archaeological phasing. In contrast the cultural scheme has to take into account detailed variation in artefacts (e.g., 'traditions' including the Oldowan and the Acheulean; and their polythetic aspects of presence and absence; that Acheulean hand-axes run on into later periods, and then changes in functional solutions, such as hafting). The other major biological scheme, that of hominid palaeontology, presents other complications as there is not full agreement over speciation issues such as chronospecies and anagenesis. To add to all this, recovery of genomes indicates that selection in large numbers of individual genes occurs through the same time. Transitions as we see them in a single discipline may thus be artefacts of the nature of the proxy; in sets of disciplines they may be reinforced or undermined by coincidental factors. Their significance may be unintentionally enhanced by our focus on them, and our tendency to ascribe a reality to entities simply because they have been named. Here a multidisciplinary approach is advocated as necessary to isolate real major changes in human capabilities. Concentrating on the total number of cultural traits available for study, the paper concludes with the view that a first human revolution had been achieved by about 1.6 million years, that a second revolution, largely silent archaeologically, had occurred by about 500,000; that a third revolution, of modernity, occurred thereafter. These are aspects within the dominating continuity of an evolutionary trend into a cognitive niche.

Introduction

This paper takes its rationale from a major contrast: in archaeology we often see a record of steps, and phases; but through the Pleistocene, from the time of the earliest technology, there has been one surprisingly smooth curve of change in brain size. It is even possible that most developments can be explained through a single feedback model. If that were so, would our phases and transitions simply be artificial impositions, or would they still embody important realities?

Traditionally, archaeologists have been able to divide up the past to their convenience. Now we are living with several competing views of the past. Each of them gives us a different proxy, but in the end they must be reconcilable. Classifications of hominid palaeontology give us one view, with several species in sequence or side by side—how do the steps fit with archaeology? Brain size, already

J.A.J. Gowlett (✉)
British Academy Centenary Project, University of Liverpool, Liverpool, UK

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mentioned, can be related to the 'social brain' in another scenario. Last, but evidently not least, the mapping of genomes is providing new evidence for positive selection of particular genes (Krause et al. 2007; Hill and Walsh 2005; Nielsen et al. 2005). They will eventually be fitted to the timescale, generating further charts with steps and transitions.

In archaeology successions of periods seem to be a structural necessity, and so inevitably we have transitions. The same might be said for history, but history operates on a different basis. If a dynasty falls, it is evident that a regime has ended, but equally that the dynamic of everything else tends to go on—the change may be superficial, or can become profound. In early archaeology, periodisation starts simply from bodies of artefacts that are static and any change (rather than no change) can lead us to think that steeper periods of transition—which might require special explanation—separate long periods of stasis. Although the new thing may not be of great significance, it may be coerced to serve as proxy for other suspected changes. More general social approaches need to transcend such disciplinary peculiarities to give broad perspectives, so it is important that archaeological classifications should reflect real and significant changes in the record (Bogucki 1999; Dunbar 2004; Megarry 1995; Runciman 2000).

My paper aims to evaluate such changes—including those leading up to modern humans—in a broader evolutionary perspective, influenced by the alternative approaches mentioned. After critical examination of these viewpoints, I attempt another approach to behavioural evidence, using larger numbers of traits.

The Archaeological View

In the frame of hominid evolution Archaeology begins formally with tool-making that can leave a record, and in general schemes it has dealt with Early, Middle, and Later stone ages in Africa, and Lower, Middle, and Upper Palaeolithic in Europe and much of Asia (all much debated: e.g., Allchin 1963; Bishop and Clark 1967). Although in the 1960s there was a move to abandon the tripartite divisions in favour of purely culture-stratigraphic sequences, it is interesting to see that the main framework survived. Indeed discrepancies between the European and African schemes have been gradually eased out, and fortunately improved dating has removed some of the apparent offsets. Broadly we can now talk of an Early Palaeolithic from 2.6 to 0.4 million years, a Middle Palaeolithic from 400,000 to 40,000 years, and a Late Palaeolithic from 40,000, in which the classic 'Upper Palaeolithic' is one regional variant (e.g., Conard 2005; Henshilwood and Marean 2003; McBrearty and Brooks 2000; Mellars 2005; cf Barkai et al. 2003 for evidence of earliest Middle Palaeolithic at Qesem Cave). Yet most archaeologists are also aware of an arbitrariness in such schemes, as shown in these discussions.

What is going on? At the simplest level, it could be that modern humans have a firm tendency to classify initially into phases of beginning, middle, and end. If we do that to 2.5 million years of Stone Age, then inevitably there will major steps between the phases. Our next step might be to smooth things, simply because we are uncomfortable with the steppiness. Arguably, this was done in the African Stone Age, through the creation of 'Intermediate' phases between ESA and MSA, and between MSA and LSA. Archaeologists soon became uncomfortable with the effects because of their evident discrepancy from reality, and in practice they soon reverted to simpler if imperfect schemes (see Recommendations in Bishop and Clark 1967, 879–901).

Another thing might well happen: initially arbitrary period divisions might migrate to the most significant change-points in the time spectrum, tuned by the search for real difference. Good dating would be prerequisite for that. The recent convergence of Early-Middle-Late Palaeolithic timelines in different parts of the Old World has little theoretical basis, but may well testify to rapid take-up of fundamental technological innovations. Certainly, the actual records appear more similar from area to area than was thought in an era of distorted dating.

The most important point to carry forward is that through the bulk of the Pleistocene, the major changes do indeed seem technical, based on new ideas rather than evidence of a cultural identity. That may be true for a change as important as the Oldowan-Acheulean transition (Gowlett 1986; Toth and Schick 2004).

Hominid and Hominin Species

Do changes in species reflect such archaeological events? There is reasonably good consensus that the genus *Homo* appeared around 2.5–2.3 Ma (Kimbel et al. 1996); that *Homo erectus* appeared around 1.8–1.6 Ma; that more modern hominins began to appear around 0.5 Ma, leading to the Neanderthals and to modern humans (see e.g., Aiello 1993; Bräuer 1992; Rightmire 1990, 1998, 2004; Wood and Collard 1999). There is less agreement about modes of speciation ('punctuated equilibrium,' chronospecies, anagenesis) or the number of species names necessary in different parts of the world—for example, whether *Homo heidelbergensis* is simply a European Neanderthal ancestor, or whether it is also the best label for African hominins that lead to modern humans within Africa (as seen by Rightmire 1998; cf Bräuer 1992; Stringer 2003). There is not consensus, but it may be possible to see an 'end' to *Homo erectus* around 500,000, except perhaps in the Far East (cf Chen et al. 1994; Rightmire 2004).

It is, however, almost impossible to map stone tool traditions closely to particular species (*pace* Foley 1987, although it does seem likely that regionally new populations sometimes brought new technologies). The Acheulean begins after *Homo erectus*, and certainly outlasts it. If we include the late Acheulean (as at Dakhla in Egypt, or in Syria; or the late cordiform bifaces of France or bout coupé hand-axes of Britain) within the 'true' Acheulean, then the tradition is also made by *heidelbergensis*, *sapiens* and *neanderthalensis* (Besançon et al. 1978; Mellars 2005; Schild and Wendorf 1977). That position is easiest to accommodate if we take the bifaces not as a signal of anything in particular, but simply to be a useful set of technical solutions, which tended to recur and recur until something distinctly better came along (as probably permitted by hafting). Some scholars see a problem in trans-species continuity, but just as the younger species must inherit DNA from their ancestors, so retention of some cultural traits in a cultural animal seems a necessity rather than a reasonable idea.

As with artefact classifications, one might expect classificatory delineations between species to migrate to the periods of fastest change. That expectation has seemed to be met in the case of the emergence of *Homo*, of *H. erectus*, and of

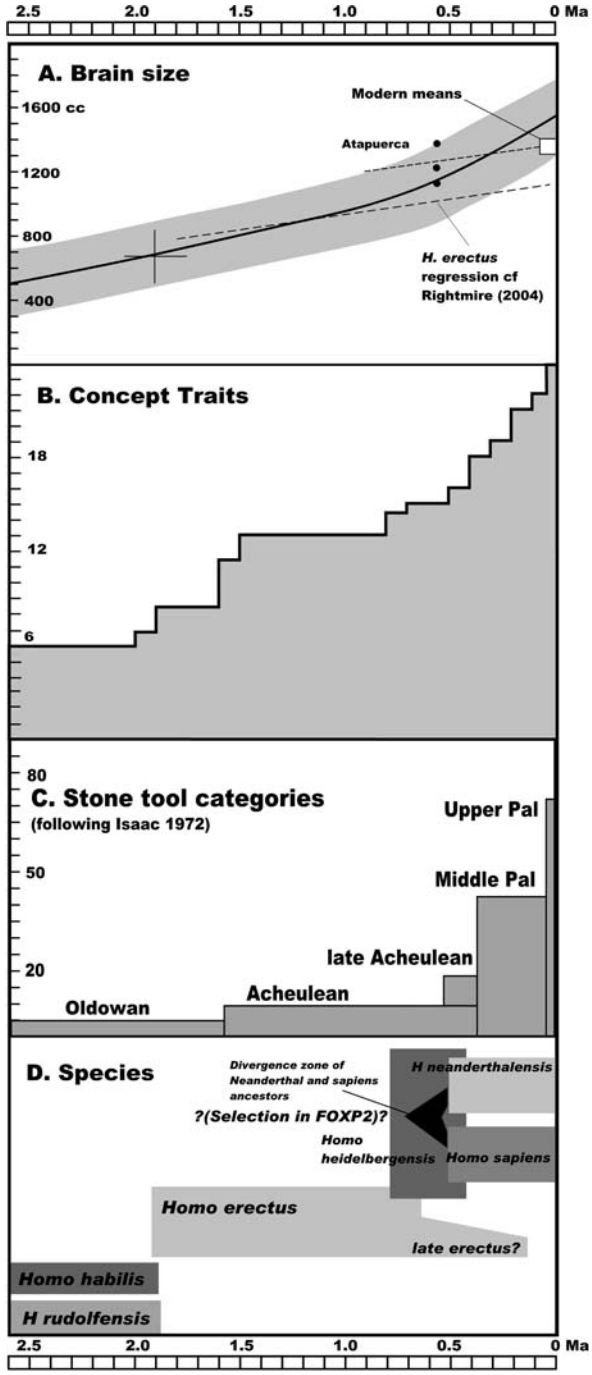

Fig. 1 Several lines of evidence in human evolution set on a common timescale. **A.** Curve of cranial capacity through the Pleistocene. Compiled with data from Lee and Wolpoff (2003), Rightmire (2004), Tobias (2005), Beals et al. (1984), Rushton (1994); the cross indicates mean 640 cc of 6 specimens of *Homo habilis* plotted by Tobias, superimposed on the general trend. **B.** Concept traits (see Fig. 2 for detailed explanation). **C.** Stone tool categories, modified after Isaac (1972). **D.** *Homo* species categorisation (*Homo ergaster* and *georgicus* are subsumed within early *Homo erectus*)

post-*erectus* species. But it also appears that these change points do not coincide closely with archaeology (Fig. 1). The old idea of an *erectus* stasis may retain some substance (see below), but it does not fit well with the Acheulean, which does not occur in all *erectus* areas, and long outlasts *erectus*.

The Brain Size Curve

The brain size curve is introduced here because, on the basis of evidence available in the early 1990s, it too appeared to have major steps (e.g., Aiello 1996).

There are complications, however: in hominoids brain size varies considerably between individuals. Total cortical area and efficiency of connections within the cortex may also be important factors (Reed and Jensen 1993; Hill and Walsh 2005). Cranial capacity is also affected by body size. The past record shows similar variation in earlier humans. Sampling is also poor. In this context it is all the more surprising that brain size now appears to increase steadily from 2.6 million years ago, in a curve which is astonishingly smooth. After five million years at ape size, it begins to increase 2.5–2.0 million years ago, becoming three times larger through the Pleistocene (Fig. 1).

Figure 1 portrays the general trend in a schematic way. To achieve statistical rigour would be very difficult without making many assumptions. The line is drawn to follow the trend of data in Lee and Wolpoff (2003) and takes into account Rightmire (2004), but emends some dates (e.g., Atapuerca Sima de los Huesos, taken as 0.2 Ma by Lee and Wolpoff, goes back to c. 0.5 Ma following Bischoff et al. 2003, 2007; Ngandong, seen as 0.25 Ma by Lee and Wolpoff, is taken as 0.04 by Rightmire, following Swisher et al. 1996).

Rightmire's regression is interesting, because it is fitted exclusively to *Homo erectus* specimens, excluding Dmanisi, but admitting Ngandong (former Solo) as a very late *erectus*. The effect is somewhat to flatten the line. Even so, Rightmire finds a steady cline through *erectus* from about 800 to 1100 cc. If that line is accepted, and 'joined' to earlier and later species' volumes, then that might reinforce the ideas of steps (or even grade change). Yet plotting all *Homo* specimens without references to the species interpretation makes the curve become far smoother. Through the last half-million years, there is commonly assumed to be another huge step up, perhaps associated in some way with 'modernity' (see e.g., Fig. 8.1 in Aiello [1996]). Again, the evidence for some major change of gear at this point is not compelling—once modern population means are taken into account. For example, the Atapuerca specimens from Sima de los Huesos, now dated to c. 500 ka (Bischoff et al. 2003, 2007) have volumes of 1390, 1125, and 1220 cc, respectively (Atapuerca 4, 5, 6). They would thus fit easily into modern populations which have overall means of c. 1420 cc for males and 1280 cc for females (standard deviations approximately +/–80) (Beals et al. 1984; Rushton 1994). (Controversies over regional differences have been tackled by Reed and Jensen [1993] and Lieberman [2001]: the only issue of interest here is the general evidence of modern human volumes).

The points to take forward are:

(1) The idea of sudden steps in the curve is suspect—they are likely to be created by sampling biases, including local geographic variation, and variable taphonomic considerations.
(2) The old supposed evolutionary stasis of *Homo erectus* is undermined by newer finds and dates. There may be a steep rise around 1.5 million years ago, partly owing to larger body size, but thereafter the evidence points to a steady rise in overall body size through a long period.
(3) The recent climb in volumes is far less steep than generally supposed.

The mechanisms for such a prolonged steady climb must result from a response to natural selection of a fairly extreme kind, given the great metabolic costs of supporting a larger brain (Aiello and Wheeler 1995; Lennie 2005). Over the years many explanations have been offered: technological ones might relate most closely to archaeological explanations, but they have seemed insufficient alongside social factors (Gamble 1998). After all, if humans were fairly successful across the Old World with limited technology and small brains—as sites such as Dmanisi demonstrate—why should such extreme change need to follow?

Social models place a strong claim to account for the change, and will be discussed in the interpretation below. Managing large numbers of relationships evidently requires a great deal of brain power (Aiello and Dunbar 1993; Aiello and Wheeler 1995; Dunbar 1993, 1998). In general, hunters and gatherers live in quite small groups. Within a band, an adult has to take into account perhaps ten other adults. It is impressive then that the human brain can take into account perhaps more than a hundred absent adults, but less evident that this should require intensive processing from minute to minute. The cost of cortical processing is high enough, however, to be a force restricting activity to a small part of the cortex at one time (Lennie 2005), casting some further light on past evolutionary pressures. Responses to these at technical and ecological levels were probably also cognitively demanding, emphasising a need for combined social-technical-competence models.

The immediate point is that step transitions are far less evident than commonly thought, suggesting a general continuity of pressures and responses, and the next question is whether genetic evidence can cast other light on this.

Genetics

Although genetics works back mainly from present day genomes, such as those of modern humans and the chimpanzee, the very rapid progress in recovering a Neanderthal genome suggests that some past *rates* of genetic change, and histories of positively selected genes, will become available (Green et al. 2006; Nielsen et al. 2005; Hill and Walsh 2005). They will tell a complex story: it seems plain already that changes in many (but not huge numbers) of different genes will be involved in creating a large brain, an enlarged birth canal, prolonged adolescence, changed sleep schedules, and many other evolutionary changes. Even if there were one major evolutionary driving force, many genes would be involved in response to it, probably with different timings.

The Neanderthal genome is especially important in establishing a comparative frame which allows a divergence point from ancestors of modern humans to be set in the past at c. 0.7–0.5 Ma (Green et al. 2006). That divergence (which probably stems from a parent population of *Homo heidelbergensis*) will enable some calibration of rates of change at particular loci. For example, the gene FOXP2, which plays a part in supporting language abilities, appeared to have been modified under strong selection within the last 200,000 years (Enard et al. 2002; Lai et al. 2001), but its presence in Neanderthals in the same derived form as in modern humans indicates a very strong likelihood that this derived form was already there in a common ancestor ~750,000 years ago (Krause et al. 2007). AHI1, involved in cortex axon pathfinding, and MCPH1, which encodes microcephalin, also appear to have been positively selected recently, probably within the Pleistocene (Hill and Walsh 2005). They are highlighted as evidence that such events have to be weighted into interdisciplinary charts.

The Rationale for a Multidimensional Approach

Most archaeologists have reservations about present classifications, but it is very hard to become free from them. A detailed classification in stone can be unhelpful and uninteresting to workers in other disciplines. We are constrained by their double purpose—on the one hand they give us convenient rule-of-thumb ways of dividing the past world into manageable segments. On the other, there is an ideal that they are supposed to represent something of the world as seen by its past inhabitants. Archaeologists have a duty to consider the latter alongside their own convenience (Camps 2004). In 'Aurignacians' or 'Magdalenians' or 'Natufians' there is still in some way a claim to recover past cultural identities, although it has long been appreciated that the Oldowan and Acheulean are entities on a vastly different scale (Clarke 1968; Isaac 1972, Fig. 7, 389).

What packages of features make up such an entity? Through the stone ages the features of distinction are often still ad hoc: thus the Oldowan, named after Olduvai (Leakey 1971), is characterised by the basic technical attributes of stone-working, not by positive stylistic features. The initial assumption was that the Oldowan was specific to Africa, but it would be hard to find a basis for excluding similar early industries in other parts of the world. The Acheulean is distinguished purely through the addition of the large cutting tools, or bifaces with a long axis. Bifaces, however, appear to have been tools with particular functions, made and used only where those functions were needed (site complexes such as Olorgesailie and sequences such as Notarchirico show equally the extent of variation and presence/absence: Isaac 1977; Potts et al. 1999; Piperno et al. 1998; Piperno and Tagliacozzo 2001; Villa 2001). David Clarke (1968) envisaged the *polythetic* entity, in which not all categories had to be present in any one occurrence. There is however a major difficulty inherent in any classification which actually depends on a single artefact category that can be locally absent for all kinds of reasons.

The position is not much easier when a phase is defined by multiple technical or typological characters. The Middle Palaeolithic is signalled through more standardised ways of making flakes, and more refined scrapers, points, and other tool 'types.' As all of these can occur in the later Acheulean (and bifaces are 'allowed' in the Middle Palaeolithic), it is not surprising that debate over the Lower/Middle Palaeolithic transition goes back a very long way (e.g., papers in Ronen 1982).

The essential problem is that conventional classification is looking for fixed criteria—either one firm signal, or two or three that hang together—in a frame of material culture that is actually a multivariate world, even from an early stage. Hence the difficulties of the 'Mode' system of Grahame Clark (1977), which has been criticised previously because it is unilinear in expression (Gowlett 1999; Villa 2001). Many industries combine Modes 1 and 2 characteristics, others certainly Modes 3, 4, and 5 (Clark himself noted that 'more often than not particular industries are seen to combine technique from more than one stage of development' [1977, 24]).

Concepts and Traits

On all these grounds, it seems desirable to seek more broadly based approaches, and to look at arrays of characteristics, or traits (e.g., Reynolds 1991; Rigaud 1989; Stringer and Gamble 1993). For these we would ideally have a better theoretical basis. Here the ***concept*** is emphasised: it is internal, but can be seen as an idea that is shaped by external experience (e.g., Lambon Ralph et al. 2001). The attribute or trait is external: material culture can however be seen as an external projection of internalised ideas. Its materialness seems to be more than a late human add-on to an older internalised ideational world. Focus on objects seems to be fundamental to the world of activity demonstrated by mirror neurons in the case of Old World monkey brains (Gallese et al. 1996, 2004), and offers the basis for jointly appreciated activities. In any event, the very essence of culture is shared ideas, but it is not easy to isolate individual concepts within the great mass of information which is somehow transmitted. There will be imprecision, yet the scheme can be reasonably robust through addressing a number of characteristics.

In this effort to generate another dimension for looking at transitions, I found it possible to assemble about 24 concepts applicable through the Palaeolithic, each of which is taken to represent a different or new idea (Fig. 2). For several of these concepts or traits there is considerable uncertainty either about the evidence or its chronology, so a doubt range is indicated for these. Then, to compile a general picture (Fig. 1) calculated at 0.1 Ma intervals, each concept/trait 'in doubt' was scored at 0.5 through the doubt range. This is at least a declared approach to roughing out a view of the evidence. As Isaac wrote with respect to artefact types: 'this diagram is deliberately contentious.... It certainly emphasizes the need for systematic study of the problems' (Isaac 1972, 394, Fig. 5). Very brief notes are offered below on the individual aspects.

In the case of stone tools, the criterion has been introduction of new major idea, such as 'imposing long axis'. I have tried to distinguish these from the simple proliferation of tool types, thus presenting separately (but not excluding) a related longstanding issue, the number of tool types. Isaac (1972) listed numbers of tool types as seen in conventional typologies (Fig. 1). If valid, each type would embrace constellations of concepts, many of them similar for each tool (as in 'appropriate length', 'appropriate breadth'). Thus the same or similar concepts would be repeated through 'multiplicity'. As an industry with 100 types has much more informational content than one with 10 types, making and managing them all exerts a greater cognitive

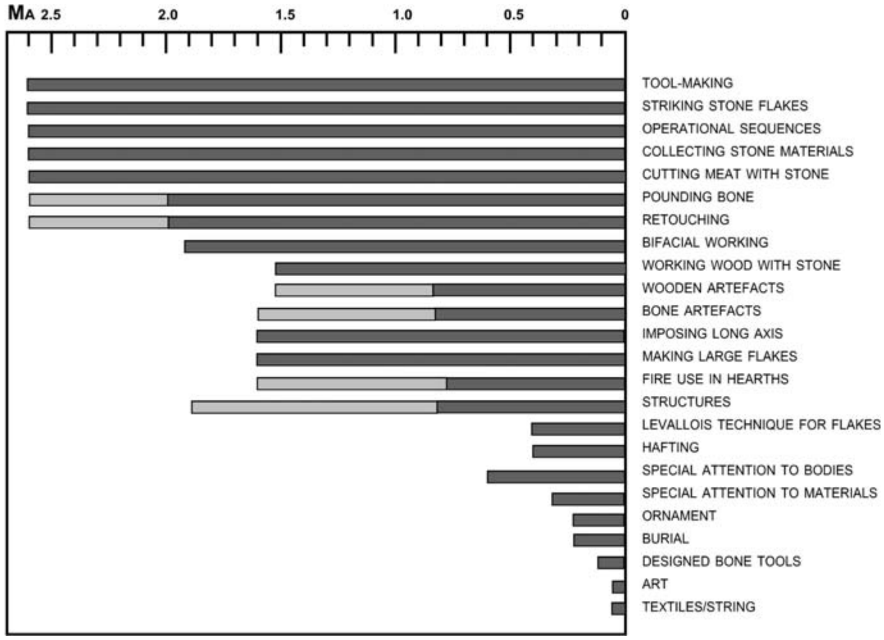

Fig. 2 The introduction of new concepts in material culture plotted through the Pleistocene. The open outlines show doubt ranges from the point of first (debated) appearance to the time of general acceptance. To provide a summary in Fig. 1, the total number of traits has been calculated at intervals of 0.1 Ma, with traits in debated range being scored as 0.5

load; the evidence is of interest. A single complex lithic (such as a biface) embraces a substantial number of different concepts, compared with a simple flake. The relations between these are of interest in studies of cognition (McPherron 2000, 2006; Gowlett 2006), but as they repeat similar content, they are not included in the list as new concepts. In the same way, the scheme as presented does not attempt to follow through greater stone transport distances (or infer territorial information), because the basic ideas do not necessarily change.

Levallois techniques, or specialised production routines for manufacture of flakes, do show a further concept and application. They are taken as appearing first around 400,000 years (e.g., Barkai et al. 2003; McBrearty and Brooks 2000), dates that also fit with the earliest signs of this technology in Europe (see also Rolland 1995). They may well be associated with hafting (see below).

In the case of wood, the earliest evidence comes from phytoliths adhering to bifaces at Peninj at c. 1.4 Ma (Domínguez-Rodrigo et al. 2001), and from microwear studies on stone artefacts of similar age at East Turkana (Keeley and Toth 1981). Far earlier use might well be expected, but there is no direct evidence. In the case of wooden artefacts, a polished plank from Gesher Benot Ya'aqov is taken as the earliest known (Belitzky et al. 1991), then there is little or no evidence until the spears at Schöningen (Thieme 1998, 1999, 2005). The earlier evidence of woodworking may well suggest that it was for tools, but that is not demonstrated (as a comparable example Thackeray et al. [2005] demonstrate use of stone for pounding bone in the Oldowan at Kromdraai, but that need not imply any use of bone for tools).

Schöningen is also important for the first evidence of hafting, in the form of short wooden staves grooved to allow insertion of a stone tool (Thieme 1998). There is no evidence for glue or twine, but the compound idea is quite definitely present. Cord or twine is directly attested in the eastern Gravettian (Soffer et al. 1998).

In the case of bone, an early large flaked piece comes from Olduvai Bed II, BK, alongside various other modified pieces (Leakey 1971, Fig. 114). Bone points believed to have been used at Swartkrans for digging would be of approximately the same age (Backwell and d'Errico 2005); thereafter, most evidence comes from the Middle Pleistocene, where bone bifaces are occasionally plentiful (e.g., Castel Guido west of Rome [Boschian and Radmilli 1999]). Artefacts made to a design specific to bone can be seen as a further concept, first appearing in a few shaped points (see Barham et al. 2002), or the harpoons at Katanda, if accepted (Yellen et al.

1995), but visible in general only within the last hundred thousand years (Villa and d'Errico 2001).

Structures present one of the longest doubt ranges. The hut or windbreak at Olduvai DK in Bed I (Leakey 1971) has often been doubted (e.g., Potts 1988). At Latamne in Syria, numbers of large stone blocks were collected and arranged (Clark 1968): they are accepted here, although others might require different kinds of evidence.

Hearths can be seen as structures, and are amongst the best evidence of controlled fire. Several early African sites have claims for hearths, but these are debated, including those at Chesowanja and Koobi Fora (Clark and Harris 1985). Gesher Benot Ya'aqov appears to have wide support at a date of c. 0.7 Ma (Goren-Inbar et al. 2004), rather older than early hearths in Europe at Beeches Pit and Schöningen (Gowlett et al. 2005; Thieme 2005). Fire is likely to have had a major role in improving food preparation and food quality (Wrangham et al. 1999). It might be seen as facilitating the expensive larger brain (cf Aiello and Wheeler 1995), but in the current state of investigations there is archaeological uncertainty about the earliest dates.

Special attention to bodies could be claimed from cutmarks on Stw 53 at Sterkfontein (Pickering et al. 2000). It is possibly inconsistent not to take more note of that, but the first example well associated with archaeology is Bodo in Ethiopia dated to about 0.6 Ma (White 1986; Rightmire 1996), where there is defleshing of the skull. This character recurs in a number of later individuals. The collection of human remains in Sima de los Huesos at Atapuerca is another case of similar date that probably qualifies as deposition showing special attention to bodies (Arsuaga 1998; Carbonell and Mosquera 2006; Pettitt in press).

Burial represents something more, both in practice and concept. The Middle East finds are the oldest, but it remains unclear whether the earlier examples are at Skhul and Qafzeh (Grün et al. 2005), or the Neanderthal burial at Tabun (Vandermeersch 2006). Either way, purely for the purposes of this exercise a date of approximately 100,000 is established.

In the case of ornament and decoration, dates have become older recently. Again, however, in most categories they do not exceed c. 100,000—as at Skhul, somewhat older than Blombos Cave (Grün et al. 2005; Henshilwood et al. 2002, 2004; Henshilwood and Marean 2003; Vanhaeren 2005; Vanhaeren et al. 2006).

The significance of other ideational or symbolic behaviour is less universally accepted, whether figurines as from Berekhat Ram, a rose quartz hand-axe from Atapuerca, or ochre in southern Africa (Goren-Inbar 1986; Goren-Inbar and Peltz 1995; Carbonell and Mosquera 2006; Barham 2004). Yet at the very least 'special attention to materials' is shown in a number of such cases. They could even be seen as special cases of the very long established selection of raw materials that goes back to the beginning of the archaeological record (Semaw et al. 1997, 2003).

Interpretation

This paper has contrasted the ideas of smooth curves and steps in the events of human evolution. The underlying issue is to know whether we are looking at one long trend, or rather sets of new impulses generating 'revolution.' Apparent smooth curves may be shaped through operation of a single model (e.g., social feedback); but equally, one evolutionary force may drive its effects through large numbers of single mutations at a biological level. In archaeology, we have primary evidence which must be described, but we are at risk of imposing step changes which may have little significance. Over-reliance on one line of evidence, or 'false concretisation' (stemming from the tendency to regard entities as real simply because they have been named), can have consequences if projected onto other disciplines—'unintended effects.' Archaeology can however attempt to gain independence from a priori 'beginning,' 'middle,' and 'end' models, and from criteria that depend excessively on a few aspects of just one segment of the record. One way to do this is through sequencing all the available individual traits.

The scoring of concepts/traits has limitations, but it seems at least as robust an approach as trying to measure things from a few tool types somewhat arbitrarily selected from lithic technology. Whatever the imperfections in the analysis, it is evident that there is a complex multidimensional record.

Steps in one area need not coincide with steps in another, but there may be relationships.

A few points can be summarised:

1) Cultural concepts or traits appear to accumulate steadily through the Pleistocene, more so than might be thought from a traditional Oldowan/Acheulean/Middle Palaeolithic/Late Palaeolithic outline.
2) There is already a considerable package of concepts/traits at the start of the visible record.
3) There remains a possible plateau at c. 1.5–0.8 Ma, coincident with the middle times of *Homo erectus* and the earlier Acheulean.
4) Thereafter traits accumulate again, not simply through the last 0.1 or even 0.3 Ma, but through >0.5 Ma.

One effect is to place increased emphasis on the period 0.7–0.5 Ma. Not only are various traits seen here, but they appear associated with *Homo heidelbergensis*, and the genetic evidence would suggest that its parent population diverged into ancestors of Neanderthals and modern humans through this same period (Green et al. 2006; Krings et al. 1997).

The large brain sizes, at least in some populations—e.g., Atapuerca and African specimens such as Saldanha and Bodo, when compared with modern cranial capacities, dispel the idea that a major size increase through the last half million years started at this point. The average of 1250 cc for several *heidelbergensis* specimens is c. 92% of modern volumes, little more than 1 sd from modern means. Thus any steep growth had already happened. Larger capacities seen in some last glacial Neanderthals and 'Cromagnons' have caught attention, but are above modern means, perhaps for some reason of selection operating locally.

In the classic social brain model, as given by Dunbar (e.g., 1998), it has been postulated that brain size has a strong relationship with social group size. This would be not the immediate group, but the network of contacts. The model does not in itself stipulate why a particular group size should be necessary, tending—on the basis of primatological evidence—to say that this depends on factors of ecology (Dunbar 1995). Social competition can be part of this scenario (Alexander 1979), and the feedback ideas from an earlier evolutionary biology may be invoked to account for the consistent prolonged trend (Huxley 1955). The figures used in this study suggest that if valid the basic social brain hypothesis is likely to operate right through the Pleistocene, but that brain size changes do not obviously provide some extra 'Factor X' through the last half-million years.

If this relative continuity is to be seen in the total accumulation of concepts or traits in material culture (as it appears), and in increases in brain size (with a certain amount of exception and cause for debate), what finally of the traditional steps in lithic industry classification, and numbers of tool types?

Here the changes merit more detailed study, partly because of the extent of variability, itself long admitted (Kleindienst 1961; Clark et al. 1966). Major technical changes are included in the concept scheme above. Although the concepts plot emphasises continuity, it is also hard to escape the impression that there are clusters of new (applied) ideas at 2.6 Ma, 1.6 Ma, 0.4 Ma, as well as within the last hundred thousand years. The question to return to is whether these are just artefacts of preservation and preconceptions.

The technical developments do seem to have an objective major importance, conferring practical advantages that depend on an adequate cognition. The bifaces give longer cutting edges, sharper edge angles, and far better leverage compared with Oldowan choppers. Hafting gives far more flexibility utilising the best properties of different raw materials. It both needs and stimulates greater shared knowledge of the world, with its emphasis on glues, binding, and maintenance. Analysis thus immediately leads out to other consequences, which are more social than technical.

It is easy to hypothesise that in a widely dispersed technically competent population, there was a large selective advantage on communication, and that the doubling in brain size is largely to do with language. If language then favoured a sort of sociocultural speciation by imposing barriers between groups, as suggested long ago by Isaac (1972), that would add to the force of selective pressures.

Finally, there is the issue, beyond all the criteria examined here, whether modern humans still require something 'extra' in explanation. It would seem fruitless to argue away the kinds of lists of additional characteristics and evidence in Stringer and Gamble (1993, 2007), d'Errico et al. (2003), or

Mellars (2005), including especially evidence of art, music, and rapid cultural change; although remnants of some other elements can be traced at earlier dates (such as tool standardisation). It does seem however that the changes derive from a general extension of social dimensions, rather than a simple addition of 'symbols' into the record. The preoccupation with demonstrating 'symbolic behaviour' as evidence for modern behaviour and language seems inadequate for gaining a broader perspective. Not only is there evidence in other primates of symbolic behaviour and capability in symbol use, but lines of anatomical evidence (Tobias 2005, Martinez et al. 2004), and the calculations of evolutionary anatomy and psychology (Aiello and Dunbar 1993), argue for language having much earlier roots.

Here it is noteworthy too that many of the newer features in cultural traits are intensifications of earlier ones:

Attention to body (before)—burial;
Attention to materials (before)—decoration, ornament;
Use of fire (before)—fire in ritual;
Use of wood and bone (before)—wood and bone in artefacts.

The intensification may be attributable at least partly to minds operating with additional levels of intentionality, a function of the demands of social worlds as discussed above. This perspective argues for one overall frame—a single gradient of 'becoming human.' Yet even the Neanderthal/modern divergence shows the possibility of stages, or different sets of outcomes based on earlier adaptations that were workable in their own right. There remain, across the lines of evidence, some indications of major sets of changes that may amount to grade changes.

Accepting these and that the recent intensification merits the label of a revolution, one can go on to argue that there were:

- A first revolution of attaining a basic human socio-cultural-economic package (c. 2.6–1.6 Ma).
- A second revolution, largely silent archaeologically, in which large brains and language evolved together in concert with factors such as fire use (c. 1.5–0.5 Ma)
- A third revolution, the final *sapient* intensification (with deep roots but gaining acceleration within the last 100,000 years).

In this reformulation there is a tension between the signs of continuity, and the ideas of revolutions (which Clive Gamble [2007] has also recently challenged in another formulation). Probably none of the revolutions would include all contemporary hominid populations. It may be said, of course, that in this paper we simply have *Homo habilis/erectus/sapiens*, or Lower/Middle/Upper, in another guise. But the whole point of the concepts analysis is to look at the record on a broader basis, and this schema arises from that examination. If in future we can demonstrate that cultural concepts/traits accumulated so continuously that there were no clear revolutions, all well and good. But in the meantime, the concept that there were *earlier* revolutions should help sharpen up criteria for testing the later ones.

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Quantifying Transitions: Morphometric Approaches to Palaeolithic Variability and Technological Change

Stephen J. Lycett

Abstract Robust assessment of lithic technological transitions requires dependable methodologies for the comparative analysis of stone tools from different localities, regions, and even continents. Many concepts of technological variability and change during the Lower–Middle Palaeolithic centre upon differences in the shape of various cores and core tools (e.g., polyhedrons, discoids, Acheulean bifaces, Levallois cores, etc.). Morphometrics is the application of the principles of geometry to the statistical analysis of shape. In palaeontology (and biology in general) powerful mathematical and statistical methods of analysis are routinely applied to detailed morphometric data sets that allow secure assessments of intra- and inter-taxonomic variability, at both regional and global levels. Conversely, Palaeolithic archaeology has been slow to adopt methods that enable the comparative morphometric analysis of lithic variability, which could potentially allow a more secure assessment of the pattern and validity of technological transitions. This paper briefly assesses the reasons why Palaeolithic archaeology has been relatively slow to adopt the morphometric approach applied in the biological sciences. Employing a new method for morphometric lithic analysis, worked examples of Palaeolithic morphometric analysis are presented. These analyses emphasize the importance of developing a 'morphometric comparative anatomy' of stone tools, particularly with regard to increasing our understanding of technological transitions and variability.

Keywords Lithics • Homology • Morphometrics • Size • Shape • Size-adjustment • Acheulean • Levallois • Soanian

Lithic Morphometrics—What and Why?

> The study of form may be descriptive merely, or it may become analytical. We begin by describing the shape of an object in the simple words of common speech: we end by defining it in the precise language of mathematics . . . [T]he form of the earth, of a raindrop, the shape of a hanging chain, or the path of a stone thrown up into the air, may all be described, however inadequately, in common words; but when we have learned to comprehend and to define the sphere, the catenary, or the parabola, we have made a wonderful and perhaps manifold advance. The mathematical definition of a 'form' has a quality of precision which was quite lacking in our earlier stage of mere description; it is expressed in few words or in still briefer symbols, and these words and symbols are so pregnant with meaning that thought itself is economised . . . We are apt to think of mathematical definitions as too strict and rigid for common use, but their rigour is combined with all but endless freedom.
>
> D'Arcy Wentworth Thompson *On Growth and Form* (1961 [orig.1917]), p.269

Writing for biologists over ninety years ago, D'Arcy Thompson paved the way for much of the 'revolution' in the study of form that has taken place within biology over recent years (Adams et al. 2004; Jensen 2003; Rohlf and Marcus 1993). 'Morphometrics' is now seen as a major field of

S.J. Lycett (✉)
Department of Anthropology, University of Kent, Canterbury, Kent, UK

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growth in biology and palaeontology, including physical anthropology (e.g., O'Higgins 2000). Put simply, morphometrics is the application of the principles of geometry to the study of shape. Others have pointed out that morphometrics may also usefully be termed 'statistical shape analysis' (e.g., Dryden and Mardia 1998). As we will see later, this requires rigorous definitions for concepts such as 'size,' 'shape,' and 'homology.' This chapter has three primary aims: Firstly, to provide an introduction to some of the terminology and principles of morphometrics for archaeologists. Secondly, to demonstrate some of the utility and potential of morphometrics for understanding Palaeolithic technological transitions. Lastly, and perhaps chiefly, this discussion aims to demonstrate that morphometric approaches should become more widely used in Palaeolithic archaeology, and hopes to encourage wider debate on these issues, particularly for furthering our understanding of technological transitions.

Why Has Palaeolithic Archaeology Been Slow to Adopt and Develop Modern Morphometric Methods?

Many concepts of technological variability and change during the Lower–Middle Palaeolithic centre upon differences in the shape of various cores and core tools (e.g., polyhedrons, discoids, Acheulean bifaces, Levallois cores, etc.). It bears repeating that every observation about the form of a stone artefact is an exercise in the description of morphology, and constitutes the basis of all taxonomic and typological schemes. In turn, these observations should lead us toward an increased understanding of both within-assemblage and between-assemblage artefact variation, as well as the factors that lead to such variability, whether this be raw material, reduction intensity, function, cultural tradition, or cognitive and/or biomechanical differences. However, while duly acknowledging the important recent contributions of certain workers (e.g., Buchanan 2006; Carper 2005; Clarkson et al. 2006; Gowlett et al. 2001; McPherron and Dibble 1999; Nowell et al. 2003; Saragusti et al. 1998, 2005; Shott 2003; Tostevin 2003; Wynn and Tierson 1990), it may be stated that Palaeolithic archaeology has been relatively slow to adopt and develop sophisticated quantitative approaches to these issues, especially when compared to the burgeoning literature that has been generated in biological morphometrics. Indeed, it might be argued that little progress has been made in this regard since the pioneering work of Roe, Bordes, and Isaac (see e.g., Isaac 1977; Roe 1968, 1994), whose system(s) for studying bifaces remain the only widely-applied morphometric methodology in Palaeolithic archaeology.

Given this situation, it raises the question as to why archaeologists have seemingly been reluctant to adopt and routinely apply methodologies that have proven so effective in other disciplines, even when colleagues in physical anthropology employing these very techniques may sometimes be only a few doors away. Several possible reasons might be suggested. One possibility is simply a lack of quantitative and statistical training. It is well-noted (e.g., Shennan 1997) that archaeologists are perhaps not the most naturally inclined to mathematical procedures of analysis, although user-friendly software is making this less important than it once was (or should be). A further reason is the expense of precision digital equipment, and the difficulties of using such instruments in archaeological field conditions (McPherron and Dibble 2003). Other possibilities are potentially more pernicious, with suspicions being raised about the 'reality' of scientific or quantitative and statistical methods, or that such methods somehow 'miss' some fundamental component of the 'technology' that more traditional methods somehow impart to the study of stone tools. It is partly the aim of this present chapter to dispel such misconceptions, if only for the reasons that morphometric methods aim to instil a level of repeatability, objectivity, rigour, and statistical analytical potential, which many qualitative methodologies can simply never match (Hughs and Chapman 2001; Thompson 1961; Rae 2002). Fundamentally, morphometric methods aid in turning mere observation into precise numerical data, which can then be analysed statistically with an associated probability estimate of confidence in any conclusions we may draw.

Elsewhere (Lycett et al. 2006) I have suggested, however, that one of the most fundamental reasons that a lithic 'morphometric revolution' has not yet taken place, is that applying morphometric methods to stone artefacts imparts a level of difficulty that colleagues in other disciplines are perhaps more easily able to overcome. That is, stone artefacts do not possess a series of readily identifiable points of correspondence (or ‘homology’), which allow a series of comparable measurements or landmark configurations to be taken across a broad range of lithic morphs, as might be encountered in many Palaeolithic assemblages. Overcoming this impediment, and applying such methods to viable archaeological questions in order to demonstrate their potential, is perhaps, the real challenge facing the science of lithic morphometric analysis.

Homology: The Crux of Morphometric Analysis

‘Homology’ can be an ambiguous term, yet one of fundamental importance in morphometric analysis. Here, the term refers to points of morphological correspondence (or ‘landmarks’), which may be identified according to explicit and clearly defined rules. Confusingly, the term homology can also be used to refer to morphological features in biological organisms that have common evolutionary (i.e., genealogical) ancestry and/or common developmental pathways (see e.g., Lieberman 1999). While the issue of phylogenetic homology in stone tools has received increased consideration in recent years (e.g., O’Brien et al. 2001; Lycett 2007b), the present discussion limits its use of the term *homology* to that of correspondence of point(s) (or measurement) across the range of lithic forms in a given analysis.

It is only armed with a concept of homology that quantitative comparative analysis of any form may proceed. Many biological objects of study (e.g., primate crania) possess a high number of easily-defined landmarks, or points of anatomical equivalence and correspondence (e.g., suture junctions, projections, foramina, etc.). In contrast, however, stone tools do not possess a series of easily-defined and precisely identifiable points of morphological homology. This lack of homologous landmarks may explain why quantitative lithic analyses tend to involve only a small number of morphometric variables, limited to particular classes of artefact. For instance, the Bordes/Roe/Isaac system of linear biface measurements provides $\leq$ 11 primary variables, and is not easily adapted to analyse or incorporate a wider range of lithic core forms.

Elsewhere, colleagues and I (Lycett et al. 2006) have described an instrument for the morphometric analysis of stone artefacts, which we have termed the Crossbeam Co-ordinate Caliper (CCC). Along with the associated artefact orientation protocol (Lycett et al. 2006; Lycett 2007a), the CCC can be used to both locate geometrically homologous landmarks on lithic nuclei, and measure the distances between them. Under Bookstein’s (1997) revised landmark terminology, such landmarks would be termed ‘semi-landmarks,’ since they are both geometrically and instrumentally defined. Using this methodology, two case studies are described below, which illustrate some of the potential utility of morphometric methods for understanding Palaeolithic technological variability. It should be emphasised that the analyses discussed below, and the specific methodology employed, are by no means designed to be the final word on these issues. Rather, they aim to stimulate discussion and illustrate something of the potential of such methods and their general principles. Likewise, flake tools and debitage are not discussed, and these also clearly benefit from morphometric approaches, as others have shown (e.g., Eren et al. 2005; Hiscock and Clarkson 2005; Kuhn 1990; Shea 2006; Shott et al. 2000; Shott and Weedman 2007).

Size, Shape, and Scaling

Before proceeding to the case studies, the issues of scaling, size, and shape require some discussion. In morphometrics, the concepts of ‘size’ and ‘shape’ are surprisingly more complex from a semantic point of view than may perhaps normally be considered (Bookstein 1989). In essence, the overall form (or morphology) of an object can be described as size *plus* shape. However, size (isometry) and shape can only be defined relative to each other, and one of the most important advances made in morphometrics in recent years has been the more explicit use of precise mathematical definitions of size in order that the two may mathematically be disentangled (Darroch and Mosimann 1985; Jungers et al. 1995).

This in turn leads us on to the issue of scaling or 'size-adjustment.' When a database of morphometric features is recorded for a series of objects, the major source of variation between these variables will regularly be due to raw size differences. Moreover, many linear (i.e., Euclidean) variables will be correlated with each other due to the effects of isometric scaling (Rae 2002). Hence, when attempting to analyse the shape differences between these objects, it is necessary to remove the confounding effect of size (i.e., scale) such that the artefacts may be differentiated on the basis of shape characteristics rather than overall size (Rae 2002). Given that absolute differences in the size of raw materials used for stone artefact manufacture may affect the ultimate size of an individual artefact (Chauhan 2003), size-adjustment may also potentially remove some of the confounding effects of raw material (i.e., blank form) variability. This then helps ensure that comparison of shape (e.g., ovate handaxes versus pointed handaxes) will be the major axis of comparison in an analysis rather than just size (e.g., large versus small handaxes). It is important to note that scaling data in this manner by no means implies that an investigator is automatically making the assumption that 'size' is an unimportant aspect of the variation between specimens. Indeed, to better understand the relationship between size differences and shape differences, it is important to have precise definitions of each.

In the analyses described below, the method of geometric mean size-adjustment was applied to Euclidean distance variables[1]. The geometric mean is one of the Mosimann family of size variables (Mosimann 1970; Mosimann and Malley 1979), and like the arithmetic mean, provides a measure of central tendency, but is not as strongly influenced by outliers or deviations from the modal data. Jungers et al. (1995) have demonstrated via experimental studies that this method (in contrast to some alternative methodologies) allows the identification of differently-sized individuals of the same shape following treatment. Size-adjustment using the geometric mean has become increasingly popular in biological morphometric analyses of shape (e.g. Ackermann 2005; Collard and Wood 2000; Dumont 2004; Klimov et al. 2004; Lycett and Collard 2005; O'Keefe and Carrano 2005; von Cramon-Taubadel et al. 2005). Note, however, that previous biological applications of such methods do not imply that such principles are only relevant in the case of biological data; the principles of size-adjustment will apply wherever there is a need to understand shape differences between objects regardless of the proximate sources of such variation. The geometric mean of a series of n variables (a_1, a_2, a_3, ... a_n) is equivalent to $(a_1 \times a_2 \times a_3 \times \ldots \times a_n)^{1/n}$. Simply, the geometric mean is the nth root of the product of all n variables (Jungers et al. 1995; Sokal and Rohlf 1995, 43). The method proceeds on a specimen-by-specimen basis, dividing each variable in turn by the geometric mean of the variables to be size-adjusted. The procedure effectively equalizes the volume of all specimens in a sample, creating a dimensionless scale-free variable while preserving the original shape information in the data.

Case Study 1: Acheulean Handaxe Variation

The 'Acheulean' (or 'Mode 2') (Clark 1994) is an example of the type of broad terminology routinely employed to describe elements of the Palaeolithic record, in the use of which I am as guilty as anyone else (e.g., Lycett and von Cramon-Taubadel 2008). Such labels undoubtedly serve as useful terms of rapid communication, and function adequately at broad global levels of description. However, I would not be the first person (e.g., Gowlett 1998; Roe 1976; Wynn and Tierson 1990) to hint at a potential problem of generality in such terms, if I were to suggest that there is a possibility of finding meaningful patterns of variability within such

[1] In biological morphometrics, landmark configurations are increasingly being analysed holistically by a particular branch of morphometrics termed *geometric morphometrics*. Generally such methods employ 'centroid size' as a measure of size, which may be defined as the square root of the sum of squared Euclidean distances from each landmark to the centroid, which is simply the mean of the landmark coordinates. Geometric morphometric methods are not discussed in the present chapter, but see Lycett et al. (2006) for discussion and application of such methods in the context of lithic studies.

Table 1 The 10 Acheulean localities, sample sizes, and raw materials employed in Case Study 1

Locality	*n*	Raw material
Attirampakkam, India	30	Quartzite
Bezez Cave (Level C), Adlun, Lebanon	30	Chert
Elveden, Suffolk, UK	24	Chert
Kariandusi, Kenya	30	Lava
Kharga Oasis (KO10c), Egypt	17	Chert
Lewa, Kenya	30	Lava
Olduvai Gorge (Bed II), Tanzania	13	Quartz, lava
Morgah, Pakistan	21	Quartzite
St Acheul, France	30	Chert
Tabun Cave (Layer Ed), Israel	30	Chert

broad categories, or that we might look for 'transitions within transitions.'

In order to explore the issue of variability within the Acheulean, data were collected for a series of $n = 255$ handaxes from 10 localities distributed throughout the Palaeolithic Old World (Table 1). No cleavers were included to ensure that the analysis was confined to a single class of artefact. In order to maximise data collection time toward obtaining samples with broad geographical coverage, a tactical decision was taken not to measure more than 30 specimens from a single given locality. Where a particular assemblage contained more than 30 total artefacts, specimens were sampled randomly from the total assemblage using the program *Research Randomizer* (http://www.randomizer.org).

Morphometric data were collected for all 255 handaxes via use of the Crossbeam Co-ordinate Caliper (Lycett et al. 2006). Artefacts were orientated in standard fashion using a geometric protocol (Lycett 2007a). This initially provided a series of 54 variables (Table 2), previously described in detail elsewhere (Lycett et al. 2006). Variables 1–48 (Euclidean distance variables) were size-adjusted by the geometric mean method (Jungers et al. 1995; Lycett et al. 2006) in order to remove the confounding effects of isometric differences in scale between various finished artefacts and initial blank form sizes. Descriptions of six additional variables used in the analysis (i.e., variables 55–60, Table 2) may be found in Lycett (2007a).

The 60 morphometric variables were subjected to a Discriminant Function Analysis. DFA is a multivariate technique that is used to provide a set of weightings (i.e., discriminant functions) that most effectively discriminate between groups that have been defined a priori (e.g., on the basis of locality). These weightings are linear combinations of the independent variables (Hair et al. 1998; Huberty 1994). The weightings determine the quantity (%) of artefacts that may be correctly assigned to their correct (predefined) group via the data inputted to the analysis. It is also possible to test the effectiveness of the discriminant functions in producing statistically significant differences between the groups via the Wilks' Lambda statistic (Kinnear and Gray 2004). Hence, it may be predicted that if there is little information regarding morphological differences between the ten groups employed in this case study, then artefacts will be assigned with a low percentage (e.g., $\leq$ 50% accuracy) to their respective locality, and that discriminant functions will be nonsignificant ($\alpha \geq 0.05$) according to the Wilks' Lambda test. The analyses were undertaken using the software program *SPSS* v.12.0.1.

Figure 1 shows the results of the Discriminant Function Analysis. Of the original grouped cases, 72.8% were correctly classified to their locality. Hence, this suggests that the Acheulean samples employed here contain morphometric information that allows handaxes at different sites to be identified in over 70% of cases. Moreover, the differences between centroids are significant ($p \leq 0.0001$) according to the Wilks' Lambda statistic (Fig. 1). Such results are inconsistent with any suggestion that the Acheulean samples considered here are highly homogeneous overall. It is particularly interesting to note the distinct separation of the African localities (positively loading) from the non-African

Table 2 The 60 morphometric variables used in Case Studies 1 and 2. For further details see Lycett et al. (2006) and Lycett (2007)

1. Core left width at 10% of Length
2. Core left width at 20% of Length
3. Core left width at 25% of Length
4. Core left width at 30% of Length
5. Core left width at 35% of Length
6. Core left width at 40% of Length
7. Core left width at 50% of Length
8. Core left width at 60% of Length
9. Core left width at 65% of length
10. Core left width at 70% of Length
11. Core left width at 75% of Length
12. Core left width at 80% of Length
13. Core left width at 90% of Length
14. Core right width at 10% of Length
15. Core right width at 20% of Length
16. Core right width at 25% of Length
17. Core right width at 30% of Length
18. Core right width at 35% of Length
19. Core right width at 40% of Length
20. Core right width at 50% of Length
21. Core right width at 60% of Length
22. Core right width at 65% of Length
23. Core right width at 70% of Length
24. Core right width at 75% of Length
25. Core right width at 80% of Length
26. Core right width at 90% of Length
27. Core length distal at 10% of width
28. Core length distal at 20% of width
29. Core length distal at 25% of width
30. Core length distal at 30% of width
31. Core length distal at 40% of width
32. Core length distal at 50% of width
33. Core length distal at 60% of width
34. Core length distal at 70% of width
35. Core length distal at 75% of width
36. Core length distal at 80% of width
37. Core length distal at 90% of width
38. Core length proximal at 10% of width
39. Core length proximal at 20% of Width
40. Core length proximal at 25% of Width
41. Core length proximal at 30% of Width
42. Core length proximal at 40% of Width
43. Core length proximal at 50% of Width
44. Core length proximal at 60% of Width
45. Core length proximal at 70% of Width
46. Core length proximal at 75% of Width
47. Core length proximal at 80% of Width
48. Core length proximal at 90% of Width
49. Coefficient of Surface Curvature 0–180°
50. Coefficient of Surface Curvature 90–270°
51. Coefficient of Surface Curvature 45–225°
52. Coefficient of Surface Curvature 135–315°
53. Coefficient of edge-point undulation
54. Index of Symmetry
55. Max width divided by width at orientation
56. Maximum length divided by length at orientation
57. Nuclei outline length (divided by geomean)
58. Area of largest flake scar
59. CV of complete flake scar lengths
60. CV of complete flake scar widths

localities (negatively loading) on DF 1, suggestive of some degree of regional patterning to the morphometric data. Likewise on DF 2, the centroids of the non-African samples are arranged along the discriminant function in an order suggestive of regional differentiation, with European localities loading lowest on DF 2, followed by the Asian specimens, followed by those from the Levant. Moreover, note that due to the scaling (size-adjustment) procedures employed, this distinction is not one merely of size (i.e., 'large' African handaxes versus 'small' non-African handaxes), but one of actual shape variation. This may imply that distinct regional shape preferences, or the socially transmitted techniques of manufacture which ultimately lead to shape variations, differ between broad geographic regions (Lycett and Gowlett 2008). Such regional patterning would be hard to account for on the basis of raw material, given the samples employed here (Table 1), and arguably would have been difficult to detect in the absence of the morphometric and analytical methods applied.

In recent decades, it has frequently been suggested that potential morphological similarities and differences within different lithic assemblages (Acheulean or otherwise) are due to function, raw material, and/or reduction intensity (e.g., Binford and Binford 1966; Dibble 1987; McBrearty 2003; Ashton and White 2003; McPherron 2000). However, it may be premature to suggest that we are at a stage anywhere approaching a full understanding of how these factors play out at a global or regional level, or whether additional factors such as social tradition, cultural variation, random cultural drift, and/or cognitive and biomechanical abilities of different hominin species are equally—or perhaps even more—important in certain situations (e.g., Lycett

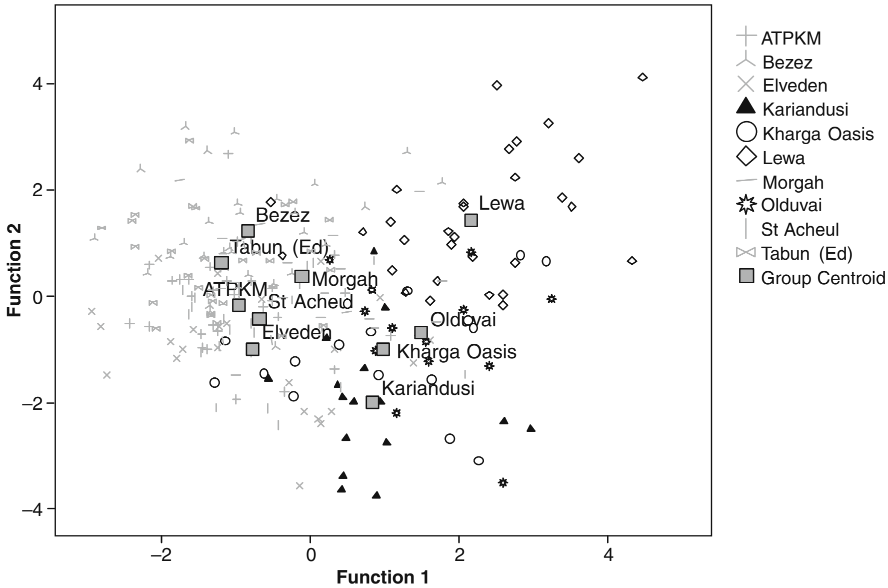

Fig. 1 Results of DFA of 60 morphometric variables for $n = 255$ handaxes. 72.8% of original grouped cases correctly classified to locality. Differences between centroids are highly significant (Wilks' Lambda $= 0.22$, df $= 504$, $p \leq 0.0001$) on DF 1. The eight variables most highly correlated (respectively) with DF 1 were variables 32, 43, 33, 41, 42, 31, 44, 40, and 54 (see Table 2 for descriptions). Hence, variables around the 'tip' and 'butt' midline of the handaxes appear to be most important in separating the African from the non-African assemblages on DF 1. Modified after Lycett and Gowlett (2008)

and von Cramon-Taubadel 2008; Lycett 2008). It is contended here that a more widespread adoption and development of morphometric approaches will help us to meet the challenge of understanding such phenomena further, identifying more clearly those areas of similarity and difference that demand interpretation.

Case Study 2: Is the Soanian a Lower or Middle Palaeolithic Techno-Complex?

The Soanian techno-complex from the Siwalik Hills of the Himalayan frontal range is traditionally seen as one of the major Palaeolithic techno-complexes in the Indian subcontinent (Kennedy 2000; Movius 1948, 1969; Sankalia 1974). However, the Soanian has seen only limited empirical research in recent decades, further plagued by a dearth of primary context sites (Chauhan 2003, 2005, 2007, 2008). Comparison with the Mode 1 industries of East Asia and those of northwest Europe (e.g., the Clactonian) are common (Chauhan 2003; Dennell and Hurcombe 1989; Kennedy 2000; Movius 1948). However, the chronological status and typo-technological relationship(s) of the Soanian to other Palaeolithic industries have been the subject of much debate. When first named and described (de Terra and Paterson 1939) the Soanian was considered to contain evidence of Levallois-style core reduction. Yet, in recent years, this techno-complex has been variously described as a chopper tool industry, a pebble tool and flake industry, a cobble tool industry, a core/flake industry, or simply as 'Mode 1' (e.g., Chauhan 2003, 2005; Davis 1987; Gaillard 1995; Ghosh 1974; Misra 2001; Petraglia 1998, 2001). Indeed, Grahame Clark (1969, 36) explicitly included Soanian industries within Mode 1 when initially outlining his well-known lithic taxonomic scheme.

There is a long history of contrasting Soanian technology with the Acheulean of the Indian subcontinent (Chauhan 2003; Gaillard 1995; Misra 2001; Mohapatra 1990; Movius 1969; Paterson and Drummond 1962; Sankalia 1967, 1974). Some, however, have suggested that the Soanian–Acheulean distinction may simply represent the ends of a technological continuum or highly variable lithic facies (e.g., Petraglia 1998). Although Soanian material has frequently been seen as contemporary with or preceding the Acheulean in India and Pakistan (e.g., de Terra and Paterson 1939; Graziosi 1964; Mohapatra 1990), it has also been argued that the Soanian may actually post-date the Acheulean (Chauhan 2003; Gaillard 2006; Gaillard and Mishra 2001). Indeed, Suresh et al. (2002) have recently dated (via optically stimulated luminescence) the deposition of an alluvial fan surface in the Pinjore-Nalagarh Dun, India, to as young as 20 Kyrs. This implies that Soanian material associated with this feature should be seen as Late Pleistocene in age rather than Middle Pleistocene or older (Chauhan 2003; Singh Soni and Singh Soni 2005).

Although isolated occurrences of Acheulean technology are known in the Siwaliks (Mohapatra 1981; Chauhan 2003, 2004; Corvinus 2006), the Soanian techno-complex is more frequently compared with biface-free or Mode 1 Palaeolithic industries. It is particularly interesting to note that Movius (1948, 376) saw the Soan material as 'one manifestation of a great complex of chopper-chopping tool found in Southern and Eastern Asia.' Hence, the chronological and techno-typological status of the Soanian is potentially of great importance in understanding the nature and significance of the so-called 'Movius Line,' which is traditionally held to represent a geographic demarcation between the Mode 1 industries of East Asia and the Mode 2 (Acheulean) industries of western Eurasia and Africa (Schick 1994). The Soanian has also drawn comparison with non-bifacial industries such as the Clactonian of northwest Europe, and is thus embroiled in debates concerning the nature and significance of Lower Palaeolithic biface-free industries (e.g., Kennedy 2000; White 2000). If it could more confidently be established that at least some of the Soanian techno-complex contains a Levallois element, this would be consistent with interpretations of this industry as a Late Pleistocene phenomenon, with attendant implications regarding the relationship between the Soanian and the Acheulean, and the relevance of the Soanian in discussions of the Movius Line.

In order to test the hypothesis that the Soanian techno-complex contains a Levallois (Mode 3) core element, data were collected from a series of Lower–Middle Palaeolithic Old World nuclei (n = 564 nuclei) representing 27 taxonomic units (Table 3). The taxonomic units were composed of Mode 1 nuclei (i.e., polyhedrons, choppers, discoids) (n = 157), Mode 2 handaxes (n = 255), and Mode 3 Levallois cores (n = 141). The latter had either previously been assigned in the literature to Levallois industries and/or conformed to commonly used qualitative morphological definitions of Levallois cores (e.g., Boëda 1995; Chazan 1997; Van Peer 1992). Boëda's (1995) six criteria for the identification of Levallois cores were given particular emphasis here.

It should be noted that 25 Mode 1 nuclei from the Soan Valley, Pakistan, were included as part of the general comparative sample (Table 3). This material represents part of the Soanian type material collected as surface finds by de Terra and Paterson (1939) from the Soan Valley during April of 1935 as part of the Yale-Cambridge expedition to India, of which modern Pakistan was then part. In addition, a sample of 11 cores was included in the analysis from de Terra and Paterson's Soan Valley collections, which also appear to display many of the characteristics commonly used to identify Mode 3 Levallois cores (e.g., Boëda 1995; Chazan 1997; Van Peer 1992). This latter group of nuclei was termed 'Soan?' for the purposes of analysis (Table 3; taxonomic unit number 27). Hence, the following analysis essentially tests the qualitative identification of these specimens as 'Levallois' via a morphometric procedure.

Morphometric data were again collected for all 564 nuclei via use of the Crossbeam Co-ordinate Caliper (Lycett et al. 2006), using the geometric orientation protocol (Lycett 2007a). This initially provided a series of 54 variables (Table 2), previously described in detail elsewhere (Lycett et al. 2006). Variables 1–48 (Euclidean distance variables) were again size-adjusted by the geometric mean method (Jungers et al. 1995; Lycett et al. 2006). Descriptions of six additional variables used in the analysis may be found in Lycett (2007a). In order to test the hypothesis that the Soanian sample contains Levallois cores, the morphometric variables were subjected to a Discriminant Function Analysis. For the purposes of this analysis, the lithic taxonomic units were treated as four separate groups: a Mode 1 group, a Mode 2 group, a Mode 3 group, and the 'Soan?' group comprised of the 11 lithic nuclei that also appear to conform to commonly employed Levallois core descriptions. Using DFA it is possible to make two specific predictions regarding how the 'Soan?' group should perform if the results of the analysis are to be consistent with the hypothesis that the Soanian techno-complex

Table 3 Samples used in Case Study 2

Locality	*n*	Raw material	Technological mode
Barnfield Pit, Kent, UK	22	Chert	M1
Barnham St Gregory, Suffolk, UK	30	Chert	M1
Lion Point, Clacton, Essex, UK	18	Chert	M1
Olduvai Gorge (Lower Bed II), Tanzania	11	Lava, chert, quartz	M1
Olduvai Gorge (Middle/Upper Bed II), Tanzania	26	Lava, chert, quartz	M1
Soan Valley, Pakistan	25	Quartzite	M1
Zhoukoudian, Locality 1, China	14	Sandstone, quartz, limestone	M1
Zhoukoudian, Locality 15, China	11	Sandstone, quartz	M1
Attirampakkam, India	30	Quartzite	M2
Bezez Cave (Level C), Adlun, Lebanon	30	Chert	M2
Elveden, Suffolk, UK	24	Chert	M2
Kariandusi, Kenya	30	Lava	M2
Kharga Oasis (KO10c), Egypt	17	Chert	M2
Lewa, Kenya	30	Lava	M2
Olduvai Gorge (Bed II), Tanzania	13	Quartz, lava	M2
Morgah, Pakistan	21	Quartzite	M2
St Acheul, France	30	Chert	M2
Tabun Cave (Layer Ed), Israel	30	Chert	M2
Baker's Hole, Kent, UK	23	Chert	M3
Bezez Cave (Level B), Adlun, Lebanon	28	Chert	M3
El Arabah, Abydos, Egypt	16	Chert	M3
El Wad (Level F), Israel	27	Chert	M3
Fitz James, Oise, France	11	Chert	M3
Kamagambo, Kenya	13	Quartzite, chert	M3
Kharga Oasis (KO6e), Egypt	11	Chert	M3
Muguruk, Kenya	12	Lava	M3
Soan Valley, Pakistan	11	Quartzite	?

contains a Mode 3 Levallois core component. That is, (1) the centroid of the 'Soan?' assemblage should be closer to the Mode 3 group centroid than that of any other group, and (2) the individual specimens within the 'Soan?' assemblage should overlap with variation exhibited by specimens included in the Mode 3 Levallois group. If both of these predictions are not fulfilled, the results of the analysis can be interpreted as inconsistent with the hypothesis that there is a definite Mode 3 Levallois core component to the Soanian lithic techno-complex, at least as represented by the samples examined here.

Figure 2 shows the results of the DFA, plotting the discriminant scores (functions 1 and 2) for the 564 lithic nuclei used in the analysis. Cumulatively, functions 1 and 2 account for 92.5% of the variation exhibited by the specimens. The six variables most highly correlated with DF 1 were variables 49 (Coefficient of surface curvature 0–180°), 52 (Coefficient of surface curvature 135–315°), 51 (Coefficient of surface curvature 45–225°), 53 (Coefficient of edge-point undulation), 50 (Coefficient of surface curvature 90–270°), and 59 (CV of complete flake scar lengths). The plot clearly shows that the centroid of the 'Soan?' assemblage is closer to the Mode 3 group centroid than that of any other group, and that the individual specimens within the 'Soan?' assemblage overlap closely with specimens included in the Mode 3 Levallois group, thus fulfilling the predictions of the hypothesis that the Soanian techno-complex contains a Mode 3 Levallois core component. Hence, the discriminant function analyses provide robust evidence that the type material of the Soanian techno-complex contains specimens that should taxonomically be termed Mode 3 Levallois. However, it should also be noted that some cores from the Soan Valley (i.e., taxonomic unit 6) fit comfortably within the range of Mode 1 cores examined here.

These morphometric analyses have important implications for current debates regarding the typological and chronological status of the Soanian techno-complex. The presence of Mode 3 Levallois

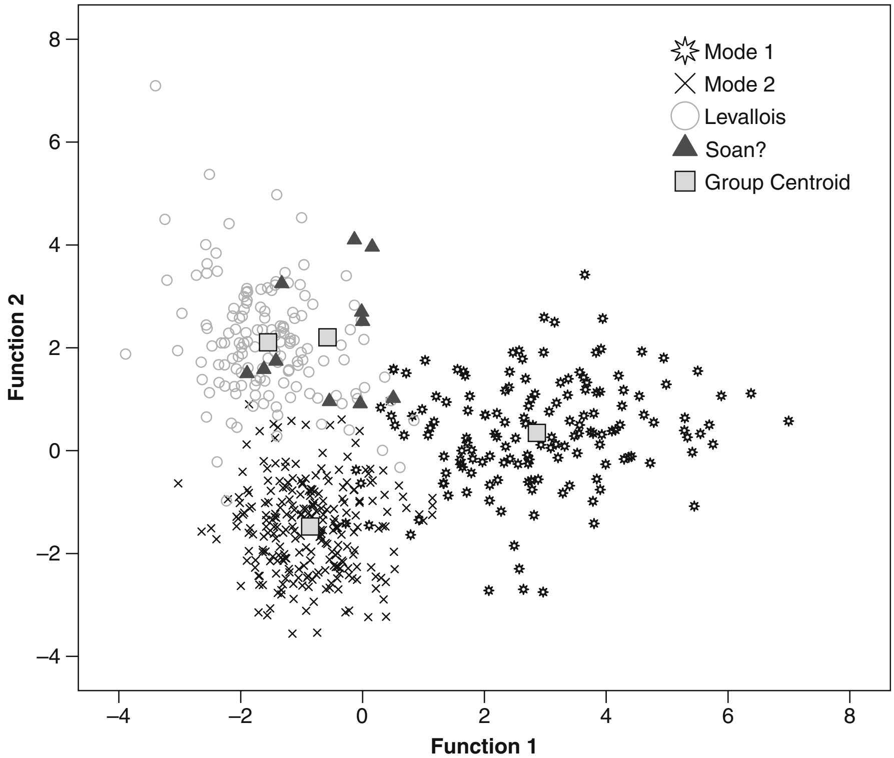

Fig. 2 DFA plot for $n = 564$ nuclei. Note that the centroid of the 'Soan ?' specimens is closest to that of the Levallois group, and that the variation of specimens within the 'Soan ?' group overlaps with that of the Levallois specimens. Function 1 accounts for 54.6% of variance and function 2 accounts for 37.95% of variance. The top six variables most highly correlated with the discriminant functions were 49, 52, 51, 53, 50, and 59 (see Table 2). Modified after Lycett (2007a)

industries has traditionally been seen as one of the diagnostic elements of the 'Middle Palaeolithic.' The finding that at least *some* sites within the Soan Valley contain a clear Mode 3 Levallois core component is consistent with the hypothesis that the Soanian techno-complex is either late Acheulean or post-Acheulean in terms of technology, and potentially Late Pleistocene in chronology (Chauhan 2003, 2007, 2008; Gaillard 2006; Gaillard and Mishra 2001). Indeed, Gaillard (2006) has recently suggested that the 'Soanian' may constitute two separate chronological and technological elements, comprised of distinct Lower and Middle Palaeolithic components. The clear recognition of both Mode 1 and Mode 3 technological components in the current analysis does not contradict such a hypothesis, but such assertions must await an increased chronological understanding of Palaeolithic assemblages in the Siwaliks. In any event, the firm identification of Levallois technology within the Soanian techno-complex renders scenarios suggesting that the Soanian is a precursor to the Acheulean in the Siwalik region, or simply part of a variable Mode 1–2 lithic facies, as problematic. Indeed, our understanding of hominin exploitation of the Siwalik frontal range must take greater account of this under-discussed Middle Palaeolithic element of their technological repertoire. It also suggests that using Soanian assemblages as an analogue for East Asian Mode 1 assemblages in order to understand factors that may potentially be mediating the so-called Movius Line, is inappropriate. Again, this analysis hints at the potential for morphometric analyses to provide new insights into old problems, and improve our understanding of artefact variability and assemblage composition.

Conclusions: Toward a Lithic 'Morphometric Comparative Anatomy'

We are potentially at a new, exciting frontier of analytical capability in lithic artefact research, one that was hinted at by David Clarke several decades ago (Clarke 1968), yet never fully realised at the time because of the very real difficulties of analysing large quantitative datasets in the absence of desktop computers. Quantitative analyses are now being used to assess the influence of raw material and reduction intensity upon Palaeolithic stone tool form (Ashton and White 2003; McPherron 2003; White 1998) and to test predictions regarding functional influences on artefact shape (Machin et al. 2007). In addition, technological lithic traditions are being analysed via novel theoretical and methodological perspectives (Bettinger and Eerkens 1999; O'Brien et al. 2001; Stout et al. 2000; Tostevin 2003; Wallace and Shea 2006; Buchanan and Collard 2007; Shott 2008). It may also now be important to compare the stone artefacts of extant primates to those of early hominins (Carvalho et al. 2008; Mercader et al. 2007; Panger et al. 2002; Schick et al. 1999; Visalberghi et al. 2007). Such new possibilities illustrate the urgency in developing more sophisticated approaches to the 'morphometric comparative anatomy' of lithic artefacts, in order to further our understanding of the many dynamics structuring Palaeolithic variability and technological change.

Several caveats are perhaps in order, lest the overriding aims of this paper be misunderstood. Morphometrics is no panacea, nor will it address all of the problems faced by lithic specialists. The traditional matters of dating, context, function, and related issues will of course remain as important as ever. It must also be emphasised that it would be naïve to suggest that the application of morphometric methods alone leads automatically to increased understanding; we must still rely on well-founded hypotheses to derive testable predictions, whether they be drawn from observation, experiment, ethnography, primatology, ethology, or social theory (Hill 1972). It should also be stressed that morphometric methods do not automatically replace, nor are they necessarily at odds with, traditional approaches to archaeological analysis involving the assessment of technological reduction sequences, *chaîne opératoire*, platform preparation, etc. Indeed, it is potentially in cases where various approaches may be combined, and the conclusions drawn from one approach tested against another, that the maximum effect of all these various methodologies is most greatly realised. The days of qualitative statements from authority, based upon vague notions that 'technology' is an empirical entity that can be adequately enunciated through an individual's own 'expert' intuition, should, however, clearly be numbered as we delve deeper into the possibilities afforded to 21st century Palaeolithic science. Several daunting challenges undoubtedly remain, not least of which is that morphometrics is not so much a 'technique,' as a complex field of study with its own complications, internal debates, and controversies; and archaeologists will find little in these methods that is simply 'plug-and-play.' Having taken up this challenge, however, we may perhaps (*sensu* D'Arcy Thompson) make analyses of Palaeolithic technological variability and change increasingly 'pregnant with meaning.'

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ESR Dating at Hominid and Archaeological Sites During the Pleistocene

Bonnie A.B. Blackwell, Anne R. Skinner, Joel I.B. Blickstein, L.V. Golovanova, V.B. Doronichev, M.R. Séronie-Vivien

Abstract In any fossil site, dating the site is essential to understanding the site's significance, because chronological data permits comparisons with materials from other sites, and ultimately enables regional settlement patterns, migration, or evolutionary rates to be determined. A dating method's ability to date significant fossil materials directly rather than just dating associated sedimentary or rock units adds to its archaeological and paleontological utility. Electron spin resonance (ESR) dating can provide chronometric ages for vertebrate teeth throughout the Pleistocene and late Pliocene. For mollusc shells and coral, ESR's effective dating range spans much of the Pleistocene.

As such, ESR has been used to assess the evolutionary ranges for both hominids and their associated cultural materials and to solve specific geochronological problems. We discuss several examples where ESR has been used to date Neanderthal burials and skeletal materials, including Mezmaiskaya, Obi-Rakhmat, and Pradayrol, as well as dating for cultural materials from pebble tool cultures, Mousterian, and Middle Paleolithic sites. In each case, ESR has provided vital geochronological data, in some cases, where no other methods were applicable.

Keywords Electron spin resonance (ESR) dating • Mousterian • Pebble tool cultures • Neanderthals • Pradayrol, France • Mezmaiskaya, Russia • Treugol'naya, Russia • Divje Babe I, Slovenia • Pleistocene paleoclimates

B.A.B. Blackwell (✉)
Department of Chemistry, Williams College, Williamstown, MA, USA

Introduction

In any archaeological or paleontological site, dating the site in order to enable comparisons with materials from other sites is key to understanding the site's significance. Without chronological data, determining regional settlement patterns, migration, or evolutionary rates becomes impossible. While many dating methods exist, all have advantages and disadvantages when applied to archaeological sites. Electron spin resonance (ESR) dating includes several methods which have applications particularly useful to the archaeologist and human paleontologist.

A dating method's ability to directly date materials with specific archaeological or paleontological significance make it much more useful than one that can only date associated sedimentary or other rock units (Blackwell and Schwarcz 1993b). $^{39}Ar/^{40}Ar$, for example, can only date associated volcaniclastic or volcanic units. Therefore, while its dates may have great precision and accuracy, its archaeological or paleontological significance depends critically on being able to definitively correlate the volcanic units to the units bearing the archaeologically or paleontologically significant materials. Thermoluminescence (TL) and optically stimulated luminescence (OSL) share a similar drawback, in that they only date sediment rich in quartz or feldspar. ESR, however, can date vertebrate teeth or mollusc shells that may have been the remains from an ancient hominid lunch. It can also date travertine and

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some calcrete deposits, allowing one to directly test for redeposition of associated fossils.

The time range over which a dating method can provide accurate and precise ages determines what archaeological and paleontological questions its analyses can address. ESR can provide ages for vertebrate teeth ranging from $\sim$ 5–10 ka to $\sim$ 2–4 Ma, with 2–8% precision. For mollusc shells and coral, ESR's effective dating range spans $\sim$ 1–2 ka to $\sim$ 1–2 Ma, with 4–10% precision. For speleothem, travertine, calcrete, and burnt flint, the time ranges tend to be shorter, but the uncertainties can approach 15–20%. In all cases, radiation dose rates in the materials and their associated sediment set the dating limits. Nonetheless, these long time ranges covering the Pleistocene and late Pliocene allow ESR to span the time gap that exists between the maximum limit for ^{14}C (40–50 ka) and the minimum limits for $^{39}Ar/^{40}Ar$ (50–200 ka), $^{238}U/^{206}Pb$ (1–2 Ma), and $^{232}Th/^{208}Pb$ (1–2 Ma) methods. Only TL, OSL, and some U-series methods effectively date materials from this gap.

Here, we illustrate how ESR dating can address specific research questions within archaeology and paleoanthropology. We will discuss how the method can date the occurrence of hominids and their artefacts from several different time periods in the Middle and Late Paleolithic. This is not intended to be a detailed discussion of ESR dating theory or methodology, which has been amply reviewed elsewhere recently (Blackwell, 2006), but rather to illustrate what ESR might do for the archaeologist or paleoanthropologist.

ESR Dating

ESR uses radiation-sensitive signals stored in mineral crystals to determine the age of the crystal. Ages are calculated by determining the accumulated (archaeological) radiation dose stored in the crystals and the radiation dose rates emanating from the dated material and its surrounding sediment. TL or γ dosimetry can measure the dose rates, as can standard geochemical analyses, such as neutron activation analyses. In archaeological settings, where the samples are usually discovered before dosimeters can be emplaced, sedimentary geochemical analyses are normally used to supplement, or replace, dosimetric analyses. Since most archaeological sites feature many thin geochemically distinct horizons replete with geochemically distinct lumps, such as fossils, tools, *éboulis*, and other rocks, volumetric averaging is usually necessary when using elemental analyses to ensure that contributions from all the sedimentary components have been included (Blackwell 2006; Blackwell and Blickstein 2001).

In hydroxyapatite, the mineral in tooth enamel, ESR dating uses the single-component signal at g = 2.0018, which has a mean signal lifetime of $\sim 10^{19}$ years (Skinner et al. 2000, 2001). Requiring as much as 100 hours/tooth, sample preparation is, nonetheless, relatively easy for most teeth from archaeological sites. Large teeth from cervids, equids, bovids, elephants, rhinoceri, and mammoths work best, but smaller teeth, such as those from hominids, ursids, canids, felids, and large rodents, can also be used. Species choices are not limited to placental mammals, as both diprotodontids and crocodylians have been successfully dated (Blackwell et al. 2004). For uraniferous teeth, the minimum ESR dating limit can be as low as 5–10 ka, while in sites with low radiation dose rates, the maximum limit can reach 2–4 Ma.

Many studies and correlation tests have shown ESR's reliability for teeth, particularly for sites less than 500 ka in age (see references in Blackwell 1995, 2001, 2006). Although enamel exhibits open system behaviour with respect to U uptake, coupled $^{230}Th/^{234}U$-ESR dating can provide a reliable age regardless of the U uptake model (e.g., Eggins et al. 2003). Isochron analyses can also confirm the U uptake model, if the external dose rate for the layers is known from other analyses. When the external dose rate from the isochron equals that for the standard geochemical or dosimetric analyses, the U uptake model used to derive that isochron then indicates the manner in which the teeth actually acquired their U (Blackwell and Schwarcz 1993a; Blackwell et al. 2001, 2002). For teeth beyond the limit for $^{230}Th/^{234}U$ dating, normally about 350–500 ka, the only way to confirm their U uptake model is using an isochron analysis. Most moderately sized and large ungulate teeth, if prepared properly, can yield an isochron.

In aragonite, the mineral in mollusc shells and corals, ESR dating often uses the signal at g = 2.0007, which remains stable for at least 10^6–10^8 years. In calcitic shells, the signal at g = 2.0053 is often used. Requiring as much as 10–20 hours/shell, sample preparation can be hampered by tufa coatings on freshwater species. Large marine species work best, but smaller species, such as *Melanoides*, can also be used if prepared in bulk (Blackwell et al. 2007b). While most applications have been in Quaternary marine studies, ESR on molluscs has been used in archaeological contexts (see references in Blackwell 1995, 2001, 2006). Molluscs exhibit only limited open system behaviour with respect to U uptake, which usually does not require coupled $^{230}Th/^{234}U$-ESR dating to assess the U uptake model. For shells, the minimum dating limit can be as low as 1–2 ka, while in sites with low radiation dose rates, the maximum limit can reach 1–2 Ma.

Most ESR dating applications within archaeology and human paleontology have used teeth. Since 1987, Grün, Schwarcz, and colleagues dated numerous hominid sites, including Skhul, Tabun, and Qafzeh, among others, to examine the migration from Africa to Eurasia by anatomically modern *Homo sapiens*. Attempts to date older Australopithecine sites, including Sterkfontein and Swartkrans, proved more challenging (e.g., Curnoe et al. 2001), but they still refined chronometric limits for these sites or defined those limits where none had existed before. ESR has been used to date several Neanderthal and Middle Pleistocene hominid sites, including Bilzingleben, La Ferrassie, La Chaise-de-Vouthon, and Atapuerca. Archaeological dating applications have ranged from Early Stone Age sites through early Upper Paleolithic sites (see references in Rink 1997; and Blackwell 1995, 2001, 2006). Here, we will illustrate several examples where ESR dating with tooth enamel or molluscs has provided reliable dates to solve significant research questions at sites ranging from 35 to 500 ka in age, often in sites where other methods were not applicable.

Pradayrol, France

At Pradayrol, Lot, in southwestern France, a partial permanent hominid incisor (Fig. 1) was found associated with an extinct Middle Pleistocene fauna and Paleolithic tools (Fig. 2) in 1998. Ongoing excavations have revealed four stratigraphic units, of which only the top two have been studied extensively (Fig. 3). Found beneath a layer with intrusive Holocene elements, including reindeer, badger, and sheep bones, Layer 2 contained a brown clay-rich sandy matrix with large pieces of *éboulis* and rounded aggregates containing bone fragments, quartzite flakes, calcite and phosphate crystals, coated by calcite cement (Séronie-Vivien and Tillier 2002). When occupied by hominids, Pradayrol was surrounded by steppe grassland with a warm, Mediterranean climate. Pradayrol's fauna included many diagnostic extinct Middle Pleistocene animals (Table 1), that occupied Europe from $\sim$ 150 to 400 ka.

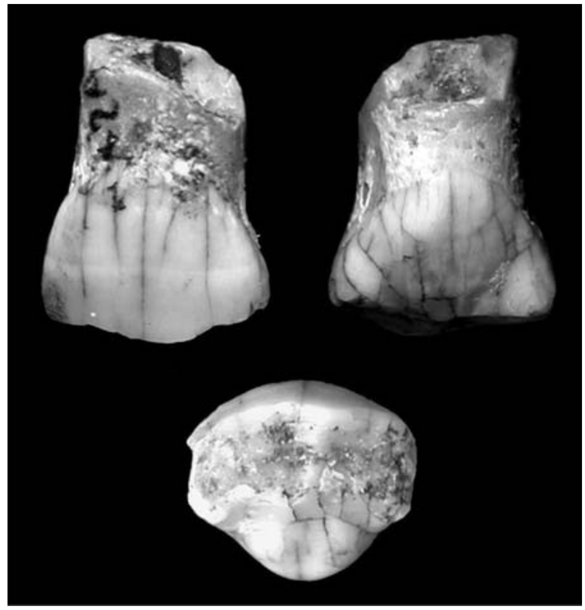

Fig. 1 The hominid incisor from Pradayrol, France. An upper right permanent incisor from an adult hominid found in Layer 2 at Pradayrol. This tooth is comparable to *Homo neanderthalensis* incisors from La Chaise-de-Vouthon (after Séronie-Vivien and Tillier 2002)

Layer 2A yielded an upper right permanent incisor from an adult hominid. The tooth is comparable in size and features with the *Homo neanderthalensis* teeth from La Chaise-de-Vouthon. Pradayrol has also yielded more than 1000 lithic artefacts (Fig. 2), of which 87% were made on quartzite, 12% on flint, and 1% on other rocks. Among the uartzite artefacts, 61% are < 2 cm in size, suggesting that these are flaking débitage from tool production. The flint tools are well patinated and

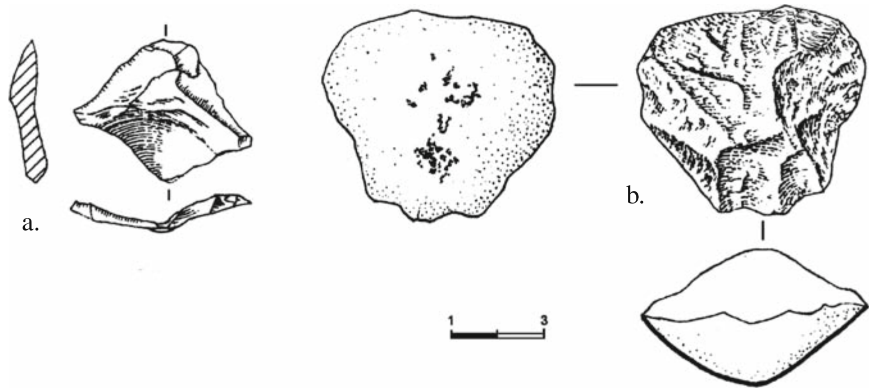

Fig. 2 Paleolithic artefacts from Pradayrol, France. Paleolithic tools were found in the same layer as the hominid tooth: a. a flint flake made on discoidal débitage. b. a metaquartzite core with discoidal and unifacial flaking

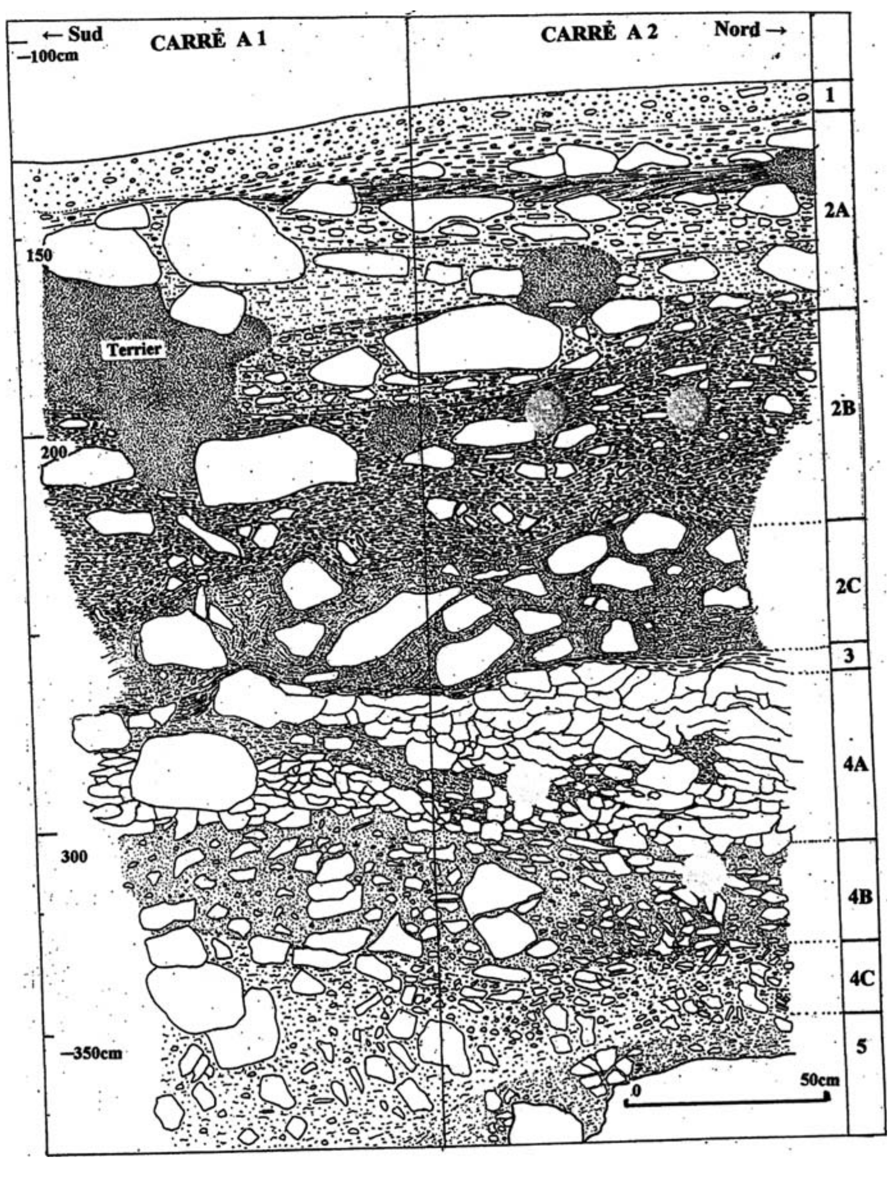

Fig. 3 The stratigraphy at Pradayrol, France. At least five stratigraphic layers have been identified in the cave. The hominid tooth was found in Layer 2A along with Paleolithic tools

Table 1 Extinct mammalian species from Pradayrol, France

Species	Common name	Appearances in Europe First (ka)	Last (ka)	Typical habit
Canis etruscus	Etruscan dog		~ 350	Woodland
Equus mosbachensis	horse from Mosbach		~ 200	steppe grassland
Equus hydruntinus	ass	~ 350	150	steppe grassland
Dicerorhinus mercki	Merck's rhinoceros	~ 450	150	steppe grassland
Ursus deningeri	European cave bear		250	alpine or forest caves
Lagarus lagarus	rabbit	300	150	steppe or open parkland
Hysterix cristata	porcupine	~ 450	190	warm steppe

(data from Séronie-Vivien and Tillier 2002)

impossible to source, but most resemble local Cenozoic or Upper Cretaceous flint. Among the 50 flint tools, only four exceeded 5 cm in length, suggesting that their makers needed to conserve their resources. Sidescrapers, denticulates, notches, and retouched flakes dominated the assemblage, but endscrapers and awls also occurred. This tool kit resembles that from La Borde in Quercy (Séronie-Vivien and Tillier 2002).

Although $^{230}Th/^{234}U$ dating was attempted for the stalagmitic deposits to determine ages for site formation, the calcite was too altered to give reliable results (Séronie-Vivien and Tillier 2002). Therefore, ESR was used to date four bovid teeth associated with the hominid incisor and tools (Table 2). Twenty bulk sediment samples associated with the teeth and one limestone sample were analyzed to determine the external dose rates (see Blackwell and Blickstein 2000). In all the teeth, the U concentrations in the enamel were very low, averaging < 0.6 ppm U. In the dentine, the U concentrations ranged from 13.81 ± 0.51 to 16.47 ± 1.48 ppm. Since all four teeth gave accumulated doses and ages which do not differ from each other statistically, the teeth appear to have been contemporaneous, with none of them reworked (cf. Blackwell 1994). Thus, the mean age for the four teeth most likely reflects the age for the hominid tooth found in the same layer. Therefore, the minimum possible age for the Layer 2A and the hominid tooth, assuming early U uptake (EU), is 236 ± 3 ka, while the maximum possible age, assuming recent U uptake (RU), is 467 ± 10 ka. The more likely age, assuming linear U uptake (LU), is 330 ± 5 ka, which correlates with the earliest phases of Oxygen Isotope Stage (OIS) 9.

Although $^{230}Th/^{234}U$-ESR analyses still must be completed to confirm the uptake model, the fact that the teeth are close to the limits for $^{230}Th/^{234}U$ analyses may preclude coupled ages. For many samples from cave sites in this time range, LU ages have proven the most accurate (Blackwell et al. 2001, 2002). The external dose rate estimated from the LU isochron agreed well with the dose rate determined for the sediment directly. This suggests that the tooth experienced LU uptake, with some minor late U uptake (Fig. 4), and thus, that the LU model is the most accurate for this tooth. Therefore, the layer and the tooth date to 330 ± 5 ka. If the fossilized tooth is that of *Homo neanderthalensis*, these ages suggest that the specimen is among the oldest of this species.

Mezmaiskaya, Russia

Two other Neanderthal burials come from Mezmaiskaya Cave in Russia. DNA from the more complete burial has been analyzed (Ovchinnikov et al. 2000), but two ^{14}C dates for the layer differed dramatically and did not agree well with the stratigraphy in the cave (Skinner et al. 2005, Table 1). For samples from many sites within the time range from 30 to 45 ka, however, many ^{14}C ages do not agree well with ages from other methods or with the known site stratigraphy (Conard and Bolus 2003).

Mezmaiskaya cave sits in the northern Caucasus Mt. of southern Russia. Seventeen Pleistocene stratigraphic layers contain sand- and clay-rich silts with *éboulis* and stalactites (Fig. 5). The cave yielded fossils from salmonids, amphibians, rock lizards, other reptiles, birds, and many rodents. *Ursus*

Table 2 ESR ages for Layer 2A, Pradayrol, France

Sample (subsam.)	Species layer		Mean U concentrations Enamel (ppm)	Dentine (ppm)	External dose Rate, $D_{ext}(t)^b$ (μGy/y)	Accumulated Dose, $\mathscr{A}_\Sigma$ (Gray)	Standard mean ESR ages[a] EU (ka)	LU (ka)	RU[c] (ka)
FT18	*Bos* sp.		0.34	15.71	754.0	409.0	244.7	344.0	493.5
(6)	2A	±	0.10	0.86	68.1	3.6	5.7	9.1	17.5
FT32	Cervid or bovid		0.38	15.25	795.4	385.1	233.7	314.5	439.9
(6)	2A	±	0.15	0.76	72.7	4.0	5.4	9.0	15.8
FT24	Bovid		0.56	16.47	847.6	447.7	222.9	318.0	469.1
(2)	2A	±	0.02	1.48	60.0	13.6	11.2	17.7	31.3
FT19	*Cervus elaphus*		0.37	13.81	783.4	394.5	243.4	334.2	464.6
(5)	2A	±	0.09	0.51	73.9	6.9	7.3	11.5	19.8
Mean	Layer 2A						235.8	330.2	466.6
(19)		±					3.3	5.4	9.6
							1.41%	1.62%	2.06%

[a] Abbreviations: EU = assuming early U uptake; LU = assuming linear (continuous) U uptake; RU = assuming recent U uptake

Calculated using
- α efficiency factor, k_α = 0.15 ± 0.02
- initial U activity ratio, $(^{234}U/^{238}U)_0$ = 1.20 ± 0.20
- enamel water concentration, W_{en} = 2. ± 2. wt%
- dentine water concentration, W_{den} = 5. ± 2. wt%
- enamel density, ρ_{en} = 2.95 ± 0.02 g/cm³
- dentine density, ρ_{den} = 2.85 ± 0.02 g/cm³
- radon loss from the tooth, Rn_{tooth} = 0. ± 0. vol%

[b] Calculated using sedimentary water concentration, W_{sed} = 20. ± 5. wt%
- sediment density, ρ_{sed} = 2.65 ± 0.02 g/cm³
- cosmic dose rate, $D_{cos}(t)$ = 0.000 ± 0.000 mGy/y

[c] Calculated using the U uptake parameter, p = 10.

spelaeus, *Cervus elaphus*, bovids, caprids, and the other mammals found typify the Late Pleistocene fauna found regionally. Most of the ungulate remains represent human kills of prime adults (Baryshnikov et al. 1996).

Layers 1–3 and 1–4 were deposited under relatively warm climate in the terminal Upper Pleistocene and produced Epipaleolithic industries. While Layers 1A–1C contained early Upper Paleolithic bladelet industries, their fauna and pollen suggest an extremely cold climate that the climate changed from extremely cold and dry to somewhat warmer and drier. In Layers 2–2A, the fauna and pollen indicate a climate cooler than today, while Layers 2B1–3 appear somewhat milder than those above. Layers 2–3 have yielded Middle Paleolithic bone and lithic artefacts with high sidescraper and bone tool, but variable bifacial tool, percentages, which have been defined as Eastern Micoquian (Fig. 6; Golovanova and Doronichev 2003). Although archaeologically sterile, Layers 4–7 were deposited under a colder climate than Layers 2–3.

A neonate infant Neanderthal skeleton was found in a flexed anatomical position in Layer 3, but without a visible pit or grave goods. If it had not been buried, however, its bones would have been broken and scattered, as the other bones in the site all were. The other infant was aged 1–2 years at death. Its skull had been broken into 24 fragments and deposited in a pit, which originated in Layer 2, but penetrated into 2B2 (Golovanova et al. 1999).

The fourteen teeth dated from Layers 2 to 3 (Fig. 7) yielded stratigraphically consistent ages (Skinner et al. 2005). Because U concentrations in the enamel averaged < 0.1 ppm, and those in the

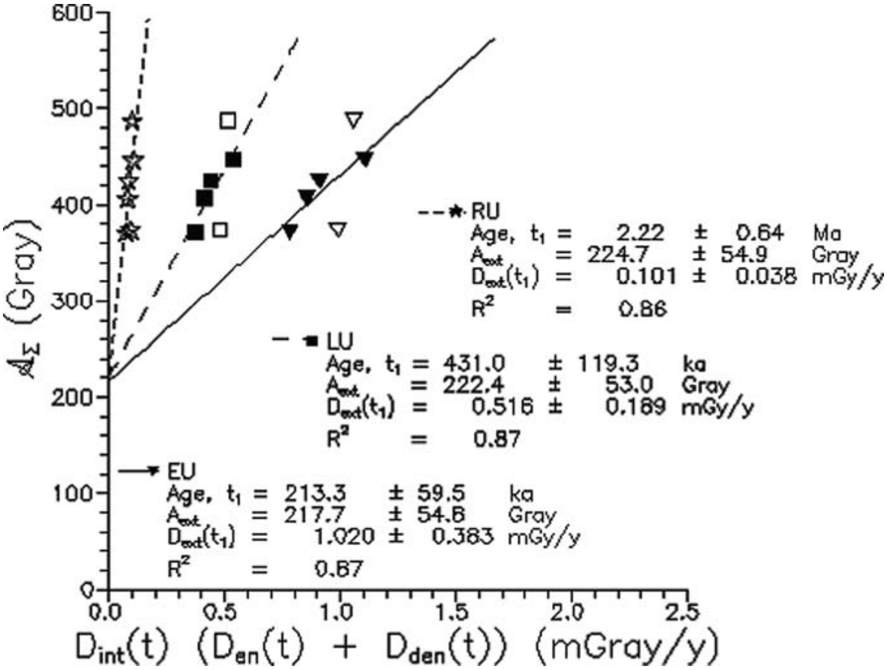

Fig. 4 The isochron analysis for FT18, Layer 2A, Pradayrol, France. Using the four subsamples which have not been affected by U remobilization (solid symbols), the model isochrons converge well at an external dose, $\mathscr{A}_{\text{ext}} = 220 \pm 50$ Gy. The LU isochron yields an age of 431 ± 119 ka, with an associated time-averaged external dose rate, $\overline{D}_{\text{ext}}(t)$, of 0.516 ± 0.189 mGy/y. These do not differ significantly from the standard ESR age and the modern external dose rate determined for Layer 2A. This indicates that RT18 experienced very minor U remobilization late in its history, and that the LU ages are probably the more reliable of the model ages

dentine averaged < 2 ppm, their ages do not depend on the U uptake model, and coupled ^{230}Th/^{234}U-ESR ages will not yield more information. All the ESR ages exceeded the reported ^{14}C dates, most notably those for Layer 3, suggesting that the ^{14}C dates are inaccurate due to contamination, or that they actually exceed the ^{14}C limit. Layers 2–2B1, with average ESR ages between 38–41 ± 1–3 ka, correlated with OIS 3, while Layers 2B3 to 3, with ages at 57 ± 4 ka to 68 ± 5 ka, correlated with OIS 4. Since the pit containing the smashed infant skull was dug from Layer 2 into Layer 2B2, its age is probably 40 ka. Although establishing the neonatal skeleton's age is more difficult due to the erosion of most overlying layers, the ages for both Layers 2B4 and 3 set some constraints. An age of 65–70 ka for Layer 3 would correlate with early OIS 4, when climates were fluctuating rapidly between very cold and very warm conditions.

Treugol'naya, Russia

Also in the northern Caucasus, Treugol'naya Cave hosts a Lower Paleolithic site with the earliest evidence for human occupation in eastern Europe (Doronichev et al. 2004). With no significant stalagmitic deposits and Middle Pleistocene fauna, only ESR dating could reliably date the archaeological deposits. Layers 4–8 contain several very inhomogeneous, silty to sandy, matrix-supported conglomerates. Layers 4–5 and 7 also contain numerous fragmentary bones, isolated teeth, and artefacts, but Layers 6 and 8 are fluvial deposits without artefacts. Two large erosional lenses and several depositional hiati also occur within the sequence (Figs. 8, 9; Doronichev et al. 2004).

Layers 4–7 contained characteristic Middle Pleistocene species, including *Canis mosbachensis*, *Ursus deningeri*, *Equus altidens*, and *Stephanorhinus*

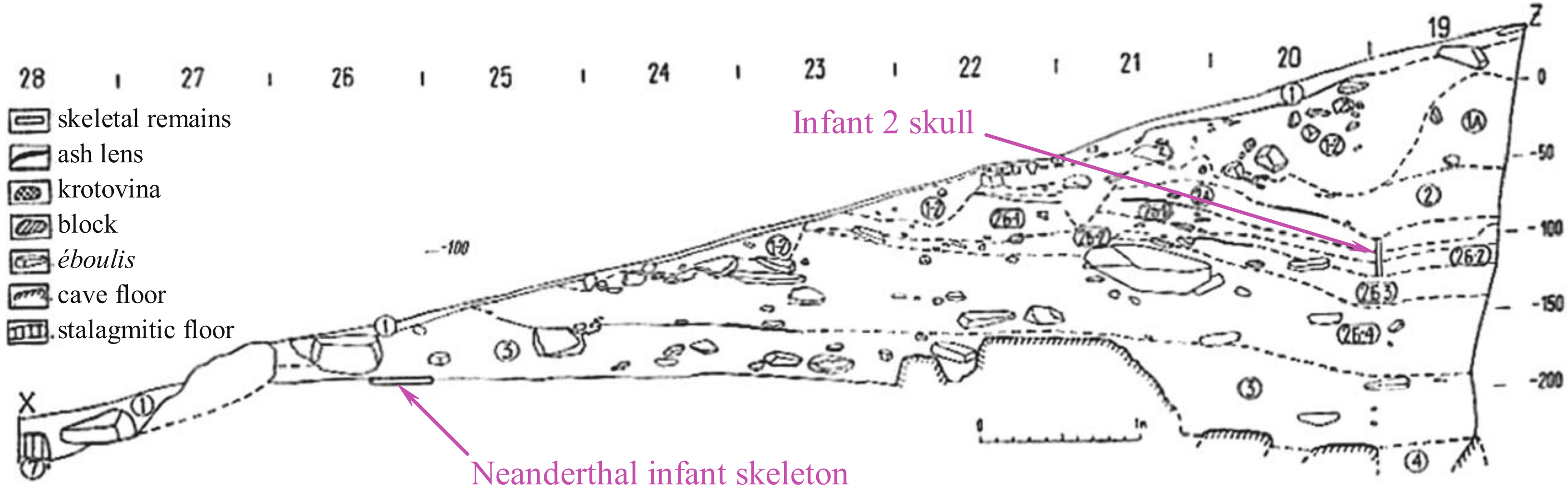

Fig. 5 **The stratigraphy at Mezmaiskaya Cave, Russia.** The stratigraphy shows 14 layers with archaeological materials. The neonatal skeleton was found in Layer 3 just inside the current edge of the overhanging roof, while the infant skull occurred at the bottom of a burial dug from Layer 2 (after Golovanova et al. 1999)

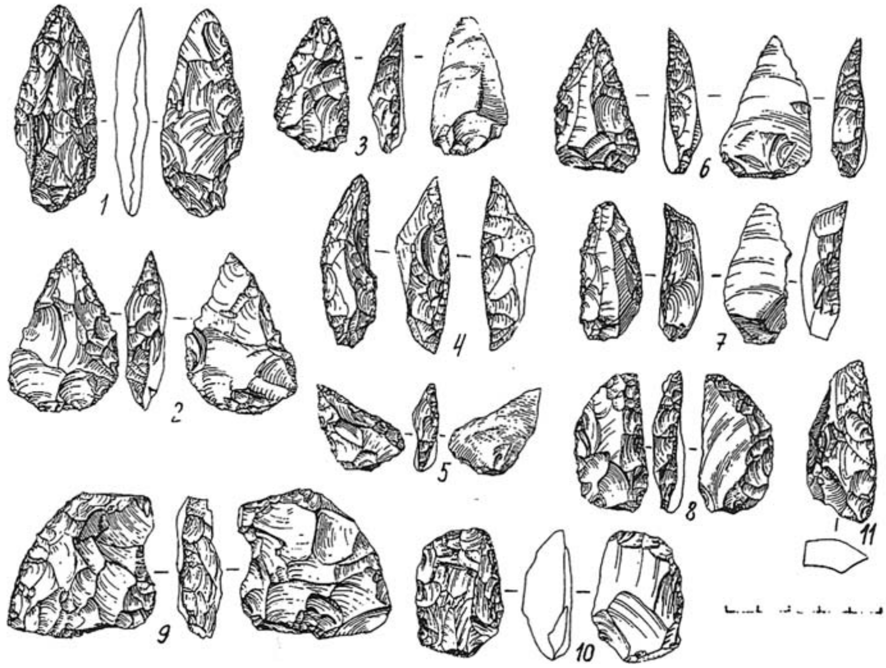

Fig. 6 Mousterian artefacts from Mezmaiskaya Cave, Russia. Endscrapers and sidescrapers from Layers 2b through 3

hundshemensis, plus several ungulate, rodent, and 22 bird species (Fig. 8; Baryshnikov and Potapova 1995). Palynological, faunal, and sedimentological analyses showed significant climatic variability, ranging from periods with well developed forest biomes dominated by trees to grassland communities to those with minimal pollen production. In Layer 5Б, the abundant, diverse, exotic arboreal

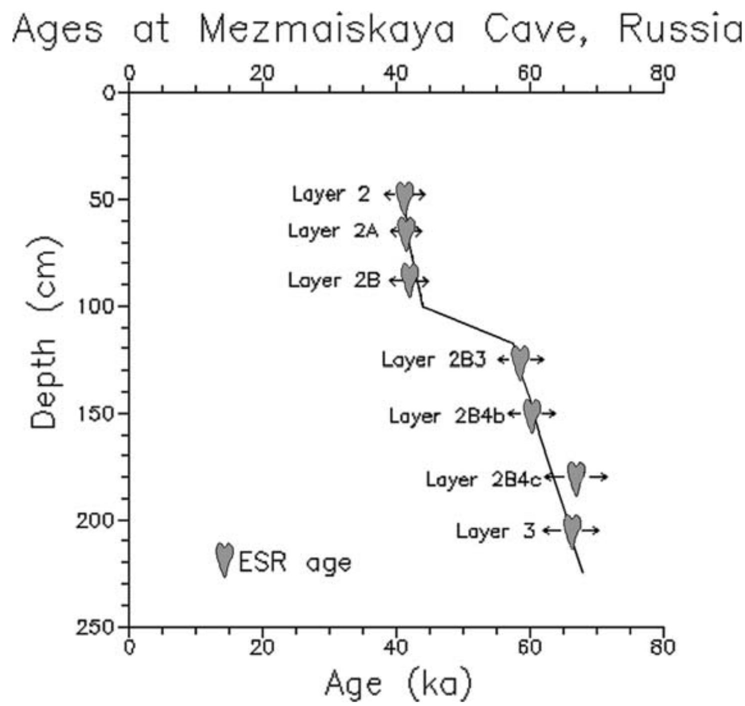

Fig. 7 The ESR ages at Mezmaiskaya Cave, Russia. Seven layers have been dated by ESR. The arrows indicate the 1 σ errors for each layer. Ages for Layers 2 to 2B averaged 38–40 ± 1–3 ka, suggesting rapid sedimentation. Layers 2B(3) to 3 range from 57 ± 4 to 68 ± 5 ka

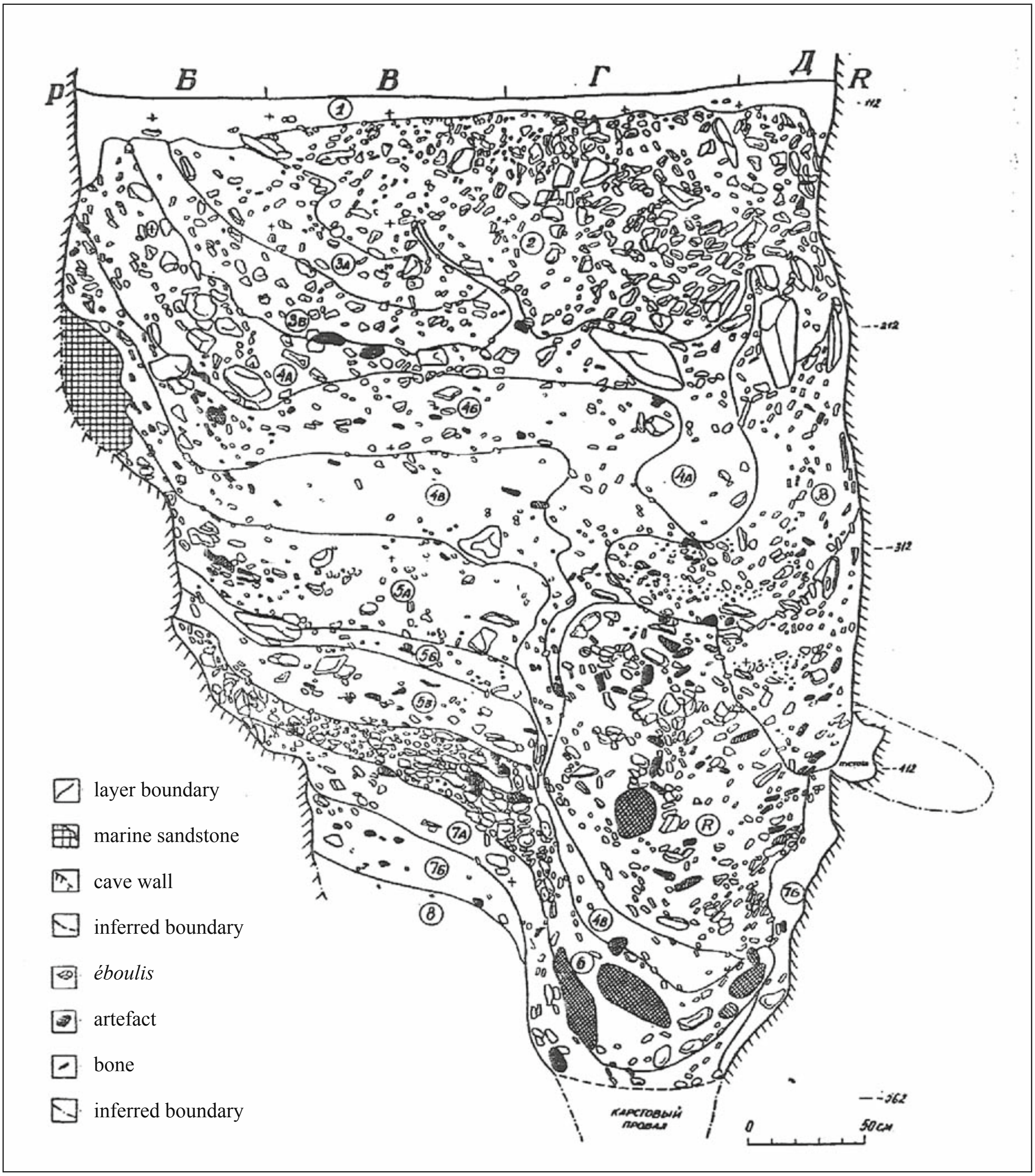

Fig. 8 Profile PR showing the stratigraphic units at Treugol'naya, Russia. Eight distinct lithological units fill approximately 4.0–4.5 m in the cave. Each layer contains a matrix-supported conglomerate with bones, teeth, artefacts, limestone *éboulis* fallen from the roof, and marine sandstone from the wall coating in a matrix of fine sand-, silt-, and clay-sized limestone and marine sandstone grains. The Lower Paleolithic archaeological deposits occur in Layers 4A to 4Г, 5A, 5B, and 7A (from Doronichev 1996)

Treugol'naya Cave								
Layer	Archaeological industry	Flora	Fauna	Climate	Mean ESR Dates (ka)	Magnetic subzones	Correlation with OIS Curve	OIS Stage Ages
(erosional phase)								
4A	"Pre-Mousterian" flake-tool industry	Wooded steppe	Singilian (Urupsky) Faunal Complex:	moderate, dry		I	Stage 10 ?	334-364
4Б		Subalpine meadows	*Canis mosbachensis, Vulpes vulpes,*	cool, dry	364 ± 11 enamel (LU)	IIa	Stage 11 probably Stage 11.1a	364 - 427
R & β	(erosional phase)		*Ursus deningeri,*	(erosional phase)				
4B	"Pre-Mousterian" flake-tool industry	Low altitude deciduous woods	*Capreolus sussenbornensis, Cervus elaphus acoronatus,*	warm, humid	376 ± 9 enamel (LU)		probably Stage 11.1b	364 - 427
		Subalpine meadows	*Bison priscus-schoetensacki, Capra ex gr. caucasica*	cold, dry (stadial extremum)		IIb (or IIc)		
4Г	Core-chopper industry						probably Stage 11.2	
5A	"Pre-Mousterian" flake-tool industry	Subalpine meadows	Late Tiraspolian Faunal Complex:	cold, dry (stadial extremum)	418 ± 10 enamel (LU)	IIc		
			Canis mosbachensis,	cool, humid		IIIa		
5Б		Wooded steppe	*Ursus deningeri, Mustella nivalis*	very warm, humid (interglacial optimum)	393 ± 27 molluscs 406 ± 15 enamel (LU)	IIIb	probably Stage 11.3	
5B	"Pre-Mousterian" flake-tool industry	Subalpine meadows	*Equus altidens Stephanorhinus hundsheimensis,*	cold, dry (stadial extremum)		IIIc	Stage 12 ?	427 - 474
			Capreolus sussenbornensis,	cool, humid		IIId		
(erosional phase)			*Cervus elaphus acoronatus,*	(erosional phase)				
6		Dry subtropical woods	*Bison priscus-schoetensacki, Capra ex gr. caucasica*	warm, dry (subtropical)	504 ± 24 enamel (LU)		Stage 13	474 - 528
(erosional phase)								
7A	"Pre-Mousterian" flake-tool industry	High alpine woods & sub-alpine meadows		cool, humid	583 ± 25 molluscs	IVa	Stage 15	568 - 621
7Б		Wooded steppe		warm, dry		IVb		
						IVc	Stage 16 ?	621-659
(erosional phase)								
8								

Lower Paleolithic occupations
Erosional phases
(adapted from Blackwell *et al*., 2005)

Fig. 9 **The time-stratigraphic interpretations for Treugol'naya, Russia.** Four archaeological assemblages occur within the strata in the cave. Six associated layers have been dated by ESR either using cervid enamel or terrestrial molluscs. From the palynology, vertebrate paleontology, and dating, Layers 4Б to 5Б all appeared to correlate best with OIS 11, while Layers 6 and 7A correlated with OIS 13 and 15 (after Blackwell et al. 2005) species indicated full interglacial conditions (Doronichev et al. 2004).

Hominids occupied Treugol'naya Cave sporadically, but repeatedly, throughout the Middle Pleistocene. Four Lower Paleolithic assemblages, which lack typical Acheulean bifaces, have been recognized in the lower deposits. In Layers 4a–4b, the tools were made mainly from a non-local grey flint. Several bones exhibit conchoidal fractures, likely from hammerstone percussion, while some cervid bones were apparently used as tools (Hoffecker et al. 2003).

ESR was used to date nine cervid teeth from Layers 4 and 5 at Treugol'naya Cave (Fig. 10). More than 110 sediment samples from fresh excavations were analyzed to assess the external dose rates. While the enamel U concentrations in all the teeth were low, averaging $\leq$ 0.20 ppm, dentinal U concentrations ranged from 10.2 ± 1.1 to 23.6 ± 0.5 ppm. Since the U concentrations had not equilibrated across the teeth, isochron analyses were possible for two teeth (Figs. 11, 12), which showed that neither U leaching from the enamel nor recent secondary uptake in the dentine had occurred for these teeth.

For Layer 4Б, the three teeth gave a mean age of 366 ± 12 ka, assuming LU. Coupled ESR-^{230}Th/^{234}U ages indicate uptake parameters of p = 0.56 ± 0.16 for teeth from Layer 4Б. These yield a mean age of 302 ± 28 ka, but the somewhat younger age for RT78 suggests that the top of the bed may represent a palimpsest deposit or that RT78 may have been reworked from a higher layer associated with erosional lens R (Fig. 8).

For the lower layers, the teeth all exceeded the ^{230}Th/^{234}U dating limit, making coupled ESR-^{230}Th/^{234}U ages impossible. Given that teeth tend to follow uptake models that tend more toward LU and RU with time, however, that the uptake parameter followed by the lower teeth should be less than 0.50 remains highly unlikely.

In Layer 4B, the four teeth averaged 375 ± 9 ka assuming LU. Although the RT82 isochron had a low regression coefficient, and large associated uncertainties (Fig. 11), it shows good convergence and a time-averaged external dose rate of 0.290 ± 0.104 mGy/y, which agreed with the value determined for Layer 4Б from volumetrically averaged bulk geochemical analysis, 0.396 ± 0.063 mGy/y. This agreement indicates that the correct uptake model for RT82 is an LU model, while the positive

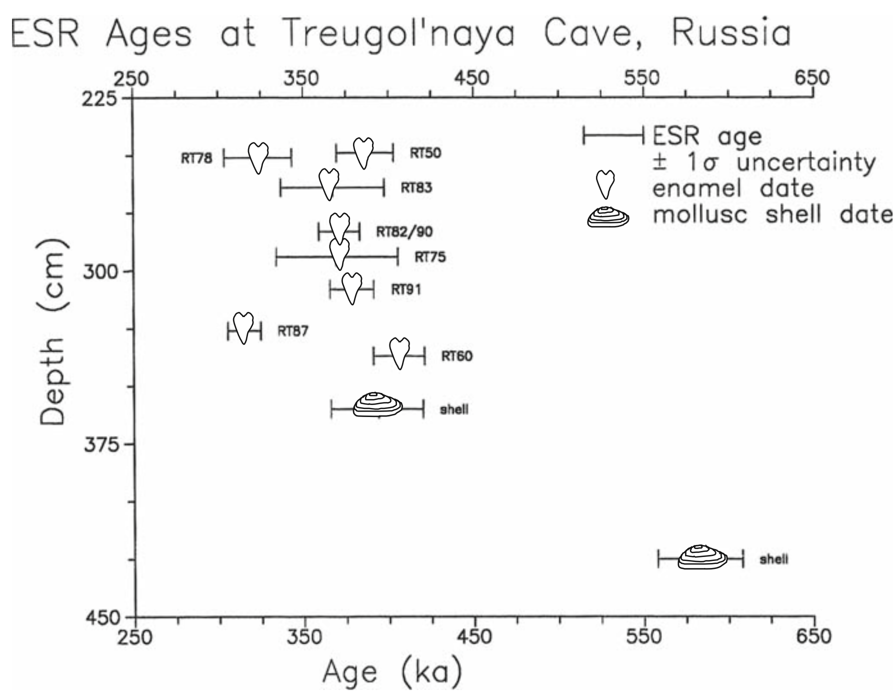

Fig. 10 The ESR ages at Treugol'naya, Russia. Terrestrial molluscs gave ESR ages of 393 ± 27 ka for Layer 5Б, and 583 ± 25 ka for Layer 7A below (Molod'kov 2001). Except for the two teeth which may have been reworked, all the LU ages for the teeth from Layers 4Б to 5Б range from 360 ± 25 ka to 406 ± 15 ka, which falls within the age range for OIS 11

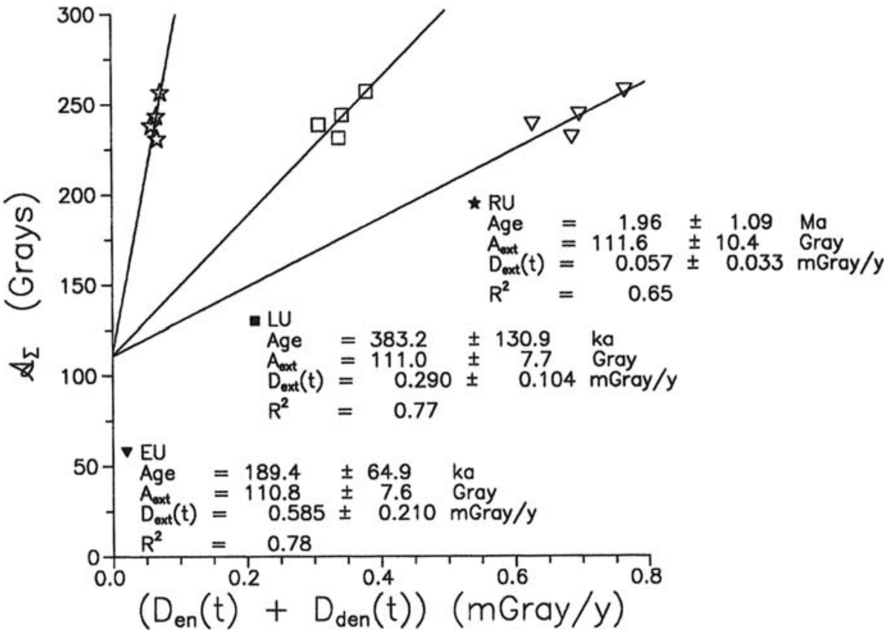

Fig. 11 **The isochron analysis for RT82, Layer 4B, Treugol'naya, Russia.** Despite having large associated uncertainties, the model isochrons converge well at an external dose, $\mathscr{A}_{ext} = 110 \pm 10$ Gy. The LU isochron yields an age of 383 ± 131 ka, with an associated time-averaged external dose rate of 0.290 ± 0.104 mGy/y. These are identical to the standard ESR age and the modern external dose rate determined for Layer 4B. This isochron indicates that RT82 has not experienced any significant U leaching or secondary uptake, and that the LU ages are the most reliable

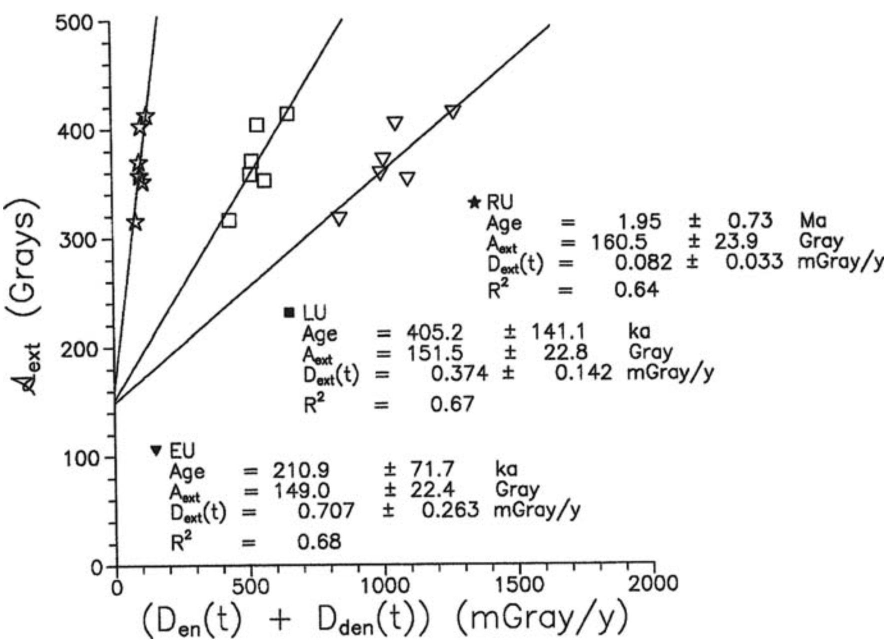

Fig. 12 **The isochron analysis for RT60, Layer 5Б, Treugol'naya, Russia.** For RT60, the isochron converges well at an external dose of $\mathscr{A}_{ext} = 150 \pm 23$ Grays. The LU age of 405 ± 141 ka and its associated time-averaged external dose rate of 0.374 ± 0.142 mGy/y do not differ significantly from the standard LU age and the modern external dose rate determined for Layer 5Б. This isochron indicates that RT60 has not suffered any significant U leaching or secondary uptake in the dentine, suggesting that the calculated LU age is the most reliable

slope and intercept for the isochron suggest that RT82 has not suffered any significant U leaching or secondary uptake (Blackwell et al. 2001, 2002).

In Layer 5Б, RT87, at 315 ± 10 ka, may have been reworked by erosion associated with the adjacent Lens R (Fig. 8). RT60's isochron also showed good agreement between the LU isochron and standard ages as well as between the time-averaged external dose rate from the isochron and that from the volumetrically averaged external dose rates (Fig. 12). This isochron shows that RT60 has not suffered any significant U leaching or secondary uptake (Blackwell et al. 2001a, 2001b), and that the LU model is the correct model for the standard age calculation. The mean LU age for Layer 5Б, 406 ± 15 ka, also agrees well with the terrestrial mollusc ESR ages (see details in Molod'kov 2001) of 393 ± 27 ka for Layer 5Б, and 583 ± 25 ka for Layer 7A below.

Except for the two teeth which may have been reworked, all the LU ages for the teeth and the molluscs dated from Layers 4Б to 5B fall within the age range for OIS 11. Although these layers, along with their Early Paleolithic artefacts, were deposited under relatively warm conditions, those conditions still varied significantly (Fig. 9). The thickness of Layers 4–5 (up to 2 m) makes this one of the thickest OIS 11 terrestrial deposits known, which will allow us to better understand the climatic changes that affected the northern Caucasus during OIS 11.

Obi-Rakhmat, Uzbekistan

At Obi-Rakhmat, attempts to date the site with ^{14}C and $^{230}Th/^{234}U$ gave stratigraphically inconsistent results (Fig. 13). While the ^{14}C ages for a single layer ranged from 12 to 45 ky BP, the $^{230}Th/^{234}U$ ages did not change significantly with depth, suggesting that they dated a single karstic depositional event unrelated to the occupation. These samples were all collected from the surface of a large stalagmitic deposit near the wall, and actually sample the dripstone layer draping the surface. Consequently, several teeth were dated by ESR.

Obi-Rakhmat contains 22 geological layers, mainly comprising sandy silt cemented by carbonate (Fig. 14). Layers 11–15 contain high concentrations of limestone *éboulis*, some up to 40 cm in diameter, hinting at cold climates. Below Layer 16, *éboulis* are less common, suggesting that the climate then may have been warmer than that during Layers 11–15 (Krivoshapkin and Brantingham 2004).

Obi-Rakhmat has yielded > 40,000 Paleolithic artefacts and > 3,000 animal bones. The lithic industries display a mixture of Middle and Upper Paleolithic traits, including many blades (Derevianko et al. 2001). Animal taxa typified those found in both mountain forest and steppe zones (Wrinn et al. 2004), while pollen analyses indicated that a dry shrub-forb steppe dominated the late Pleistocene landscape (Kul'kova 2004). Layer 16 yielded six hominid teeth and many hominid cranial fragments (Glantz et al. 2004).

Bovid teeth from four layers (Fig. 13) at Obi-Rakhmat were dated by standard ESR (Blackwell et al. 2007a). Enamel U concentrations ranged from 0.9 to 4.0 ppm, while dentinal U ranged from 118 to 155 ppm. The high dentinal U concentrations suggest saline to hypersaline groundwater in the cave, indicating a dry climate outside. The high U concentrations represent the teeth's single largest

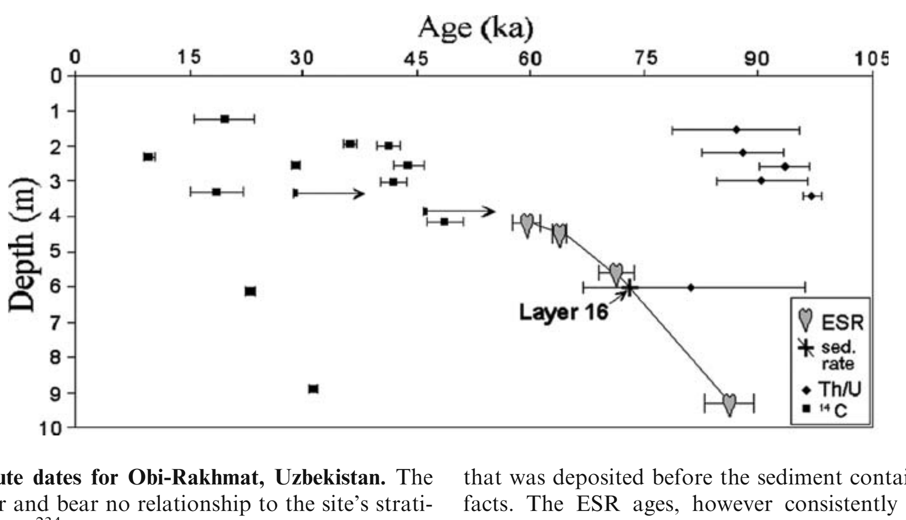

Fig. 13 Absolute dates for Obi-Rakhmat, Uzbekistan. The ^{14}C ages scatter and bear no relationship to the site's stratigraphy. The $^{230}Th/^{234}U$ ages hardly vary with depth, suggesting that they date a stalagmitic flowstone draping the wall that was deposited before the sediment containing the artefacts. The ESR ages, however consistently increase with depth. Using the mean sedimentation rate, Layer 16 dates to ~ 74 ka (after Blackwell et al. 2007)

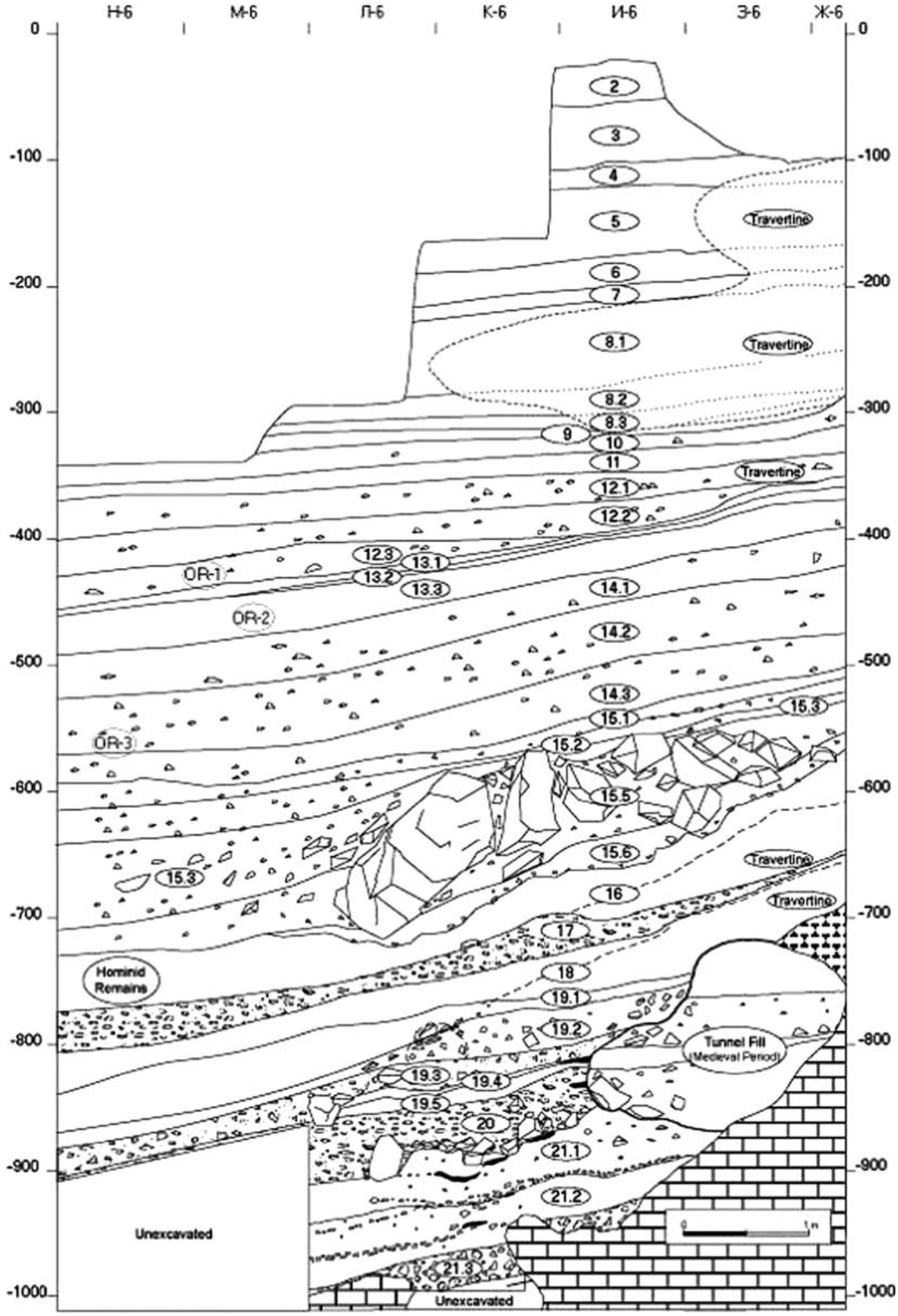

Fig. 14 The stratigraphy on the excavation's west wall at Obi-Rakhmat, Uzbekistan. Several layers, especially the lower layers, contain large amounts of *éboulis*. Layer 15 hosts a large roof collapse

radiation source, reducing the dependency of the ages on the sedimentary dose rates.

For the four layers dated, the ESR ages increase consistently with depth, which did not occur for either the ^{14}C and $^{230}Th/^{234}U$ ages (Fig. 13). From Layer 12.1, FT41 gave a mean LU age 56.9 ± 2.4 ka. For Layer 13, 11 subsamples from three teeth averaged 65.5 ± 1.5 ka. From Layer 14.3, FT26 yielded a mean age of 65.6 ± 1.6 ka. In Layer 21.2, six subsamples from three teeth averaged 87.1 ± 3.9 ka (LU). In both Layers 13 and 21.2, all the ages showed no significant differences, suggesting that none have been reworked. For both Layers 12.1 and 14.3, however, at least two more teeth need to be dated to ensure reworking has not affected these layers (Blackwell 1994). The ESR ages are all slightly younger than the $^{230}Th/^{234}U$ ages for the stalagmite, ranging from 87 to 97 ka, as would be expected, given that the $^{230}Th/^{234}U$ ages date the dripstone draping the stalagmite that was deposited before the archaeological occupation.

The high U concentrations mean that the U uptake model significantly affects the calculated ESR ages. For FT25, the LU isochron suggests that the modern external dose rate, 588 ± 204 μGy/y, measured from the sediment geochemistry, agrees with the time-averaged dose rate, 983 ± 583 μGy/y, from the LU isochron (Fig. 15), better than those from the other isochrons. Therefore, an LU model ($p = 0$) probably represents the initial U uptake event well. The six points are scattered somewhat around the isochron, suggesting that some minor, very recent U remobilization has affected this tooth (cf. Blackwell et al. 2002). Since any secondary U remobilization for these teeth occurred within the last few thousand years, it does not introduce any significant uncertainty into the standard ESR ages. For FT33, a coupled ESR-$^{230}Th/^{234}U$ age of 69 ± 5 ka indicates that the U uptake has followed a model with $p = 1.4$. Since the coupled age does not different significantly from the LU age, 63.0 ± 2.6 ka, using LU models for the other samples provides reasonable estimates for the ages of the other teeth.

Assuming constant sedimentation in Layers 21.2–13, the Layer 16 hominids date to ~ 74 ka. ESR dating teeth from other layers would yield more accurate sedimentation rates, improving the age estimates for the hominids and other Paleolithic cultural deposits at Obi-Rakhmat.

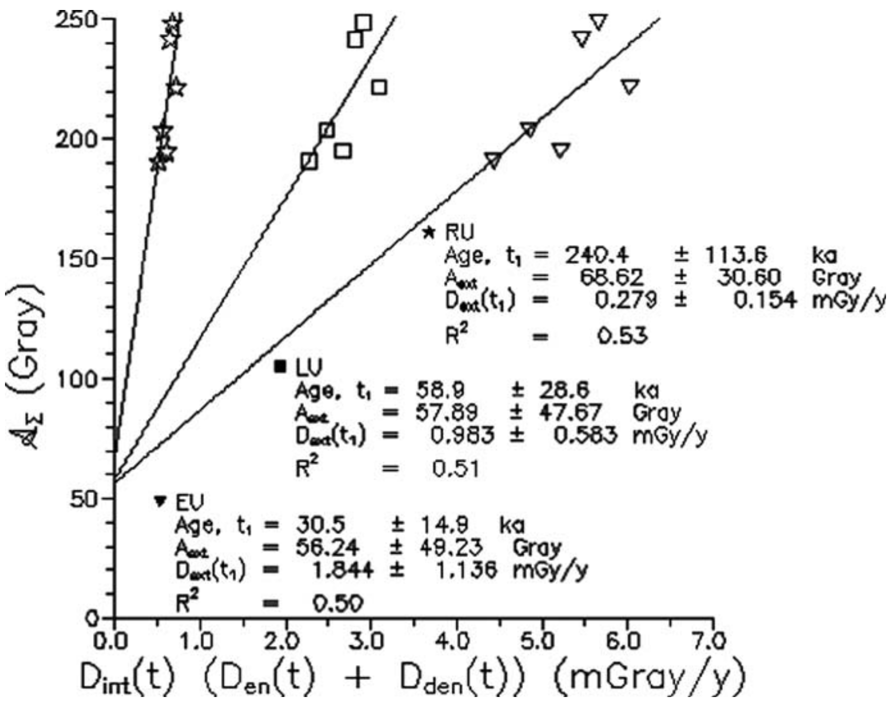

Fig. 15 The isochron for FT25, Obi-Rakhmat, Uzbekistan. The LU isochron data show that the modern external dose rate, $D_{ext}(0)$, calculated from the sedimentary geochemistry, agrees with the time-averaged external dose rate, $\overline{D}_{ext}(t)$, and, hence, that the LU model represents the actual U uptake well. The six points scattering slightly around the isochron hint that some very recent U remobilization has affected this tooth

Divje Babe I, Slovenia

Divje Babe I, Slovenia, is most famous for its Neanderthal flute (Fig. 16; Turk et al. 2005b, 2006), discovered in association with Middle Paleolithic artefacts and numerous hearths. Most ^{14}C dates attempted exceeded the dating maximum limit (Nelson 1997; http/www.esc.cam.ac.uk/oistage3/Secure/arch-dbase.xls). Only those for Layer 2, at 35.3 ± 0.7 ky BP, and Layer 6, at 43.3 ± 1.4 ky BP, appear reliable. Consequently, 26 teeth were dated by ESR (Fig. 17).

Its 26 inhomogeneous stratigraphic layers all contain significant quantities of dolomitic *éboulis* (Fig. 18). A Late Pleistocene *Ursus spelaeus* den, the cave yielded the first fossilized cave bear hair along with > 60 faunal species. The fauna, pollen, and charcoal all indicate an alpine and predominantly temperate forest near the cave, similar to today's environment, with occasional boreal elements (Turk et al. 2005a).

Most layers, especially 4 and 10–14, yielded Middle Palaeolithic lithics, including some bone awls and several fragmented bone points (Figs. 19, 20; Turk et al. 2005a; http://site.viola.fr/housitzky). Several layers preserved well defined hearths, all with large quantities of charcoal. The many scrapers and denticulates show heavy wear, including fracturing on one or more edges and pointed tips (Bastiani et al. 2000). In Layer 8 and deeper layers, many borers or *becs* have lost their tip, damage typically produced by carving green bone (Fig. 19; Bastiani and Turk 1997). Layer 8 yielded unambiguous evidence for human worship of cave bear skulls, analogous to the much younger example from Chauvet, France. Evidence for cave bear hunting is sparse and ambiguous (Turk 2003). While definitely an occupation, the visits were likely limited in duration, and perhaps seasonal or sporadic, probably to exploit the cave bear bones as tools or for their fat and marrow extraction.

Near a hearth, Layer 8a yielded a partial juvenile *Ursus spelaeus* femur with four holes (two of which are now notches) on its posterior side aligned along the diaphysis midline, and a notch on the anterior side that aligns with the first posterior hole (Fig. 16). All posterior holes penetrate 4 cm of compact bone,

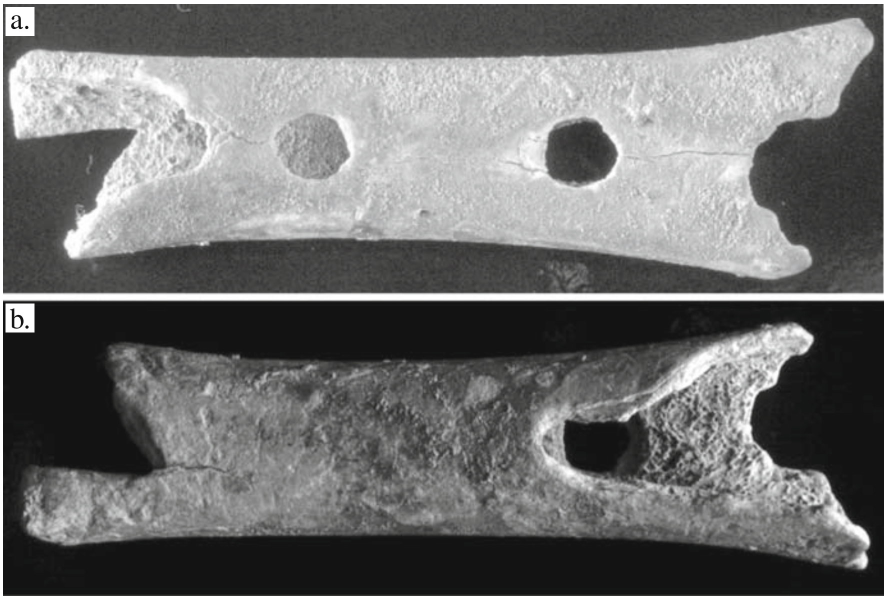

Fig. 16 The cave bear femur with five holes, Divje Babe I, Slovenia. Found in Layer 8, the juvenile femur has 4 holes on the posterior side and one on the anterior side: a. Parts of the metaphyses were lost from this bone, probably by gnawing by a wolf after the flute's abandonment at the site. A crack runs along the posterior side connecting all the holes, but it does not penetrate the entire diaphysis. Another crack runs partially on the anterior side. b. The offset between the two holes that are aligned on opposite sides is approximately 4 mm. One or both epiphyses may have been cut off during the bone's preparation by humans, or one or both may have been gnawed off (adapted from Turk et al. 2005b)

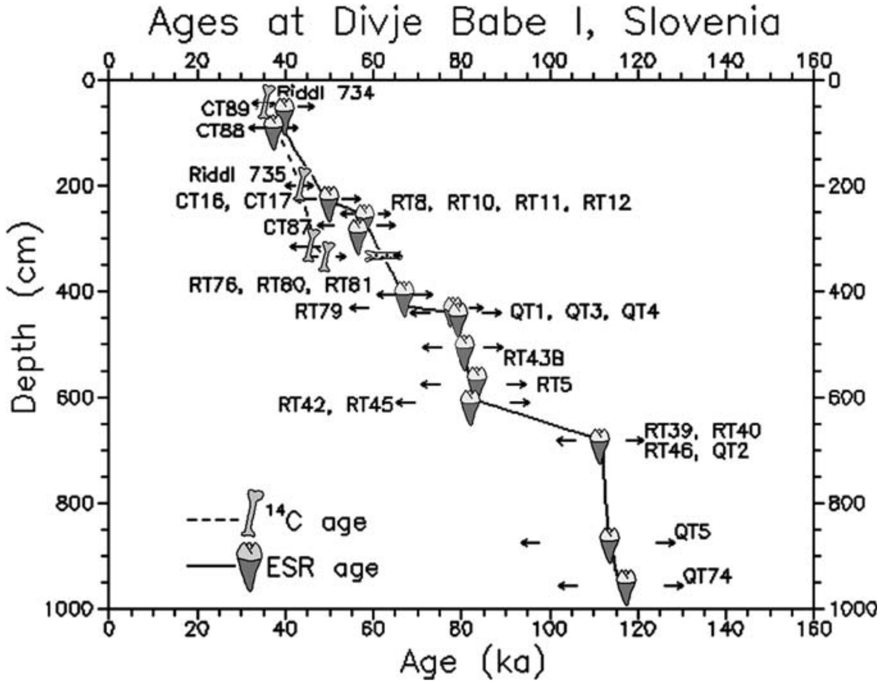

Fig. 17 **ESR dates at Divje Babe I, Slovenia.** From the 26 teeth dated here by ESR, the ages are internally extremely consistent, despite the somewhat larger than normal uncertainties (denoted by the span between the arrows). The four bones successfully dated by ^{14}C hint that ^{14}C ages in the range from 40 to 50 ka may require a calibration of + 2 to + 5 ky to bring them into line with calendric ages, like ESR. The ESR dates show that the cave filled with sediment episodically. A major depositional slowdown or hiatus occurred within Layer 17a2 between about 6.15 and 6.7 m below datum from approximately 105 to 85 ka. Another slowdown or hiatus occurred between Layers 12 and 13 lasting from ~ 78 to 70 ka. Another slowdown occurs from ~ 55 to 50 ka

but do not align with any on, or penetrate to, the anterior side (for details see Turk et al. 2006). On the anterior, no marks can be detected at a position corresponding to the spot where a second animal tooth should have damaged the bone (*contra* Chase and Nowell 1998; d'Errico et al. 2003). Detailed analysis along the hole edges showed evidence for chiseling on at least one hole (Turk et al. 2006). Computerized tomography showed that all four holes are actually intentionally made holes rather than the product of carnivore activity (Fig. 21). The posterior interhole distance ratio, 1:2:1.75, matches that seen in later Aurignacian and Gravettian flutes, including the Isturitz (Buisson 1990), Istállóskõ, and Lokve flutes (Horusitzky 2003). Several worked bones occurred in the other Mousterian layers (Fig. 20).

For the ESR analyses, > 190 sedimentary component analyses were used to do the external dose rate determinations (Blackwell and Blickstein 2000). All the teeth contained no or very low U concentrations, with no dentine or bone having more than 1–3 ppm U. Thus, the ages are independent of the U uptake model. Ranging from 40 ± 5 ka to 50 ± 6 ka for Layers 2–7 (Fig. 17), the ESR ages agree within their uncertainties with the ^{14}C ages for Layers 2 and 6 at 35.3 ± 0.7 and 43.3 ± 1.4 ky BP (OIS 3). Nonetheless, the consistent offset suggests that, at this age range, the calibration between the ^{14}C ages and calendric ages may average ~ +2 to +5 ky. Given the ages for Layers 8a–8c at 54–59 ± 3–9 ka, and for Layer 10–12 at 67–70 ± 4–13 ka, the flute probably dates to ~ 60 ka (OIS 4). For Layers 13–23, dates range from 80 ± 8 ka to 116 ± 12 ka (OIS 5a–5d; Blackwell et al. 2009).

Sedimentary morphometric and diagenetic features delineated several dramatic paleoclimatic fluctuations during OIS 3–5 (Fig. 22; Turk et al. 2001, 2002, 2005a). Paleotemperatures were estimated using the abundance of specific frost-shattered clasts

(a)

(b)

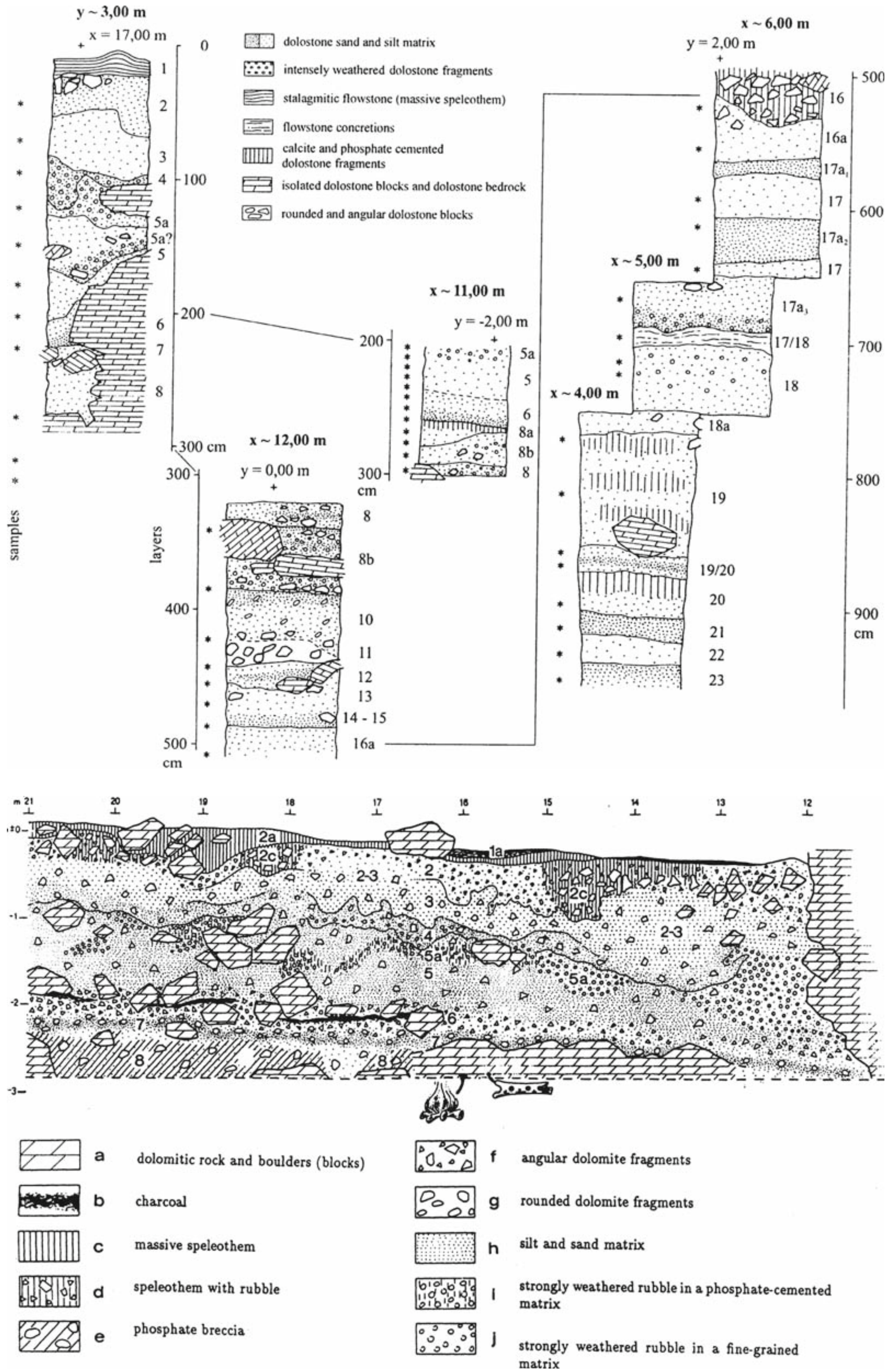

Fig. 18 (continued)

(congelifracts) in each layer, while paleohumidity was determined using evidence for corrosion, dissolution, cementation, and aggregate formation. This sequence contains one major hiatus, and another two depositional slowdowns or short-lived halts, in deposition. These data are the first from a Slovenian cave to permit such direct regional or continental paleoclimatic correlations. The strong agreement between the Divje Babe paleoclimatic curves and those determined from deep oceanic $\delta^{18}O$ and terrestrial palynological records suggests that the lag time between the climate change and its effect in the Divje Babe sediment is less than the uncertainty associated with the ESR ages.

From approximately 115 ka until 40 ka, Mousterian peoples visited Divje Babe I, sporadically leaving behind their flint and bone artefacts. Hearth frequency suggests that cave utilization was more intense in OIS 3 and 4 than in OIS 5. OIS 5 (Layers 13–23) saw warm, but alternately dry to moderately humid conditions. From $\sim$ 70 to 55 ka (mid OIS 4 to early OIS 3; Layers 12–8c) highly variable but cold temperatures with higher humidity dominated. During OIS 3 (Layers 8–2), temperatures still varied, but humidity also fluctuated more dramatically. From OIS 2, little sediment has survived, except as isolated pockets trapped within post-depositionally cryoturbated Layers 5a–2.

Humans made and abandoned the flute at about 60 ka. Aurignacian peoples then used the cave briefly from 40 to 38 ka, after which no Paleolithic deposits occur.

Conclusions

The aforementioned examples serve to illustrate that ESR dating can date samples from archaeological and paleontological sites spanning much of the Pleistocene. In sites where U concentrations and external dose rates are low, teeth as old as 2–4 Ma can be dated. As illustrated in the examples here, ESR is particularly useful for sites exceeding 35–50 ka, where ^{14}C dating becomes much less reliable to impossible, and in sites which lack suitable stalagmites for $^{230}Th/^{234}U$ dating. While TL and OSL can date the same time range as ESR, their associations with the archaeologically significant material often remain more tenuous, which can hinder their applicability. Even when other methods than ESR are applicable, however, the dating analyses cannot be considered finalized unless two independent methods that use different critical assumptions give similar results (Blackwell and Schwarcz 1993b). With the chronometric data provided by ESR, making intersite comparisons to examine patterns and rates of cultural and hominid evolution, spatial distribution, and migration becomes possible. When ESR is used to date many teeth from many layers, extremely detailed chronologies, like that at Divje Babe I, permit detailed paleoenvironmental reconstructions that ultimately can examine hominid responses to paleoclimatic changes.

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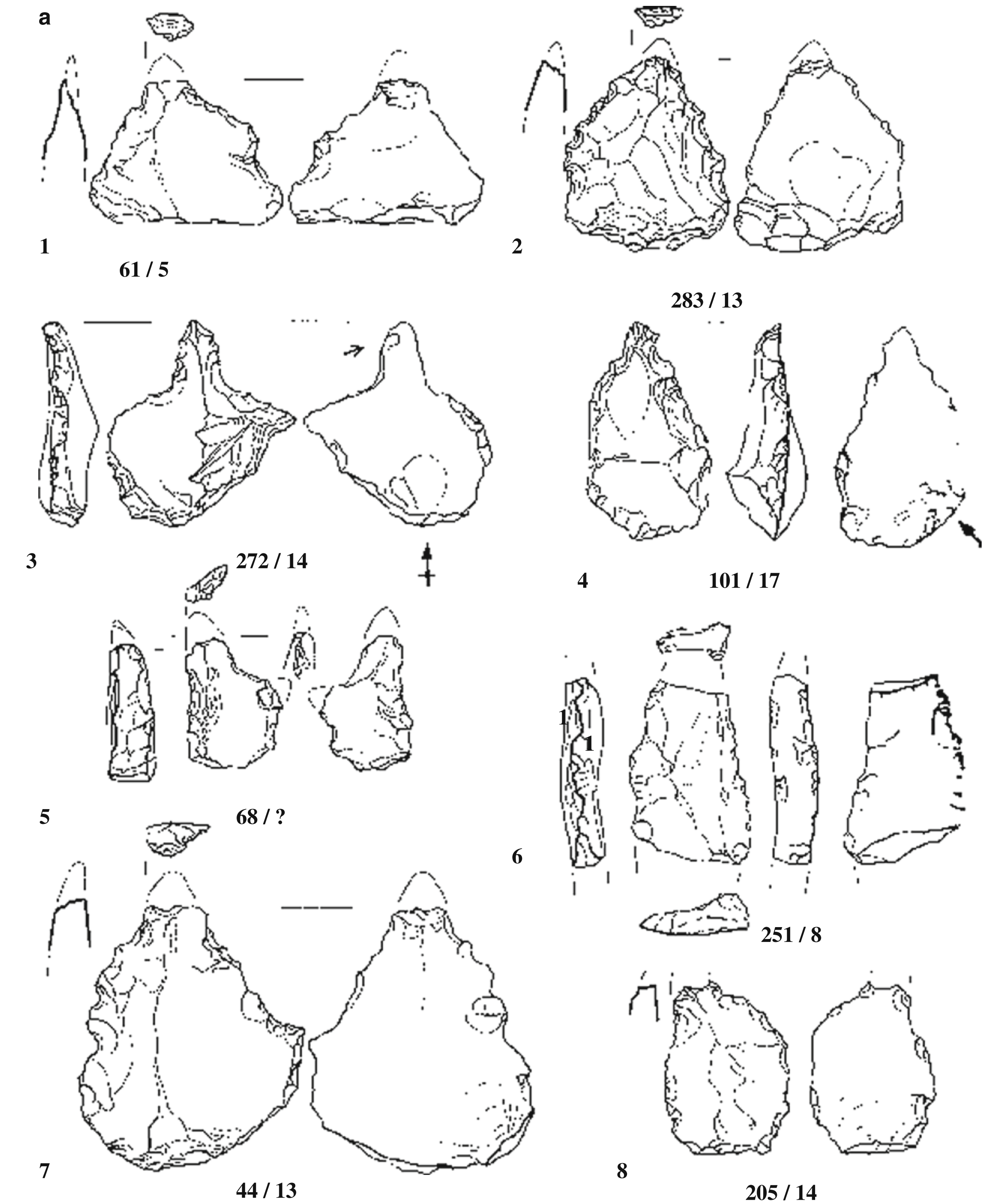
Fig. 18 **The stratigraphy at Divje Babe I, Slovenia.** At least 26 stratigraphic layers have been identified in the cave: a. A composite section containing several cuts in the 1998–2000 excavation used to recover sediment for ESR and paleoclimatic analyses from various locations in the cave. b. Cut $y = -2.00$ m at the rear of the cave. The flute was found 30 cm from a hearth associated with Mousterian tools. Many layers contain significant amounts of large dolomitic *éboulis*, which make all the layers inhomogeneous, especially near the cave mouth. Aurignacian tools occur in Layer 2, while Layers 4–20 host Mousterian artefact assemblages, along with hearths. The bone flute was found at 2.8 m depth $\sim$ 30 cm from a hearth in Layer 8 (adapted from Lau et al. 1997; Turk et al. 2005a)



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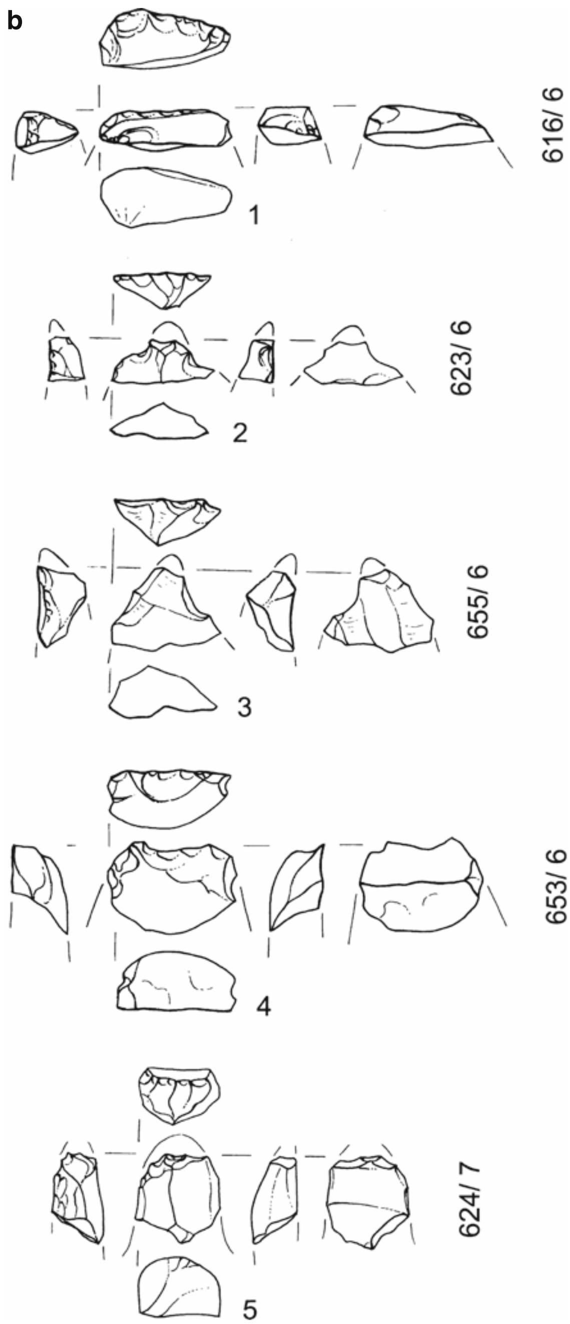

Fig. 19 Mousterian tools found in Divje Babe I, Slovenia. Numerous tools suitable for boring bone have been found in the Mousterian layers at Divje Babe I: a. Artefacts 1, 2, 5, 6, 7, 8, all have lost their pointed tips, while 3 and 4 have large flakes broken off during use. Such damaged flakes and broken tips typically occur when tools are used to carve bone and wood. Tools 3 and 4, which retain their tips, have points ideal for punching bone or wood. The denticulated edges on all the tools also can be used to carve or shave bone and wood. b. Many broken tips, such as those here, can be found in the Mousterian layers. Some, such as 2 and 5, show multiple generations of tip breakage. All are shown at 1:1. The label below or beside the artefact gives its accession number and layer number (adapted from Bastiani et al. 2000)

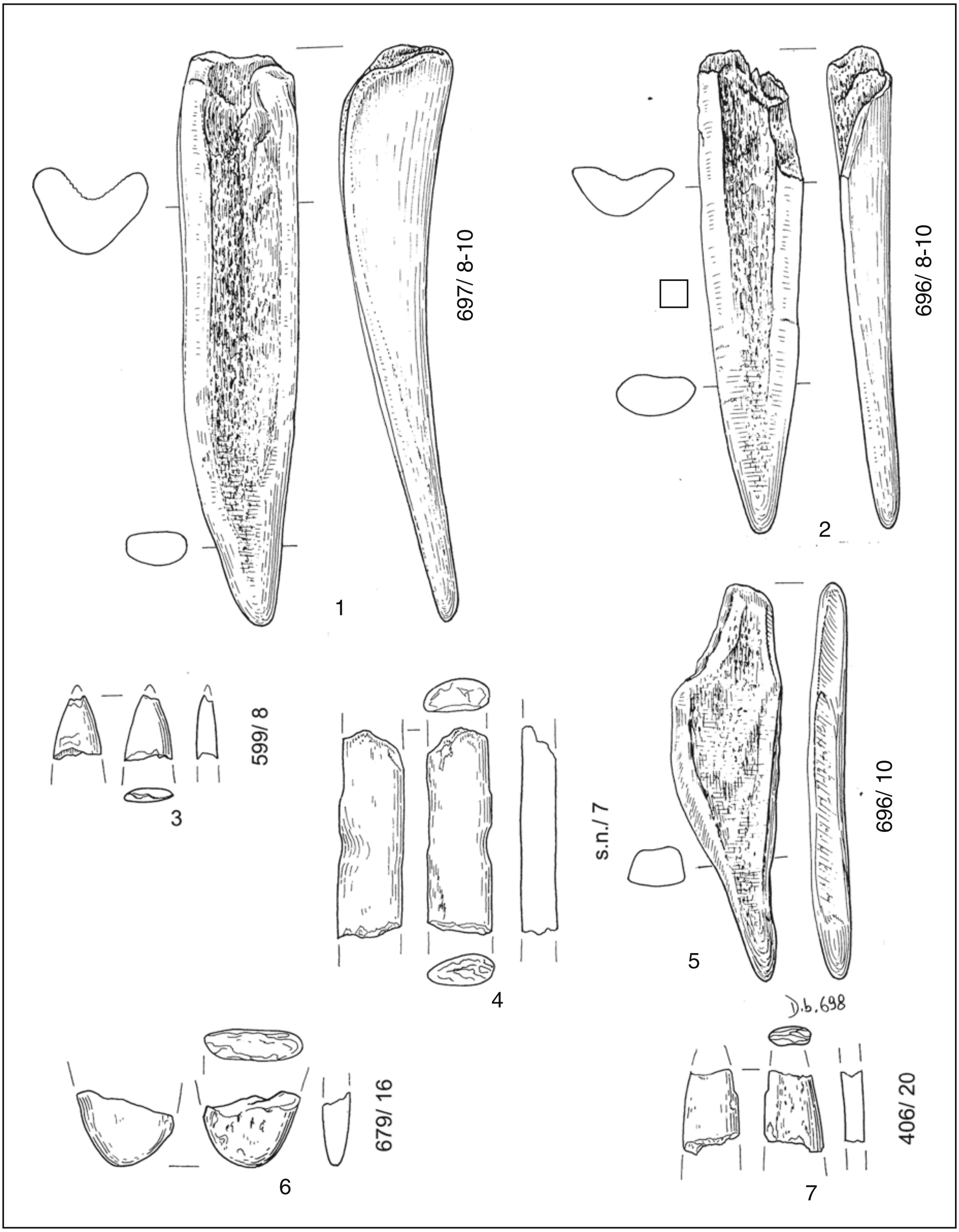

Fig. 20 **Worked bones from Divje Babe I, Slovenia.** Worked bones have been found in several layers, including these from Layers 7, 8–10, 16, and 20. The layer and catalogue number are shown beside the pieces. In the case of Samples 1, 2, and 5, these long bone diaphyses were fractured while still fresh (actual size; adapted from Turk et al. 2006)

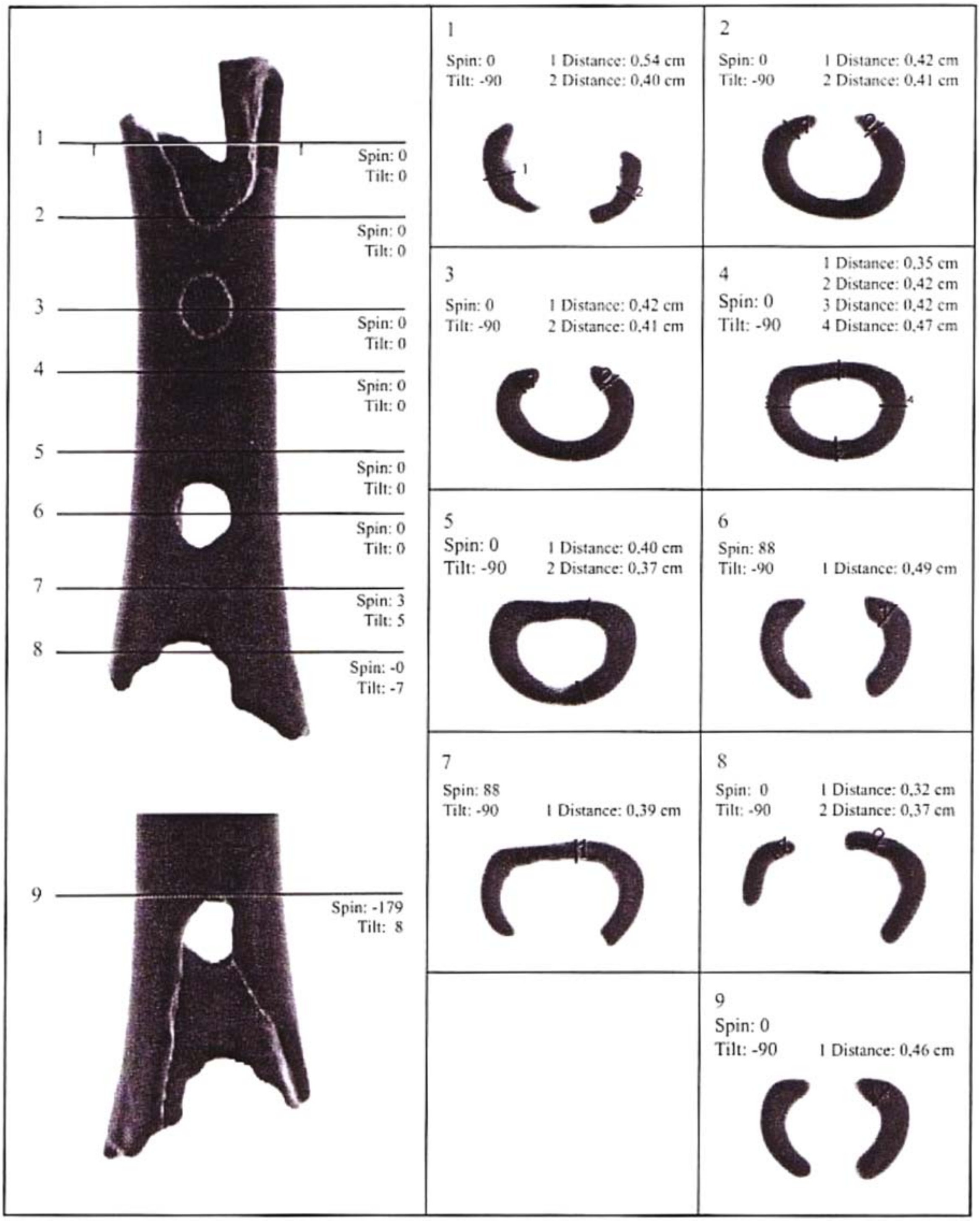

Fig. 21 Computerized tomography of the bored cave bear femur, Divje Babe I, Slovenia. Computerized tomography of the femur shows that none of the holes show the classic funnel-shaped indentations that would result from piercing by animal teeth. Instead all had to be formed by punching then boring by humans (adapted from Turk et al. 2005b)

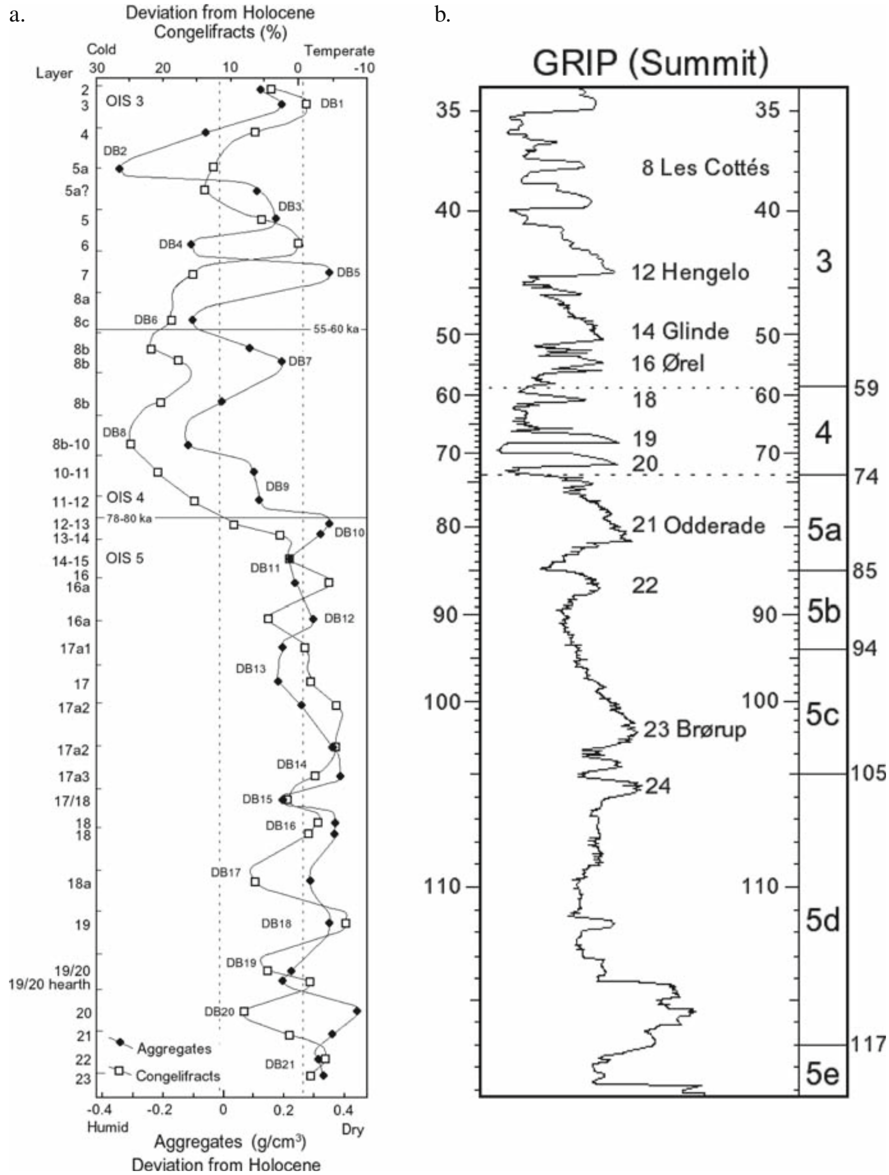

Fig. 22 The Late Pleistocene paleoclimatic record at Divje Babe I, Slovenia. The Late Pleistocene shows major climatic fluctuations which correlate well with the climatic record in other Late Pleistocene records: a. By comparing the Holocene frequency of aggregate and congelifact formation in the cave against that seen in Pleistocene sediment, relative temperatures and humidity profiles were constructed. For each curve, the dotted line represents the Holocene mean, while the solid line gives the deviation within the sedimentary layers. b. The GRIP (summit) record for Pleistocene climate (adapted from Weismüller 1997). This strong correlation in OIS 3 and 4 suggests relatively continuous sedimentation. At the boundary between Layers 12 and 13 dated at ~ 80 ka, a short depositional hiatus occurred. A short hiatus or depositional slowdown may have also occurred between Layers 6 and 7, and possibly within Layer 17a2

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The South Asian Paleolithic Record and Its Potential for Transitions Studies

Parth R. Chauhan

Abstract The Indian subcontinent contains a rich and continuous behavioral record of hominin occupation since at least the early Middle Pleistocene. All lithic assemblages demonstrate the presence of Lower, Middle, and Upper Paleolithic features and variable patterns of blank reduction, being in general congruence with other parts of the Old World. However, empirical lacunae continue to persist, such as the lack of absolute dates for many important sites and well-excavated spatial information. As a result, it has been challenging to assess the timings and nature of these technological transitions and compare that data with other regions. Although broad ages have been assigned to most assemblages on the basis of lithic typology, stratigraphy, and biochronology, they are inadequate when discussing the precise *causes* of the behavioral shifts and resulting adaptive strategies. Accumulated data, to date, reflect diverse techniques of raw material acquisition, transport, and reduction. The few stratified sites that have yielded evidence of technological phases include both open-air and rock-shelter/cave contexts. Both the Lower to Middle and Middle to Upper Paleolithic transitions vary at an interregional level, particularly in peninsular India. This probably reflects the collective impact of a suite of factors: demography, raw material type, topographical prominence, water resources, cognitive capabilities, mobility and settlement patterns, and subsequent hominin dispersals from peripheral regions. This paper discusses the dynamic character of the archaeological record in Pleistocene South Asia and attempts to highlight key behavioral changes. From a broader comparative perspective, the general contextual, technological, and chronological attributes are also discussed for the best-known sites.

Keywords Indian Subcontinent • South Asia • Paleolithic • Transitions

Introduction

Broadly situated in the center of the Old World, the Indian subcontinent arbitrarily encompasses Pakistan, India, Nepal, Sri Lanka, Bangladesh and Bhutan. The region comprises diverse ecological zones with complex geological and climatic histories including a biannual monsoon, all of which had major impacts on faunal and floral distributions and associated hominin adaptations. Since the first Paleolithic investigations in the late 19th century in southern India, a large amount of paleoanthropological data has accumulated in the form of lithic assemblages, invertebrate and vertebrate fossils (including hominin), and paleoenvironmental signatures (Kennedy 2000). In addition to surveys and excavations, archaeologists have also employed other multidisciplinary approaches to interpret the prehistoric record: multivariate metrical analyses of lithic assemblages, site-formation processes, hunter-gatherer ethnoarchaeology, and taphonomic observations (Settar and Korisettar 2002). Table 1 broadly lists some salient features of this region and Table 2 highlights current problems in South Asian paleoanthropological research. Table 3 depicts some of the most

P.R. Chauhan (✉)
Stone Age Institute & CRAFT Research Center, Indiana University, Gosport, IN, USA

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Table 1 Key attributes of the Indian subcontinent

Geographically in the center of the Old World
Ecologically diverse landmass constrained by the Himalayas and oceans
Prominent monsoon regime since the Miocene
Easternmost occurrence of rich and classic Acheulian assemblages
A continuous archaeological sequence since the Brunhes-Matuyama boundary
Numerous tribal groups with diverse linguistic, cultural, and genetic backgrounds

important features of the South Asian paleoanthropological record, some of which are discussed below. Figure 1 illustrates the key Paleolithic localities in the Indian subcontinent as discussed in the text.

Table 2 Major problems or lacunae in South Asian paleoanthropological research

No consensus on the age and taxonomic identity of the Hathnora specimen
Scarcity of pre-modern hominin fossils (with exception of Hathnora)
Paucity of absolute dates from well-stratified sites
Lack of well-stratified and well-excavated sites
Evidence of pre-Middle Pleistocene occupation (i.e. Oldowan) remains equivocal
Age of the earliest and youngest Acheulean remains unknown
Ambiguity regarding ecological adaptations and seasonal land-use
Age of the ealiest Levallois evidence remains unknown
Timing of the earliest occupatin by modern humans remains unknown

Table 3 Salient paleoanthropological features in the Indian Subcontinent (see Harrod, 2007; Petraglia, 2008)

Period	Site or Region	Age	Significance	Reference
			Lower and early? Middle Paleolithic feature	
O	Riwat*	ca. 2.0 ma	Possibly the oldest Oldowan evidence	Rendell et al. (1987)
O	(Pabbi Hills)*	2.2–1.0 ma	Oldest Modes 1 evidence in stratigraphic association with vertebrate fossils	Dennell (2004)
O?	Durkadi*	?	The only-known stratified core-and-flake site in India	Armand (1983)
EA	Isampur*	1.27–0.73 ma	Possibly the oldest Acheulian evidence & 1st known quarry	Paddayya et al. (2002)
A	Dina & Jalapur	400–700 ka	Oldest securely dated Acheulean	Rendell and Dennell (1985)
EA	Singi Talav	>800 ka?	Transport of non-utilitarian quartz crystals; 1 of 2 sites in clay context	Gaillard (2006)
EA	Chirki-on-Pravara	>350 ka	Preservation of fossilized tree fragments	Corvinus (1971)
A	Kuliana	?	First Lower Paleolithic site to be excavated	Bose and Sen (1948)
A	Attirmpakkam	?	Bovid and elephant footprints and shell impressions; 2nd site in clay context	Pappu et al. (2003)
A	Attirampakkam	?	Buried bifaces found in vertical and oblique positions	Pappu et al. (2003)
A	Hunsgi Valley	?	Twenty hematite nodules, one with striations (from use?)	Paddayya (1982)
A	Hunsgi locality V	?	Possible stone alignment	Paddayya (1984)
LA	multiple sites	?	Earliest evidence of the Levallois or prepared-core technique	Multiple publications
LA	Bhimbetka +	?	Cupulue and engraving on rockshelter wall	Bednarik (2003)
LA	Bhimbetka	?	Oldest known blade production	Misra (1982)
LA-M	Bhimbetka	?	Largest, lengthiest, earliest and stratified cave/rockshelter complex with rock art	Wakanker (1973)
LA	Paisra	?	Possible stone alignment and post-holes	Pant and Jayaswal (1991)
LA	Zia Piarat Shaban	?	The only chert bifaces known and in quarry context	Biagi and Cremaschi (1988)
LA	Maihar	?	Flat sandstone disc, centripetally flaked	see Bednarik (2003)
LA-MP?	Hathnora	?	Oldest pre-modern fossil hominin, attributed to various species of *Homo*	see Athreya (2007)

Table 3 (continued)

Period	Site or Region	Age	Significance	Reference
LA-MP?	Hathnora	?	Oldest post-cranial fossil specimens (clavicles and rib fragment?)	Sankhyan (1977, 2005)
LA-MP	Daraki-Chattan	?	500+ cupules, 2 engraved grooves, stone floors	see Bednarik (2003)
LA-MP?	Adi Chadi Wao	~69 ka	Youngest dated handaxes	Marathe (1981)
			Late? Middle and Upper Paleolithic features	
MP	Jwalapuram	~74 ka	Open-air stratified lithic assemblages above and below Toba ash	Petraglia et al. (2007)
MP	Hathnora	>33 ka	Possible engraved lithic artifact	Patnaik et al. (2009)
MP	Bhimbetka	?	Earliest stone structure in rockshelter context	Misra (1989)
MP	Kalpi	45 ka	Burnt bones and diminutive choppers; possible cut-marks	Tewari et al. (2002)
MO-UP?	Site 55	45 ka	Stone-lined pit, low wall, blades, microblades in open-air context	Dennell et al. (1992)
UP?	>40 Indian sites	40–20 ka	Numerous sites with ostrich eggshells	Multiple publications
?	Chandrasal	39 ka	Oldest engraved ostrich eggshell fragment	Kumar et al. (1988)
MP-UP	Fa Hien Cave	31 ka	Earliest known modern human fossils & geometric microliths	Deraniyagala (1992)
?	Khaparkheda	?	OEB production site	Kumar (2000–01)
UP	Bhimbetka III A-28	?	2 OEBs found with modern human burial	Kumar et al. (1988)
UP	Batadomba-lena	28.5 ka	Geometric microlithic toolds; bone points & OEB present	Deraniyagala (1992)
UP	Kurnool Caves++	?	Earliest known use of controlled fire, bone tools, cut-marked bones	Nambi and Murty (1983)
UP	Patne	25 ka	Incised ostrich eggshell fragment	Sali (1989)
UP	Baghor	8–9 ka?	Oldest Paleolithic shrine (still practiced in the region today)	Kenoyer et al. (1983)
?	Belan Valley	?	Bone harpoon point	Bednarik (2003)
LLP	Jwalapuram	?	Beads and harpoon in rockshelter context	see Petraglia (2007)

* denotes controversial or ambiguous evidence.
+ viewed as controversial by James and Petraglia (2005).
++ called into question by Petraglia (1995).
Legend: O: Oldowan; EA: Early Acheulean; A: Acheulean; LA: Late Acheulean; LP: Lower Paleolithic
MP: Middle Paleolithic; UP: Upper Paleolithic; M: Mesolithic; LLP: Later Late Paleolithic; OEB: ostrich eggshell beads.

The South Asian Lower Paleolithic

The South Asian Lower Paleolithic (SALP hereafter) has been traditionally divided into core-and-flake and Acheulean lithic industries that occur independently as well as in shared geographic and geomorphologic contexts (Jayaswal 1982). The behavioral record is particularly continuous from the early Middle Pleistocene, and comprises a rich and diverse array of technological, structural, and symbolic evidence. Stone tools are frequently found in stratified or surface association with fine-grained fluvial and lacustrine sediments, ferricretes, laterites, and gravel or conglomerate deposits (Pappu 1985). The current evidence indicates major archaeological gaps prior to the Middle Pleistocene, partly owing to the dearth of absolute dates for known assemblages, and partly to the region's discontinuous occupation prior to the early Middle Pleistocene (Dennell 2003). Most of the Indian localities have been directly dated through the Uranium-Thorium (^{234}Th-^{230}U) and thermoluminescense (TL) methods and include a predominance of Acheulean sites (Mishra 1992, 1995; Petraglia 1998). Ages for other occurrences such as Riwat, Dina, Jalapur, Pabbi Hills, Morgaon, and Satpati Hill have been estimated using paleomagnetism and geostratigraphic correlations. At Teggihalli, Chirki-Nevasa, and Yedurwadi, the ^{234}Th-^{230}U ages for the Acheulean extend beyond 350 Ka (or 390 at Didwana), the

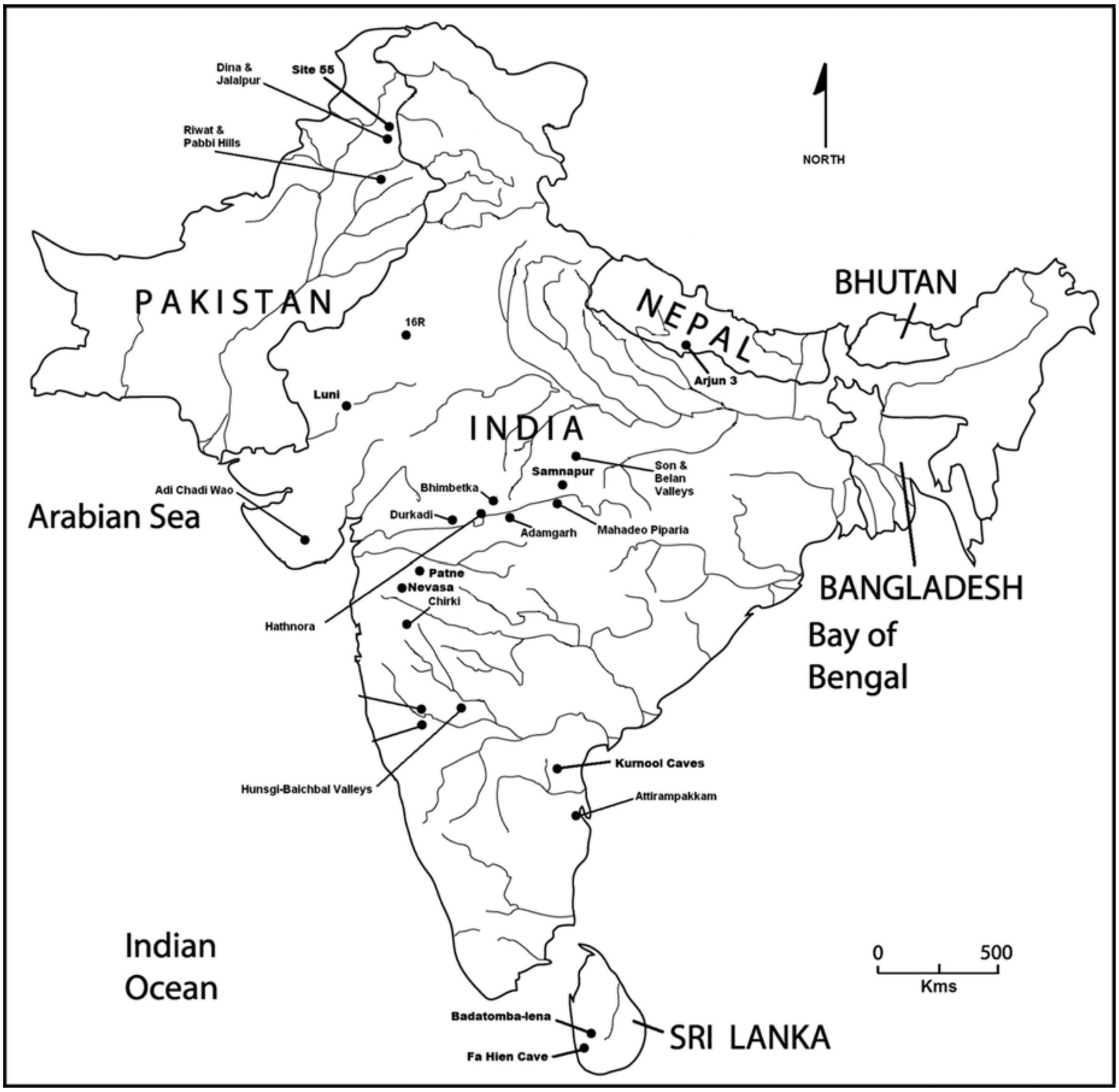

Fig. 1 Locations of key Paleolithic occurrences in the Indian subcontinent

maximum limit of the dating methods, an assessment partly supported by lithic typology. With the possible exceptions of the Satpati Hill site in Nepal and Morgaon and Chirki-on-Pravara in Maharashtra, there is no unequivocal evidence of Acheulean occupation prior to the Middle Pleistocene in the subcontinent. Though the site of Isampur in the Hunsgi Valley has been dated to c. 1.27 Ma using electron spin resonance (ESR) on herbivore teeth associated with the cultural horizons (Paddayya et al. 2002), this estimate is preliminary and requires corroboration. The youngest dates for the Acheulean come from Umrethi (>190 Ka) and Adi Chadi Wao (c. 69 Ka) in Gujarat, and Kaldevanhalli in Karnataka (166 and 174 Ka) (Marathe 1981; Szabo et al. 1990). The terminal Acheulean evidence is not well established and the use of diminutive bifaces persisted well into the Upper Pleistocene as parts of early Middle Paleolithic assemblages (Misra 1989; Rajaguru 1985).

Most SALP sites are not known to preserve behavioral features other than clusters of stone tools. Some exceptions are possible stone alignments and postholes at Paisra and stone alignments at Bhimbetka and Hunsgi (Misra 1987; Paddayya 2007; Pant and Jayaswal 1991). Though viewed as being controversial (James and Petraglia 2007), a rockshelter at Bhimbetka has yielded cupule marks thought to be contemporary with the Late Acheulean (Bednarik 2003). At Singi Talav, an Early Acheulean level—Layer 4—yielded six complete and unmodified quartz crystals (though one may have some use-wear), possibly suggesting the transport of nonutilitarian objects from elsewhere (d'Errico et al. 1989; Gaillard et al. 1983). A similar example comes from the Acheulean layer at Hunsgi, which yielded almost twenty haematite pebbles, geologically exotic to the region, including one with striations interpreted as a sign of utilization (Bednarik 1990). The only known premodern hominin fossils in the subcontinent may be contemporary with the Late Acheulean phase and come from Hathnora in the central Narmada Valley (Kennedy 2001). They include a partial calvarium (possibly female) and possibly associated clavicles, and a rib fragment (Sankhyan 1997, 2005; Sonakia 1984). The calvarium was originally identified as an "advanced" *Homo erectus* (de Lumley and Sonakia 1985), and later reclassified as an archaic or early form of *H. sapiens* (Kennedy et al. 1991). Phylogenetic reevaluation of the calvarium reveals that it shares key morphological features with *H. heidelbergensis* and *H. erectus* (Cameron et al. 2004), and has been recently classified as *Homo* sp. indet. (Athreya 2007). Additional detailed information about individual SALP sites, site clusters, and associated contextual, chronological, and behavioral interpretations can be found in numerous review publications (e.g., Chauhan 2009a; Kennedy 2000; Korisettar 2002; Mishra 1994, 2001; Pappu 2002; Petraglia 1998).

The South Asian Pre-Acheulean

In the 1960s, Khatri (1963) argued for an indigenous origin of the Indian Acheulean from the Mahadevian industry, equated to the Oldowan, at Mahadeo Piparia in the Upper Narmada Valley. A similar claim was later made by Armand (1985) who reported a comparable assemblage at Durkadi from excavated contexts in the lower part of the valley. The large size of the Mode 1 tools, "protobifaces," "Clactonian-type" flakes, and flake scars were particularly emphasized (Jayaswal 1982). Later work (Supekar 1985) refuted Khatri's claim because Mahadeo Piparia seemed to contain a mixture of Lower and Middle Paleolithic tool types. Additionally, it is now generally accepted that the South Asian Acheulean is a result of technological dispersal from Africa rather than representing convergent technological evolution in the subcontinent. Durkadi requires additional investigations regarding its chronology and technomorphological affinities. Numerous core-and-flake assemblages have also been reported from the Konkan coast, Karnataka, Uttar Pradesh, Bihar and West Bengal, Orissa, Andhra Pradesh, and northeastern India (Jayaswal 1982). Unfortunately, none of these assemblages has been dated and they remain technochronologically undiagnostic; most appear to postdate the Acheulean (Chauhan 2009b). The most systematically studied pre-Acheulean evidence in the subcontinent is also the most controversial and comes from the Siwalik deposits of northern Pakistan. The oldest archaeological evidence here is represented by the c. 2.0 Ma finds from Riwat and the 2.2–0.9 Ma old Mode 1 assemblages from the nearby Pabbi Hills. At Riwat, only three out of 23 specimens have been promoted as being most convincing as artifacts. The assemblages from the Pabbi Hills comprise a total of 607 lithics, and the investigators chronologically divided them based on the underlying strata and associated vertebrate faunal assemblages: 102 specimens dated to 0.9–1.2 Ma; 307 specimens to between 1.2 and 1.4 Ma; and 198 specimens to between 2.2 and 1.7 Ma. Unfortunately, the Riwat and Pabbi Hills material do not come from fine-grained excavated contexts as other well-dated Oldowan sites, and should be viewed as tentative evidence for a pre-Acheulean occupation of South Asia.

The South Asian Acheulean

With the exception of northeast India and parts of Konkan Maharashtra, western Kerala, south of the Cauvery River in Tamil Nadu, and Sri Lanka, Acheulean assemblages are found throughout most of the

Indian subcontinent (Misra 1989; Pappu 2001; Petraglia 2006). The South Asian Acheulean is generally divided into Early or Late developmental phases, based primarily on typo-technological features, assemblage compositions, comparative stratigraphy, and associated metrical analyses (Paddayya 1984). Although general technomorphological differences suggest that this division is probably chronologically applicable, previous researchers have rarely taken into account other factors such as their chronology, manufacturing stages, raw material constraints, and artifact functions (Petraglia 1998). As more absolute dates and detailed metrical data become available, current classifications of many assemblages are likely to change. While the term "Middle Acheulean" has been occasionally applied to "transitional" assemblages, such a facies have never been systematically justified. Early Acheulean assemblages are known to comprise handaxes, choppers, polyhedrons, and spheroids, usually a lower number of cleavers (but not always) and flake tools, the predominant use of the stone-hammer technique, and a marked absence of the Levallois technique (Misra 1987). The Early Acheulean bifaces are often asymmetrical, large with thick butts or midsections, and possess large, bold, and irregular flake scars, indicative of hard-hammer percussion. In contrast, Late Acheulean assemblages are defined by the low proportion of bifaces, the high ratio of cleavers to hand axes, the very high ratio of flake tools such as scrapers, and the extensive employment of the soft-hammer technique and the Levallois and discoid-core techniques (Misra 1987). These bifaces are also generally smaller, thinner, and morphologically more refined, with a significant increase in the degree of retouching and controlled bifacial thinning/flaking.

The Earlier Acheulean

The Early Acheulean phase is typologically and chronostratigraphically represented by several occurrences, including Nepal, the Thar Desert, and parts of Maharasthra, Karnataka, and Madhya Pradesh. From the available geochronological information and comparative geology and typology, most of these assemblages appear to be older than c. 400 Ka. Currently, the oldest securely-dated Acheulean evidence comes from find-spots at Dina and Jalalpur in northern Pakistan. Rendell and Dennell (1985) assigned a bracket of 700–400 Ka to the material. In Nepal, the older evidence comes from the Satpati Hill site where Corvinus (2006) recently reported Acheulean bifaces from the folded Upper Siwalik Boulder Conglomerate Formation, a stratigraphic context similar to that of Dina and Jalapur. In the Didwana region of the Thar Desert, excavations in the Amarpura Formation at Singi Talav exposed an Early Acheulean assemblage on quartzite and quartz in fresh condition, thought to be c. 800 Ka from regional chronostratigraphy (Gaillard 2006). Metrical and typological studies indicated a younger Acheulean facies with small bifaces and flake-dominated specimens in the upper horizons (Gaillard et al. 1986). A lengthier lithic sequence of Lower Paleolithic to Mesolithic assemblages in stratified context was found nearby at 16R (Fig. 2), a stabilized fossil sand dune in which a 19 m trench was excavated (see discussion later). In Gujarat in western India, Late Acheulean sites are often associated with miliolite pebbles, and the Early Acheulean artifacts occur in gravels that do not contain miliolite (Marathe 1981). In the Hunsgi-Baichbal Valleys (Karnataka), systematic surveys and excavations were conducted since the mid 1960s by K. Paddayya, revealing numerous occurrences belonging to all Paleolithic phases (Paddayya 2001). Probably the most important Early Acheulean site from the Hunsgi complex is Isampur, representing the first known occurrence of in situ artifacts in a quarry context in India (Petraglia et al. 1999), and perhaps one of the earliest in the world if its early (but tentative) age of 1.2 Ma is further corroborated. The region of Tamil Nadu, where stone tools were first reported in India, has been studied for over a century by various researchers. The most significant site in the region is Attirampakkam, located in the Kortallayar valley and investigated intermittently for several decades. Most recently, it has contributed to revising previous geological, contextual, and behavioral interpretations (Pappu 2007). Cultural levels at the site derive from a 7m section and, like the 16R dune in Rajasthan, are thought to range from the Lower Paleolithic to the Mesolithic (Fig. 3). Preliminary lithic analyses

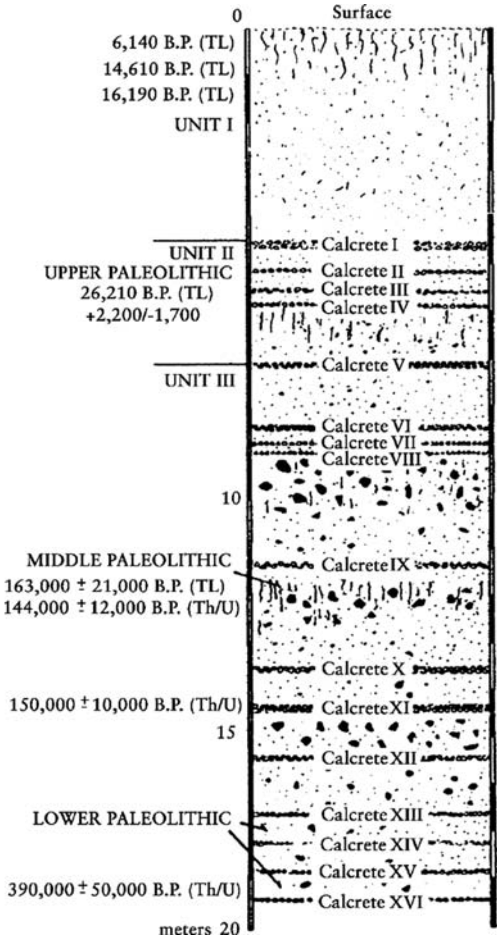

Fig. 2 The stratigraphic profile, archaeological horizons, and associated dates from the 16R dune at Didwana, Rajasthan (after Misra 1989)

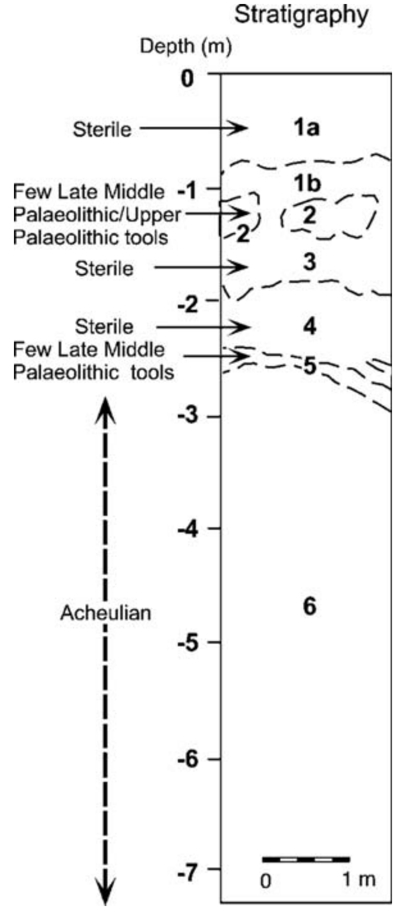

Fig. 3 The stratigraphic profile and archaeological horizons at Attirampakkam (after Pappu et al. 2003)

reveal that a part of the Attirampakkam assemblage exhibits both Early and Late Acheulean characters (Pappu and Akilesh 2006).

The Later Acheulean

The Late Acheulean sites in South Asia occur in greater numbers, possibly reflecting population dynamics and associated land use intensity during the later Middle Pleistocene. This evidence marks the earliest, but undated, employment of the prepared-core and Levallois technology in the region, which are in the form of discoidal cores and the Victoria West technique (Cammiade and Burkitt 1930), as well as the initial production of large blades at sites such as Bhimbetka (Misra 1982). The Rohri Hills in southern Pakistan are one of the few SALP occurrences produced on chert, and the assemblages come from numerous localities comprised of hundreds of artifacts (Biagi and Cremaschi 1988). In Nepal, the site of Gadari indicates occupation along the banks of the Babai River, as the handaxes were recovered from the basal gravels of the alluvium, the oldest period of the Dang *dun*, a shallow intermontane post-Siwalik valley (Corvinus 1990). Most of the South Asian Late Acheulean evidence, however, is located in central and peninsular India, including parts of Rajasthan, Gujarat, Maharshtra, Madhya Pradesh, Bihar, Karnataka, Andhra Pradesh, and Tamil Nadu (Pappu 2001). The Kaladgi Basin in

Karnataka preserves rich evidence of transitional assemblages ranging from the Late Acheulean to the early Middle Paleolithic (Petraglia et al. 2003).

Some of the best-known Late Acheulean assemblages in north-central India come from Bhimbetka (Misra 1978), where hundreds of rock-shelters (many with rock paintings) are situated in a hilly and forested area in Madhya Pradesh. Wakanker (1973) initially proposed that the Acheulean horizon at one of the excavated rock-shelters was underlain by a "pebble-tool" horizon, both being separated by a sterile layer, implying possible technological progression between the two traditions. However, subsequent excavations by Misra (1985) at Shelter III F-23 did not support Wakanker's claims for a pre-Acheulean industry in this area. Three trenches in a cave (III-F-24) yielded a 3.8 meter Lower and Middle Paleolithic sequence as well as Mesolithic material at the top (Fig. 4). The palaeoanthropological record of the island country of Sri Lanka is comparatively less well known, but has a significant bearing on the evolution of modern humans in the subcontinent (Kennedy 1999). Some of the most well-preserved South Asian fossils of modern *Homo sapiens* come from various cave deposits in Sri Lanka such as Fa Hien Cave. Renewed paleoanthropological research is critically required, however, to identify and date the earliest occupation in this region, which currently appears to be no older than 30 ka. The Ratnapura region in the southwestern wet lowlands (Deraniyagala PEP 1953; Deraniyagala SU 1992) has yielded quartz and quartzite lithic artifacts, but these remain undated and ambiguous.

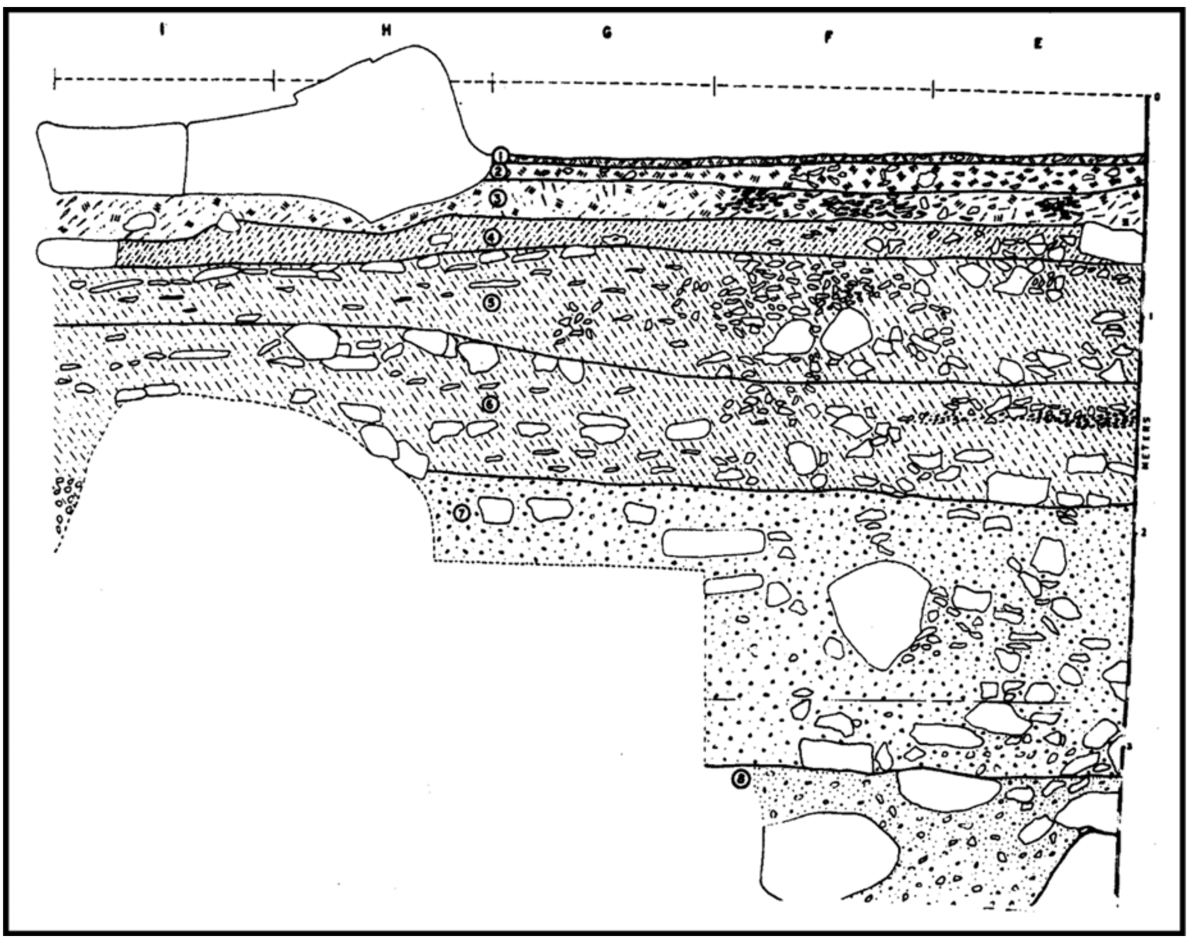

Fig. 4 The stratigraphic profile of Bhimbetka rock-shelter IIIF-23 (after Misra 1978)

The South Asian Middle Paleolithic

The South Asian Middle Paleolithic (SAMP hereafter) has been clearly defined from a large number of occurrences found throughout the region (see Pal 2002 for a recent review). The current chronological framework, however, is not adequate for large scale global comparisons or delineating Paleolithic transitions in the subcontinent. Middle Paleolithic assemblages appear to have been first collected in the late 19th century from the Son valley of Uttar Pradesh (Kennedy 2000). The concept of the Middle Paleolithic as an independent technological system was acknowledged by Indian prehistorians only in the mid 1950s. H.D. Sankalia was the first to formally recognize and define the SAMP from his work at Nevasa. Sankalia based his observations and definition of the SAMP from the lower frequency of Acheulean bifaces and the greater number of flakes and flake-based tools. Such assemblages had been designated earlier as belonging to "Series II" (Cammiade and Burkitt 1930). Another factor that aided in identifying the SAMP phase is that most assemblages often derived from contexts geostratigraphically younger or different than the typical Lower Paleolithic (i.e., Acheulean) assemblages. All of these attributes were frequently marshaled by subsequent investigators from other regions of the subcontinent to identify SAMP assemblages. Initially, however, Sankalia associated the evidence from Nevasa with the African Middle Stone Age rather than the European Middle Paleolithic. As Pal (2002, 67) writes: "As in the early phase of these discoveries the nomenclature of Indian Palaeolithic cultures was not finally settled, these were ascribed various names like the Middle Palaeolithic . . . , Middle Stone Age . . . , Series II . . . , Nevasian . . . , and Flake Culture . . . by different scholars." The subsequent and final shift in characterization from "MSA" to the "Middle Paleolithic" for the South Asian evidence is thought to be due to the Mousterian and Levallois affinities between assemblages in the northwestern region of the subcontinent and other penecontemporaneous occurrences in Central Asia, northern Africa, and Europe (Kennedy 2000). One of the major lithic tool types utilized to recognize Mousterian affinities in the Indian record is the denticulate scraper (Ghosh 1974).

Separating the Middle Paleolithic horizons from the Late Acheulian ones, however, has proved to be a recurrent methodological problem (Mishra 1995) because the Levallois technique and other forms of prepared-core technology are also present in the Late Acheulean phase of the subcontinent. Additionally, the SAMP sites often overlap geographically with the Late Acheulean occurrences and indicate successful adaptations and exploitation of a range of ecological and topographic settings. Older assemblages often appear to contain diminutive handaxes, and younger assemblages may have an increasing blade component. These observations, however, need to be verified through a more robust chronological framework. The SAMP sites vary in their assemblage compositions, which generally include cores, choppers, discoids, scrapers, flakes, points, debitage, and so forth. One main feature is an increase in the intensity of tool use as well as formal tool preparation (i.e., retouching, rejuvenation). This transition in raw material exploitation and a corresponding decrease in tool size are generally regarded as parts of a distinct shift in human behavioral patterns, marked by changes in land use, technology, demography, and mobility. In recent decades, some of these Middle Stone Age features are viewed as representing the emergence of modern human behavior (Stringer 2002). At the same time, it is important to observe that "Though no physical remains of Neanderthal man have been found in India, stone tools very similar to those found with this hominid species in Europe and other regions occur widely in the subcontinent" (Misra 2001, 495).

Despite detailed interregional metrical and typological comparisons (Jayaswal 1978), the timing and character of the South Asian Middle Paleolithic phase remain poorly understood in comparison with similar evidence from Africa, Europe, and West Asia. Some well-studied stratified examples are Nevasa (Mishra 1995b) in Maharashtra, Samnapur (Misra et al. 1990) in Madhya Pradesh, and the evidence from the Kortallayar Basin (Pappu et al. 2003) in Tamil Nadu. Assemblages produced on quartzite and jasper and recovered from the Garhwal Himalaya in the Alakananda valley of northern India (Nautiyal et al. 1982) reflect hominin adaptations to high-altitude environments during the SAMP. Though not as high in altitude as the Alakananda finds, the site of Arjun 3 in Nepal also signifies the occupation of the sub-Himalayan or Siwalik ecozone. SAMP sites are least common in Assam, Bengal, and Kerala (Kennedy 2000). This is probably related more to a survey/research bias than to factors of preservation, and requires further work in these areas to confirm the presence/absence of such sites. In northern India, an important record of MP evidence comes from Budha Pushkar. Here, Allchin et al. (1978) reported abundant MP sites often associated with paleosols or weathered soil deposits. In other parts of Rajasthan, they have been found to be stratified in stabilized paleo-sand dunes (Didwana) and fluvial contexts (Luni and Berach Basins). The $\sim$19 m dune sequence at 16R, Didwana, represents one of the best known occurrences in the entire subcontinent and has often been cited as an example of lengthy and diverse ecological adaptations (but associated problems are discussed below). In a similar ecozone in the Sind region of southern Pakistan, the Rohri Hills have yielded MP assemblages in surface association with chert outcrops (Allchin 1976). Since choppers and diminutive handaxes are often found in certain Middle Paleolithic contexts (Corvinus 2002; Guzder 1980; Tewari et al. 2002), it may be suitable to arbitrarily divide SAMP assemblages into two separate groups: light-duty assemblages and heavy-duty assemblages. The factors for such variation in assemblage composition may include function, raw material variability, ecology, culture, style, and/or natural post-depositional formation processes.

In comparison with the South Asian Acheulean, the four features that distinguish Middle Paleolithic assemblages are: (i) a decrease in size of the artifacts, (ii) a noticeable shift from large Acheulian bifaces to more smaller, specialized tools, (iii) an increase in the prepared-core technique, and (iv) a preference for fine-grained raw material (such as quartz, fine-grained quartzite, chert, jasper, chalcedony, flint, agate, crypto-crystalline silica, lydianite, and bloodstone (Kennedy 2000). In some regions such as Rajasthan, parts of Andhra Pradesh, parts of coastal Maharashtra, and the Narmada Valley, quartzite continues to be used. Some of the new types that either first appear or become prominent in the SAMP are prepared-cores, discoids, flakes, flake-scrapers, borers, awls, blades, and points. A consistent geoarchaeological feature of Middle Paleolithic sites in South Asia is that they are often found near sources of raw material, such as gravel or conglomerate beds. The cultural horizons are found within sandy-pebbly gravel horizons, generally overlying the basal boulder gravels comprising Lower Paleolithic artifacts (Guzder 1980). In fact, Korisettar and Rajaguru (2002, 332) have observed: "In general the Middle Palaeolithic sites are rarely buried with Quaternary sequences in the peninsular region; this possibly indicates the dominantly erosive mode of the streams in the Deccan. They are common on the surface with rubble and fan gravels and generally lie away from the streams but close to quarries or sources of raw material." However, certain Middle Paleolithic assemblages have also been recovered from within sandy gravels overlying silts, which often cap cobbly-pebbley horizons, such as at Samnapur in the central Narmada Basin (Misra et al. 1990).

Radiocarbon dating efforts on shell, wood, etc., from different sites in peninsular India over two decades ago, revealed that the Indian Middle Paleolithic is younger than 100 kyr (Guzder 1980). Later work has revealed that this technological phase may extend back to at least 140 kyr (Korisettar and Rajaguru 2002) or to be 150–250 kyr old (see Dennell 2000, 2001). Other localities in the subcontinent have been bracketed to be between 125 and ?40 kyr old (see Mishra 1995), although some dates may be too young (see Kusumgar and Yadava 2002). Recent efforts were made by Tewari et al. (2002) in the Ganga Plains at the site of Kalpi, which yielded vertebrate fossil remains as well as core tools such as choppers, which are uniquely small in relative size. Using TL methods, the investigators estimated this site to be about 45 kyr in age. In eastern Pakistan, the Middle and Upper Paleolithic in the Potwar Plateau is stratigraphically associated with extensive deposits of loess. One such site in that zone, an early Upper Paleolithic assemblage at Site 55, was also dated to 45 kyr (Rendell and Dennell 1987). These convergent ages for vastly different assemblage compositions (i.e., flake-dominated vs. blade-dominated) pose a problem in understanding regional techno-functional development during the Upper Pleistocene in the Indian subcontinent. Interestingly, choppers apparently form a prominent feature in a flake-blade industry from the Singhbhum region of Bihar (Ghosh 1970), thus perhaps explaining the simultaneous occurrence of Kalpi and Site 55 at 45 ka. Additionally, some of the MP evidence in the coastal zone of Saurashtra in Gujarat has been dated to approximately 35 ka and correlated with miliolite deposits from fluctuating sea levels (Kennedy 2000). Sanghao Cave, of Mousterian and Upper Paleolithic cultural affinities, was excavated by Dani (1964) and shows dates ranging from 42,500−4000 to 21,950−350 B.P. The cave is located near Peshawar in northern Pakistan and has yielded 12 cultural layers, of which the bottommost five layers have been identified as MP. Artifacts are made predominantly from locally available quartz and schist, and include prepared cores, scrapers, blades, flakes, tanged and triangular points, and gravers or burins.

The South Asian Upper Paleolithic

The South Asian Upper Paleolithic (SAUP hereafter) is not as clearly defined (James and Petraglia 2005) as the region's Acheulean or the SAMP, nor well understood; as a result, it still requires extensive multidisciplinary research at a large scale. As with the SAMP, the SAUP was first recognized in the subcontinent based on specific tool types already known from Africa and Europe and classified as "Series III" by Cammiade and Burkitt (1930). The SAUP was formally described for the first time in southern India in the late 19th century by R.B. Foote (as *Magdalenian*) and J.A. Brown; the evidence came from Late Pleistocene contexts (see Kennedy 2000 for a useful historical review). However: "Discoveries made before 1956 were not appreciated as constituting a true upper Paleolithic tradition in India for several reasons: the south Asian blades and burins contained certain non-Eurasian stylistic features; scrapers outnumber other tool types at many sites; African rather than Eurasian parallels seemed more obvious, and this bias was reinforced by Subbarao's (1956) efforts to introduce African lithic classification terminology into Indian archaeology. With the recent location of so many upper Paleolithic sites in India, the European parallels become much more obvious" (Kennedy 2000, 166).

The dominating and defining features of SAUP assemblage compositions include a notable increase in the production of more specialized tools such as blades, burins, and borers. Although the production of blades is known from Late Acheulean levels at a few sites (e.g. Bhimbetka [Misra 1985]), this behavior became highly prominent, prolific, and technologically consistent and standardized only during the SAUP. Additional tool types during this technochronological period include flakes, knives, awls, scrapers, cores including cylindrical types, choppers, and bone tools. At Bhimbetka for example, end-scrapers dominate the UP assemblages and are often made from the bases of blades and burins (Kennedy 2000). The bone tool kits included varieties of "scrapers, awls, perforators, shouldered projectile points, chisels, barbs, and spatulate tools" (Kennedy 2000, 166; see Petraglia [1995] for doubts regarding the bone tools from the Kurnool Caves). The techniques of making many of these lithic and nonlithic tools also changed from the preceding technochronological phases. For example, the use of pressure flaking and the soft hammer technique for flake detachment appears to increase significantly as compared with the SAMP and the later Acheulean. The degree or intensity of retouch also appears to increase considerably compared with Lower and Middle Paleolithic assemblages in general. In recent decades, the SAUP has often been divided into two developmental phases: Early and Late (e.g., Sali 1989). Differences between the two, for example, include variations in assemblage compositions and the dominance of certain tool types such as scrapers in the former, and refined blades in the latter; these differences however are regional and require absolute dating and systematic investigations. Compared with earlier Paleolithic technology, the SAUP shows a greater degree of regional typo-technological variation as well as an increase in different types of scrapers (e.g., steep, convex, convergent) and backed blades (Misra 2001).

Additional unique features of the SAUP include (i) the exploitation of ostrich eggshell fragments for making beads at Patne, Mehtakheri, Bhimbetka, Batadomba-lena, and Jwalapuram rock-shelter, and nonutilitarian artifacts such as engraved geometric or cross-hatched patterns; (ii) possibly the oldest evidence of a shrine in the region at Baghor II; (iii) stone platforms at Bhimbetka and Site 55, and bone harpoons from the Belan Valley and Jwalapuram rock-shelter (James 2007; James and Petraglia 2005; also see Table 1 in Petraglia [2007]). Some of the later Paleolithic assemblages, such as Badatomba-lena and Sites 49 and 50, comprise the earliest geometric microlithic evidence in South Asia at about 28.5 ka (James 2007). Although extensive fluvial deposits have yielded faunal remains in stratigraphic association with Paleolithic assemblages, the Kurnool Caves are the best-preserved source of Upper Paleolithic faunal assemblages and the only known source of cut-marked bones from the South Asian Paleolithic (see Chauhan, 2008b). The SAUP seems to typologically appear in the archaeological record during the middle part of the Late Pleistocene; however, a sound chronological framework is lacking. Currently, the ages from dated sites range from 45 ka (Site 55 in Pakistan) up to the terminal Pleistocene (e.g., Baghor) (Misra 1989). Associated sites and lithic assemblages are known from various parts of the subcontinent (Sankalia 1974), but the richest and best-known sites and site complexes (or stratigraphic sequences with UP assemblages) include the Son Valley sites and the Bhimbetka rock-shelters (shelters IIIF-23 and III-A-28) in Madhya Pradesh, the Kurnool caves and several river basins in Andhra Pradesh, the Belan Valley sites in Uttar Pradesh, the Singhbhum region of Bihar, Patne in Maharashtra, Mehtakheri in the Narmada Valley, Visadi in Gujarat, the Budha Pushkar region in Rajasthan, the Rohri Hills in Pakistan, the Chota Nagpur region in Bihar, the Sanghao rock-shelter and Site 55 in Pakistan, and Batadomba-lena and Fa Hien Cave in Sri Lanka (e.g., Allchin et al. 1978; Biagi and Cremaschi 1988; Ghosh 1970; Kennedy 1999; Misra 2001; Murty 1979; Raju 1988; Sali 1989; Sharma and Clark 1983). Some regions where SAUP sites are not well distributed or well preserved include Punjab, Haryana, western Bengal, Orissa, and Kerala, but their absence may be a result of survey bias (Kennedy 2000) rather than the absence of an Upper Paleolithic in these regions. In some regions such as the Thar Desert, SAUP sites are comparatively sparse, presumably related to changing climatic factors (i.e., arid and semiarid environments) (Misra 2001).

Discussion

The majority of Paleolithic sites in the Indian subcontinent are from open-air contexts near raw material sources for stone tools and water resources such as rivers, streams, ponds, lakes, and springs. The earliest Paleolithic occupation or exploitation of caves and rock-shelters appears to begin with the Late Acheulean, and includes Adamgarh, Bhimbetka, and Susrondi (Joshi 1978; Marathe 2006; Misra 1985). The occupation of such contexts visibly increases during the Middle and Upper Paleolithic and Mesolithic periods. Some ecozones of the subcontinent have yielded evidence of *regional* transitions from the Late Acheulean to the MP, and include the Orsang Valley in Gujarat (Ajitprasad 2006), the Kaladgi and Hunsgi Basins in Karnataka (Paddayya 1982; Petraglia et al. 2003), the Renigunta region in Andhra Pradesh (Murty 1966), and the Dang-Deokhuri Valleys in Nepal (Corvinus 2002). Some of these occurrences represent no visible hiatus during the Late Acheulean to Middle Paleolithic transition, while other sites have yielded sterile layers or evidence of discontinuous occupation (e.g., Chirki in Maharashtra Ansari et al. 1977). Regarding the absence of Paleolithic evidence in some parts of the Indian subcontinent, the northeast region of the subcontinent may have been avoided for long-term occupation by hominins due to its unique climatic and topographic features, which set it apart from most other ecozones. For example, Cherapunjee in the state of Meghalaya is known to receive the highest amount of rainfall in the world, a climatic feature that may have affected regional environmental conditions during the Pleistocene, including sedimentation rates, seasonal raw material availability, and access to required resources for subsistence (as compared to other regions of the subcontinent).

From a broader perspective, the geographic overlap between Late Acheulean and Middle Paleolithic sites in the Indian subcontinent attests to their technochronological relationship, a pattern evinced from global Paleolithic records (Lycett 2007; Schick 1994). For a similar regional example of a Middle-to-Upper Paleolithic transition: " . . . the Thar Upper Paleolithic appears to have emerged from the Middle Paleolithic of the region, gradually developing more refined parallel-sided blades from prepared unidirectional cores without loss of core-and-flake production that continued alongside the newer methods . . ." (Kennedy 2000, 167). The Rohri Hills in Pakistan is a rare occurrence of more or less continuous exploitation of the same raw material source—chert outcrops—from the Lower Paleolithic to Harappan times (Allchin 1976). Indeed, most regions of the subcontinent contain assemblages belonging to almost all three Paleolithic phases of technochronology, reflecting continuous occupation in various regions but at different levels (e.g., Rohri Hills in southern Pakistan; Hunsgi-Baichbal Basins in southern India; the Son valley in Madhya Pradesh). As has been demonstrated in this broad review, however, continuous stratigraphic and archaeological sequences from the Lower Paleolithic to the Upper Paleolithic and Mesolithic phases at single locations are rare in South Asia (Table 4). Exceptional occurrences have been reported from the 16R dune (Rajasthan), the Bhimbetka and Adamgarh rock-shelter complexes (Madhya Pradesh) and Attirampakkam (Tamil Nadu), all of which preserve continuous archaeological sequences. Some sites have shorter behavioral sequences, such as Patne (Maharashtra), which has Middle and Upper Paleolithic and Mesolithic assemblages but no evidence of Lower Paleolithic occupation (Fig. 5). Though these sites have variably preserved multiple technochronological horizons ranging from the Lower Paleolithic to the Mesolithic, the sequences are not stratigraphically (i.e., chronologically) continuous. For example, the sterile horizon between the Middle Paleolithic horizon and the Upper Paleolithic horizon at the 16R dune is over five meters thick. Similarly, there are major occupational gaps between *each* documented cultural horizon at Patne (i.e., between the Middle Paleolithic, Early Upper Paleolithic, Late Upper Paleolithic and the Mesolithic, respectively), and at Attirampakkam, there are three distinct sterile horizons (although the Acheulean here is more or less continuous for over four meters). What this

Table 4 Individual sites with lengthy prehistoric sequences

Site	Sequences
Attirampakkam (Tamil Nadu)	Acheulean, Middle Paleolithic, Upper Paleolithic, Mesolithic
16R dune (Didwana, Rajasthan)	Lower Paleolithic, Middle Paleolithic, Upper Paleolithic
Bhimbetka rockshelters (Madhya Pradesh)	Late Acheulean, Middle Paleolithic, Upper Paleolithic, Mesolithic
Patne (Maharashtra)	Middle Paleolithic, Early Upper Paleolithic, Late Upper Paleolithic, Mesolithic

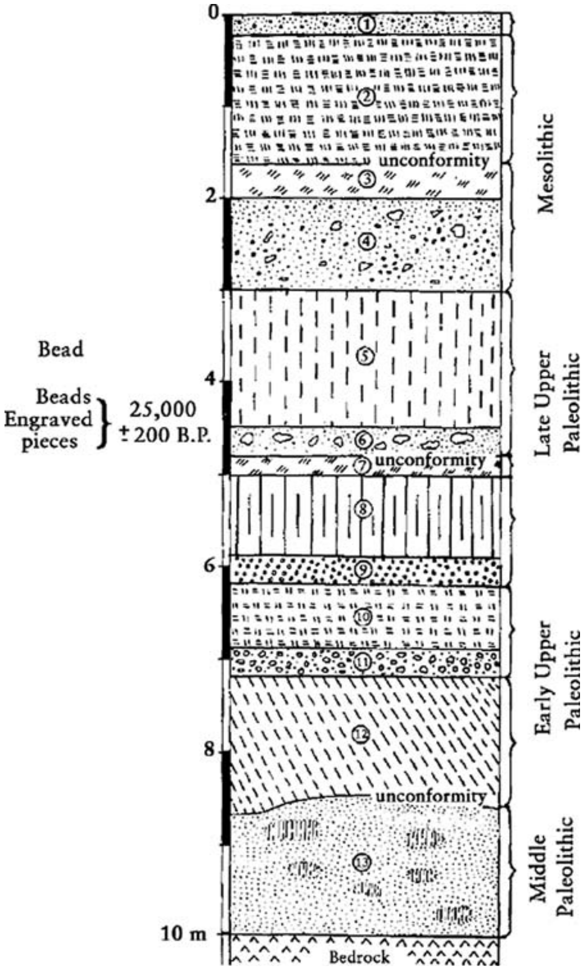

Fig. 5 The stratigraphic profile and archaeological horizons at Patne in Maharashtra (after Sali 1989)

signifies is that while the sterile horizons highlight intermittent land use patterns at such locations over time, they also preclude or severely limit attempts to reconstruct accurate transitional scenarios at these locations. For example, the absence of archaeological evidence may exist for a number of reasons (e.g., geostratigraphic discomformity, post-depositional processes, lack of preservation), rather than representing a genuine absence of hominin activity at the site. Likewise, the seemingly abrupt appearance of Paleolithic assemblages within the stratigraphic sequence of a site may not represent the first appearance of a specific lithic tradition or culture (i.e., it may be absent at that specific site but present in the region). Most importantly, the interstratification of sterile and archaeological horizons make it exceedingly difficult to (a) distinguish between gradual and abrupt archaeological transitions at specific locations and between pre-existing hominin groups and first-time occupants of the region; and (b) identify and correlate technocultural links (if any) between chronologically older and younger lithic assemblages at these locations. Finally, many of these sites, particularly those excavated decades ago and/or at a small level require re-investigations at a larger scale. For example, the 16R sequence near Didwana not only requires accurate redating but a typological revaluation of its cultural horizons, as blade frequencies and assemblage compositions of the Upper Paleolithic levels are not clearly understood (Gaillard C [pers. comm.]). In fact, the two uppermost cultural horizons may both be Middle Paleolithic, and the Upper Paleolithic component may actually be absent in the 16R sequence (Gaillard 2006; also see comments on associated "Upper Paleolithic handaxe specimens" below).

It is unclear exactly when handaxes and cleavers disappeared from the South Asian archaeological record. In the SAMP, diminutive cleavers do not appear to be as abundant as diminutive handaxes, possibly reflecting a shift to certain functional activities for which the former tools were not required. On the other hand, the Upper Paleolithic horizon at 16R (Didwana) has yielded handaxes. Though such specimens may have been produced there during the Upper Paleolithic phase, other possible factors cannot be ruled out: (i) geoarchaeological mixing, (ii) the collection and use of Acheulean handaxes by Upper Paleolithic groups. These possibilities are especially important when considering that such bifaces including handaxes have rarely been reported in such young contexts from elsewhere in the subcontinent and possibly the entire Old World. At the regional level, localities mostly vary in their artifact frequencies, assemblage compositions, geological contexts, and site densities. For example, from the Mahanadi Basin on the Orissa side and other valleys in the region such as the Brahmani, Mohapatra (1962) has reported a low frequency of Levallois flakes and an almost complete absence of prepared cores. Such traits vary at both interregional and intersite levels. Though rare, there appear to be some regional typo-technological variants within the South Asian Paleolithic. For example, the cleaver manufacturing technique from Chiri-on-Pravara (Corvinus 1983) is not found anywhere else in the subcontinent. Likewise, the Middle Paleolithic Jamalpur industry from Bihar (Pant and Jayaswal 1976) shows higher than "normal" frequencies of end-scrapers, notched tools, and denticulates, as well as typo-morphologically unique knife and scraper types. Another example of a regional Middle Paleolithic variant is the Luni industry found at Hokra and Baridhani in southwestern Rajasthan (Misra 1967). This industry may represent occupation of the Thar Desert during the last humid phase, from 45 to 25 ka (Kennedy 2000). The MP assemblages from the Rohri Hills near Sukkur in southern Pakistan also exhibit a regional pattern—one comprising large tools and chert cores with little or no preparation (Allchin 1976).

While the South Asian Paleolithic record is unique and important in its own right, it is also important to appreciate the absence of certain features that are commonly found elsewhere. Many tool types within the South Asian Paleolithic are also known from other regions of the Old World, thus suggesting broad similarities in their overall functional and behavioral aspects, as well as shared subsistence strategies. At the same time, the conspicuous absence or low profile of specific tool types, such as classic tanged bifacial (projectile) points, may reflect the absence of associated behaviors (e.g., hunting of large mammals with hafted points on short thrusting spears) in the subcontinent. Some ethnoarchaeological observations have indicated that South Asian hunter-gatherer groups regularly exploit small mammal resources (Ansari 1999, 2000), a behavior that may have also been dominant over large game hunting during the Pleistocene. Additionally, given the diverse range of functions and versatility of tool types such as handaxes, for example, the South Asian counterparts may have been utilized for purposes radically different than other regions of the Old World.

Conclusion

The behavioral record comprises both Mode 1 and Acheulean lithic assemblages, but many associated issues require clarification regarding their chronology, context, and adaptations. The known South Asian core-and-flake evidence in different parts of the subcontinent, including a large portion of the Soanian industry (Dennell and Rendell 1991), either requires absolute dating or does not appear to be Lower Paleolithic (Chauhan 2008a; Lycett 2007b). Though systematically studied and logically defended, the late Pliocene-Early Pleistocene artifacts from northern Pakistan remain equivocal and require corroboration. The earliest *unequivocal* evidence of hominin occupation of the subcontinent, particularly peninsular India, currently belongs to the earlier Acheulean tradition, which tentatively ranges from ~400 Ka to at least the Brunhes-Matuyama boundary or slightly earlier. Therefore, even if the "Oldowan-like" evidence from Pakistan is properly confirmed, there continues to be a major archaeological gap (over 1.3 myr long) between these 2 myr-old assemblages and the earliest Acheulean in the region (excluding Isampur at 1.2 Ma, which is yet to be supported by further evidence). In Sri Lanka, the earliest paleoanthropological evidence is comprised of modern human fossils dating to the middle or later half of the Late Pleistocene, and lithic industries from the Ratnapura Formation which have both Middle and Upper Paleolithic typo-technological affinities. Because many of these assemblages are not well dated, they remain ambiguous, and thus it is difficult to compare them with contemporaneous assemblages from the rest of the subcontinent. Many of these Paleolithic assemblages contain a prominent microlithic component and represent some of the earliest such occurrences in the subcontinent; they have been termed "later Paleolithic" (James and Petraglia 2005).

Most typologically Late Acheulean evidence appears to be <400 Ka and extends into the Upper Pleistocene. While differences in manufacturing refinement, cleaver to handaxe ratios, and size variations suggest two dispersals of Mode 2 technology (Bar-Yosef and Belfer-Cohen 2001), there is a possibility of an intermediate Acheulean phase in the Indian subcontinent. Lengthy and continuous sequences of Acheulean occupation at single locations have not been recovered or may not be preserved (due to hominin mobility patterns and/or post-depositional factors); therefore understanding the precise nature of the transition from Early to Late Acheulean in the subcontinent is currently difficult. Both hard- and soft-hammer percussion methods appear to have been used during the entire South Asian Paleolithic, except for Early Acheulean artifacts, which were predominantly made from hard-hammer percussion. The use of the soft-hammer method can be inferred from the types of flakes and finished artifacts recovered. No preserved evidence representing soft-hammers such as cervid antlers and wood or bone, has ever been recovered from archaeological contexts. Retouching occurs at variable degrees within these assemblages on both core tools and flake tools. Often it has been difficult to typologically distinguish retouched choppers from heavy-duty core scrapers (especially when the raw material blanks are the same), a problem commonly reported from other Old World assemblages. The emergence of Middle Paleolithic technology, marked by the prepared-core or Levallois technique, signifies a dramatic change in hominid cognition and subsistence strategies. The current chronological range for the SAMP is broadly from 150 ka to about 50 ka. The SAMP and SAUP may represent a combination of indigenous development as well as technological and behavioral influences from incoming populations. In sum, it is currently difficult to distinguish chronologically abrupt changes from gradual technological progression within the Indian subcontinent; landscape-level transitions appear to be more transparent than those at the individual site level. Despite some of the theoretical and empirical lacunae discussed in this paper, the South Asian Paleolithic record continues to have immense potential for clarifying this ambiguous but unique "transitional" evidence in a geographically vital region of Asia.

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DISCUSSION 1: An Overview of Matters Transitional, From the Outside Looking In

Angela E. Close

Abstract This is a response to other chapters in this volume and its content is largely determined by theirs. Gowlett and Chauhan tackle entire continents (Africa and South Asia, respectively) and vast periods of time. Gowlett synthesises the Plio-Pleistocene, during which nothing startling happened. Chauhan tries to do similarly for the Palaeolithic of South Asia, but is bedevilled by a lack of data. The chapters by Lycett and Blackwell et al. are methodological and I cannot assess them as fully as they deserve. Three of the seven chapters are confined to the Middle-Upper Palaeolithic transition in Europe (Clark, Soffer and Straus) and two of those (Clark and Straus) are further confined to southwestern Europe. Their emphases are deliberately upon cultural change. However, modern humans ("modern" in all respects) evolved in Africa and the European Middle-Upper Palaeolithic transition reflects their arrival in Europe and the rapid extinction of the Neandertals. I thus believe that decoupling cultural from biological change is what we should not do at this particular transition.

Keywords Hominins • Modern people • Neandertals • Symbols • Palaeolithic

The OED on "Transition"

In "*A Sourcebook of Paleolithic Transitions,*" some importance must be attached to the very notion of transition; if we claim the same mastery as Humpty Dumpty, we are likely to talk past each other. "Qualitative statements from authority" do play a role (*pace* Lycett, this volume) and I thus yield to the *Oxford English Dictionary*, where the first definition of transition is "A passing... from one condition... to another." The fourth definition refers to passing "from an earlier to a later stage of development or formation" and cites many geologists. That is, there need be nothing "sharp and abrupt" (*pace* Straus, this volume) about a transition, and the conditions on either side of the transition may well be parts of a single development. I will return to this below, where I suggest that what transpired in Europe between about 45,000 BP and 30,000 BP (these numbers may be adjusted at the reader's will) is not well-characterized as a transition.

Our Cognitive Niche

Although he takes the meaning of transition as self-evident, Gowlett's thoughtful chapter is perhaps the most purely theoretical of this group. By this, I more specifically mean "geographically widest," which is inevitable for a paper that scarcely touches upon the last 100,000 years.

Gowlett's discussion of changes in hominin brain-size through the Pliocene and Pleistocene is wonderfully liberating. People have always been the most important part of each other's environment and if, as Gowlett strongly suggests, increasing brain size was driven by the need to deal with more people—"the social brain"—then we are freed from the obligation to ponder the cognitive significance of hand axes. He

A.E. Close (✉)
Department of Anthropology, University of Washington, Seattle, WA, USA

M. Camps, P. Chauhan (eds.), *Sourcebook of Paleolithic Transitions*, DOI 10.1007/978-0-387-76487-0_8,

also stresses that the rate of increase in brain size was constant, effectively decoupling brain size and technology altogether. However, his curve does not (according to the figure caption, although they are referred to in the text as having "small brains") include the Dmanisi fossils (*Homo*), three of which have cranial capacities of about 600 cc and date to *ca*. 1.8 million years ago (Rightmire et al., 2006); nor does it include the recent find of *Homo* from Lake Turkana, which has a cranial capacity of $<$700 cc and an age of *ca*. 1.55 million years ago (Spoor et al., 2007). The Dmanisi bodies were smaller than that of the Nariokotome boy, but Lieberman (2007: 291) describes their relative brain size as falling within the range of the australopithecines. Their addition to Gowlett's figure would hardly alter the curve, if at all, and they would all fall within the grey-shaded area (which I assume to be statistically meaningless). Nonetheless, most of the Dmanisi fossils would be placed almost on top of Tobias's mean for *H. habilis*, while the newer find from Turkana is scarcely larger ($\sim$690 cc) but nearly half a million years younger.

Perhaps equally as important as large brains, is our need to classify (the same can be said of any creature with a brain and of some without). Classification is not evil (Adams and Adams, 1991); it is an essential part of how we cope with the world (and with each other). Gowlett recognizes this, and that the nature of the discipline means that some archaeological classifications will be more or less chronological—our periodizations. Furthermore, the evolution of the social brain brought about major behavioral and other changes in the creators of the archaeological record themselves, so that we can say, quite correctly, that the "Acheulean" is socially (though perhaps not technically) meaningless at a human scale, but it does not follow from this that the same would be true of, for example, the "Solutrean" (*pace* Clark, this volume).

Gowlett's suggestion (surely not tongue-in-cheek) that we tend to classify things into threes has good historical support. Caesar divided Gaul *in partes tres* (De Bello Gallico I, i, Unpublished) and then subjugated the Iron Age Britons merely by classifying them as, "Weeny, Weedy, and Weaky" (Sellar and Yeatman, 1960: 10). Modern archaeologists faced with extant bipartite classifications have felt the need to insert a third part: the original European Palaeolithic and Neolithic were later separated by the Mesolithic (Clark, 1980), and the Early Stone Age and Late Stone Age of southern Africa were similarly separated by the Middle Stone Age (Mitchell, 2002: 34), even though the definition of the last was essentially that it was neither of the other two (Thackeray, 1992: 388–390).

Turning finally to transitions and what periods of time might usefully be separated by them, Gowlett feels that for most of the Pleistocene (presumably up until some time within the last 100,000 years), artifacts were technical solutions to problems rather than markers of social persona(e), and so he is free to identify 24 technically important new ideas or concepts that appear in the Plio-Pleistocene record. His Figure 1B is perfectly in accord with my telling an introductory prehistory course, "Then nothing happened for the next million years." He identifies three revolutions (not transitions)—the first two of which each occurred over a period of a million years. McBrearty recently (2007: 134) expressed "bewilderment" that Zilhão could write of a revolution that took 70,000 years. One imagines her reaction to a million-year-long revolution, and I admit to feeling a little queasy about it myself. Perhaps it is time to abandon the word in the context of hominin cultural and biological evolution (McBrearty, 2007).

Gowlett's Figure 2 shows the accumulation of new ideas through the Pleistocene. Unlike similar recent graphics (McBrearty and Brooks, 2000: Figure 13; McBrearty, 2007: Figure 12.1), some of the concepts do have long "doubt ranges," where the age of their initial appearance is not sure. However, it remains that such models of the past are strictly cumulative, and we are adjured to abandon nineteenth-century, progressive approaches (Hovers and Kuhn, 2006: 117). Hominin cultural and biological evolution was not driven by the purpose of becoming modern, and ideas may be lost as well as found: consider the impoverishment of Tasmanian material culture after fishing was given up 3,500 years ago (Jones, 1977), although this can alternatively be seen as a positive adaptation that involved eating fattier meats (Bowdler, 1982). On the other hand, Gowlett explicitly concentrates on concepts that did survive to the present day and the scale of his charts is in millions of years. If a good idea was discovered, lost, and then rediscovered, it makes very little difference on such a time scale. Gowlett views the Big Picture in terms of who best occupied the "cognitive niche"—ourselves—and not the particularities of family members who fell by the wayside.

Transitions Assumed

Chauhan's chapter is a brave one. His coverage is less in both space and time than that of Gowlett, but the quantity of high-quality information available to him is, by comparison, vanishingly small, and not well-known outside South Asia. Chauhan has therefore felt it necessary to summarize what is known about the entire Palaeolithic of the Indian sub-continent. This may be a more manageable task than summarizing what is not known. It also makes it clear that it is very hard to think about transitions when one's data consists almost entirely of patches and scatters of stone artifacts (as well as just plain stones) that are mostly not archaeologically in situ and are rarely associated with reliable dates.

The data do manage to show that, as expected, a great deal went on during the South Asian Palaeolithic and that we are very far from understanding this variability. Chauhan concludes that "the earliest *unequivocal* evidence of hominin occupation of the subcontinent" (this volume, emphasis in the original) is early Acheulean and not much older than about 780,000 years ago. This is an admirably conservative estimate based upon South Asian evidence only. However, dates for artifacts in the Nihewan Basin (40° North) now extend back to 1.66 mya (Zhu et al., 2004), and it seems most likely that tropical hominins arrived there by way of the Indian subcontinent. Even if Ulalinka (western Siberia) should prove to be Lower Pleistocene in age, the "artifacts" are generally not accepted as such (Larichev et al., 1987: 422–424). Attempts to reinstate Diring-Ur'akh (Diring Yuriakh) (eastern Siberia) as an important Lower Pleistocene (or even Pliocene) location (Waters et al., 1997) have been equally unsuccessful. Luminescence dates indicate an age of about 300,000 years, which is extraordinary and unlikely for a site at 61° North (T. Goebel quoted by Holden, 1997). Finally, I have yet to understand why the lack of evidence for early hominin evolution in Asia can be taken as an indication that it may have occurred there (Dennell and Roebroeks, 2005). I am thus quite confident that South Asia may one day yield unequivocal evidence for the presence of hominins around 2 million years ago.

The Acheulean is certainly and abundantly present in South Asia. It is intrusive and probably African in (ultimate) origin. Petraglia has recently synthesized the South Asian Acheulean and makes an admirable attempt to humanize it (2006: 404–409), but even he says little about diachronic change. The Acheulean is generally seen as having earlier and later stages (Chauhan, this volume), but there is no evidence of what, if anything, might lie between them. The two are distinguished on the basis of the refinement of the hand axes and some change in assemblage composition, and Chauhan (this volume) is not absolutely sure that typological and chronological differences correlate. The Acheulean beyond South Asia tells us that assemblage composition can mean almost anything, while the long Acheulean sequence at Olduvai shows very little patterned change over more than a million years: "time trends are not strong and they concern general rather than detailed aspects of biface morphology" (Roe, 1994: 221). Chauhan reports that most of the (typologically) earlier Acheulean occurrences are buried and most of the later ones were on the surface. However, it is not clear that there are any direct stratigraphic relationships between the two sets. If there really is chronological separation, then the suggestion that they represent two instances of population dispersal (Bar-Yosef and Belfer-Cohen, 2001, cited by Chauhan, this volume) makes behavioral sense. Whatever their reasons, hominins were apparently in the habit of leaving Africa over and over again.

The Middle Palaeolithic also exists, there seems to be quite a lot of it, and it is extremely varied. An important part of its definition is (I infer) that it is not Acheulean. I noted above that this was originally a defining characteristic of the African Middle Stone Age, reflecting (in both cases) archaeologists' obsession with hand axes. Chauhan echoes Misra's observation that the stone tools of the South Asian Middle Palaeolithic are very similar to those made by Neanderthals during the European Middle Palaeolithic. This is also true of the North African Middle Stone Age, or Middle Palaeolithic, where it is simply convergence or coincidence—there having been no Neanderthals in Africa. Very late Neanderthals did begin to expand into new territories, but this was eastward and northward into central Asia and Siberia (Krause et al., 2007), as might be expected of a cold-adapted hominin. I think it very unlikely that there were ever Neanderthals in South Asia.

On the other hand, at least some of the later Middle Palaeolithic artifacts in South Asia must be the work of modern human beings, who (it is assumed) took the southern route eastwards, arriving in Australia before 40,000 years ago. In the Thar Desert, in the northwestern part of the subcontinent, the Upper Palaeolithic developed gradually out of the Middle Palaeolithic (Chauhan, this volume). *Homo sapiens* would have arrived first in the northwestern area, and such a smooth transition may reflect the role of modern humans as creators of both the local Middle and Upper Palaeolithic. In this respect, I am much intrigued by the absence of modern humans from Sri Lanka before about 30,000 years ago—at least ten millennia after their conspecifics to the east had boated from Sunda to Sahul.

Chauhan regards the Upper Palaeolithic as less well-defined or understood than either the Lower or Middle Palaeolithic. I had previously been happily unaware of the South Asian facies of the Magdalenian and, indeed, such miscegenation may be symptomatic of a major problem underlying the impenetrability of the South Asian Palaeolithic. Even into very recent times, there seems to have been a determined effort by archaeologists working in South Asia to force their data into the mould of the European Pleistocene and Palaeolithic and, in particular, the Pleistocene and Palaeolithic of western Europe.

> (T)his sequence (of river terraces in northern India) appears to run more or less parallel with that long ago determined first in the Alps and later in Northern Europe ... As, both in Europe and in India, man-made tools have been found in many of the river terraces associated with this sequence of climatic changes, one would expect that the long-distance correlation established between the natural phenomena would be repeated in the tool types – and this is indeed the case, with parallel evolution in techniques taking place in both areas (Piggott, 1950: 26).

Europe is a very small place that lies thousands of kilometers away from the Indian subcontinent. On both micro and macro scales, it is environmentally very different from South Asia, so I consider it highly unlikely that hominins in the two regions should have responded in similar ways to the climatic fluctuations of the Pleistocene. This approach is, of course, ultimately a product of an Empire. I am surprised at its persistence so long after the end of imperial rule.

Chauhan bravely concludes, "(I)t is currently difficult to distinguish chronologically abrupt changes vs. gradual technological progression within the region;" this is incontestable. There was a Palaeolithic in South Asia. It lasted a long time and was not exactly the same throughout that time, therefore there must have been transitions (*Transeanda in alia sunt*).

Comparative Morphometrics

Lycett's contribution is methodological and, as his subtitle indicates, application of his methods is not limited to transitions per se. I admit to being one of those whom Lycett wryly describes as having colleagues in physical (biocultural) anthropology "only a few doors away," and I have been quite unaware of comparative morphometric analyses. However, a recent cladistic analysis of the hominins (González-José et al., 2008), based upon comparative morphometrics, gave results that are so close to my own view of the world that I am already (almost) a convert.

My conversion is qualified for two reasons. The first is one that Lycett notes: stone artifacts have very few (agreed-upon) landmarks (or points of correspondence or equivalence) so that very few equivalent ("homologous" in morphometrics) measurements can be made. The second is one at which Lycett only hints: the shapes of hominin bones were determined initially by genes, which did not have agency, while the shapes of stone artifacts were determined by hominins themselves, who did have agency. The nature of variability in crania is probably not the same as that of variability in handaxes.

Lycett then goes on to outline two applications of the technique, of which I shall essentially ignore the second. "Soanian" and "road metal" look well together in a single sentence, while Grahame Clark's system of modes was not one of his major contributions to archaeology (Gowlett, this volume). The Acheulean, on the other hand, seems to exist.

On the basis of morphometric data, discriminant function analysis (Lycett's Fig. 1) assigns some 70% of the hand axes correctly to a site (so about one in three is incorrect). This is "inconsistent with any suggestion that Acheulean samples are highly homogeneous"—a statement that is unobjectionable, although I do not know who would make such a suggestion. Groups of hand axes of differing provenance can, indeed, appear somewhat different from each other, and this is especially true of the "typical" or "characteristic" examples that were formerly traded among museums.

Lycett's Fig. 1 also makes a separation between African and nonAfrican hand axes. Except for the Lewa sample, the separation would be quite subtle if the centroids were not labeled, and probably impossible to spot if the centroids were omitted altogether. Thus, in addition to fine differences between sites, the technique has also succeeded in identifying patterned variations on a continental scale. However, we have long known that (subSaharan) African hand axes were often made on large flakes while nonAfrican hand axes were not (with the exception of the earlier layers of Gesher Banaat Ya'aqov (Bar-Yosef, 1994: 241-244)), but the morphometric data used here (specifically, the lack of measurements of thickness) give no indication of whether or not this might be what is driving the detected separation.

Lycett's thesis is not well-served by the examples he has used (and I recognize that he probably would have preferred others), so I sound much more negative than I really am. Morphometrics is obviously a very powerful quantitative tool and it is unfortunate that Palaeolithic archaeologists did not become aware of it decades ago. Lycett (this volume) refers to "the pioneering work of Roe, Bordes, and Isaac," and laments that little progress has been made since. Indeed, Roe's analyses of the later material from Olduvai (Roe, 1994) essentially follow the methods he laid out in 1968 (Roe, 1968). In fairness (and in parentheses), one notes that Roe's analyses are what he was asked to do in 1969 and were carried out in the mid-1970s. The publication by Isaac that Lycett cites is the formal monograph on Olorgesailie (Isaac, 1977), but by the beginning of the 1980s, not long before his death, Glynn Isaac had moved in a different direction (for reasons that were not "potentially more pernicious" [Lycett, this volume]). It is instructive to compare the second paragraph of Lycett's chapter (this volume) with a historical and synthetical paper written by Glynn at that time.

> During the late 1960s there was a strong if unstated sense that the first order of business for paleolithic archaeology was to amass a large series of quantitative analyses of assemblages ... All of us ... seemed to share a tacit assumption that what we wanted to know about early prehistory would in large measure emerge from comparative study of quantitative data. It seemed that it would be possible to recognize *stages* (i.e., time-bounded sets), *regional variants* (i.e., culture-geographic entities), and *activity facies*, and that knowledge of the characteristics of these classificatory entities would be a basis for understanding technological development, adaptation, ecology, and culture history. This aspiration is still inherently reasonable, but emphasis and priority have shifted in subtle ways... [b]ecause many researchers came to realize that what the standardized quantitative analyses were mainly producing was numbers rather than understanding (Isaac, 1984: 44; emphases in the original).

Lycett is correct that the methods of comparative morphometric analysis hold great potential for the study of flaked stone, whether transitions are involved or not, and they should find a place in the Palaeolithic archaeologists' tool box. His final paragraph is thought-provoking and one tries to think of ways to use morphometrics in one's own data sets. In the very end, however, he is mistaken: if the archaeological profession can turn the methods of GISc into plug-and-play, I am sure we can do the same with those of morphometrics.

Dating: The *sine qua non*

The chapter by Blackwell and colleagues on ESR dating is also methodological, and their main point is the unassailable one that dating (as accurate as possible) is essential if one is to look beyond the limits of a single site. I add that the Radiocarbon Revolution (I believe it was short enough to count as a revolution (McBrearty, 2007)) has taught us that useful consideration of transitions at any scale is impossible without something more than the relative chronology given by stratification. Beyond the range of radiocarbon—which is where almost all of prehistory lies—dating is problematic for those areas not blessed with local vulcanism. Blackwell and colleagues suggest that the lower limit for $^{40}Ar/^{39}Ar$ is 50,000–200,000 years, but with dedicated equipment, dates can be obtained within the Holocene. Indeed, one of the first $^{40}Ar/^{39}Ar$ dates to be run was on artifacts from the eruption of Vesuvius that destroyed Pompeii; the result was not quite as accurate as the known historical date (1929 BP, or AD 79), but the range was correct (1935 BP ± 94 years) (Deino et al., 1998: 74). In any case, the point is that vulcanism is far from ubiquitous.

ESR is not the only dating technique that extends beyond the radiocarbon limit. My academic affiliation gives me a prejudice for luminescence dating, but I recognize that even luminescence can be abused (Jinmium comes to mind). Blackwell and others give several examples of ESR dating in contexts where other techniques were inapplicable or gave inconsistent results. I was bemused to encounter the resurrected "flute" from Divje Babe I. On the other hand, since I was also unaware of the "unambiguous evidence for human worship of cave bear skulls" (Blackwell et al., this volume), this is probably a result of my own ignorance. In passing, I note that a musical instrument of this type is named "pipe," rather than "flute" (d'Errico et al., 2003: 41).

Hominins and Hominids

The remaining three chapters are concerned only with parts of Europe and only with what happened between the Middle Palaeolithic and the Upper Palaeolithic periods: determinedly and explicitly in the cases of Soffer and Straus; and somewhat less so in the case of Clark, although he is clearly most comfortable in southwestern Europe. Hoping to minimize confusion, I point out that, unlike Gowlett, Chauhan, and Lycett, the three Europeanists retain the older meaning of "hominid" (shades of Humpty Dumpty!). In current usage, the living hominids are the great apes (*Pan*, *Gorilla*, and *Pongo*) and ourselves (*Homo*). Fossil hominids are those believed to fall within the same family (Hominidae) and may be ancestral to one or more of the living hominids, or not. We are the only living hominins. Fossil hominins all share a common ancestor not shared by other hominids and may be our ancestors or not (as in the cases of *Paranthropus, H. erectus* and *H. neanderthalensis*). Alternatively, the living hominins are *Pan* (bonobos and chimpanzees) and ourselves, while the fossil hominins have a common ancestor not shared by *Gorilla* and *Pongo* (Cameron and Groves, 2004: p. 61). Since the entire fossil record for the genus *Pan* consists of a few teeth dating to long after the emergence of the genus *Homo* (McBrearty and Jablonski, 2005), one's preferred definition of hominin makes essentially no difference in terms of fossils.

HDM, HBE, Science, and History

Having gotten past the teratoid "paleoarchaeology," I found that Clark's chapter is primarily concerned with insisting that archaeology should be science rather than history, without really explaining why. To assert that "History, of course, is another matter altogether" (Clark, this volume), does not clarify anything. I infer that he believes that "science" must use the hypothetico-deductive method (HDM) and should involve replicable experiments whenever possible. Philosophers of science found logical positivism (*sensu* Popper) and HDM to be wanting many years ago (A. Wylie, 2008, pers. comm.). Wylie prefers to define science of any kind simply as "systematic, empirical enquiry." Schiffer claims to be a scientist and a positivist *sensu* Comte: "striving to create positive knowledge for illuminating the empirical realm of human behavior" (Schiffer, 1999: 7). Scholars as varied as Collingwood and Foucault have not hesitated to classify history as a science (Taylor, 2008), and Trigger has noted (*pace* Clark) that "(H)istory and evolution are complementary rather than antithetical concepts" (1989: 19). Archaeologists as temporally and theoretically separate as Childe (1942) and Barker (2008) have stated that history, with all its particularity, is what archaeologists should be doing.

Clark believes that (in particular) we must abandon the analytical units derived from cultural history because they are not reproduced within the framework of behavioral ecology, outside of which nothing worthwhile can be done. I disagree. Although Clark refers repeatedly to *human* behavioral ecology (HBE), there is nothing specifically human about it and nor even specifically primate. At the heart of behavioral ecology is the assumption of optimal adaptations resulting from the making of various trade offs. Optimality is measured ultimately in reproductive success and proximately (usually) in terms of energy (humans were not mentioned in the previous two sentences). As humans, we deal in many currencies other than energy. In practice, behavioral ecology ignores the other currencies, largely because they are hard to quantify, and so we are left with *Homo economicus*—an impossible hominin. Referring to primates as a whole, Thierry writes, "Societies are integrated systems (*sic*) made of multiple relations that individuals generate through interaction processes. Such interconnections limit the number of structures that can be realized, thus exerting strong stabilizing selection that opposes the adaptive changes possibly required by the ecological milieu" (2008: 95).

Clark makes many points to which I cannot respond without writing a chapter as long as his own. However, one of his major points is that the analytical units of Palaeolithic cultural history are based upon the classification of flaked stone, especially (in the period of concern here) the classification of retouched flakes, or tool typology. (Gowlett [this volume] gives a splendid alternative view of hand axes.) He quotes Sackett's remark that typology is hard to do—as, indeed, it is—but Sackett was referring to "intergradation between *types*" (1988: 418; emphasis added). Intergradation is not often a problem with Upper Palaeolithic tool classes: backed blades do not grade into burins (although a single artifact can be both). Clark continues with the assertion that, "*all* paleolithic tools... were heavily subjected to modification over their use-lives by continual use, breakage, subsequent rejuvenation and/or intentional reworking" (emphasis in the original). This is something that is impossible to know as true, but that is possible to know to be untrue. He wraps up the matter of typology with phrases such as "any hypothetical 'cultural' component" and "even if there were a 'cultural' component in the form of paleolithic stone artifacts." This is reminiscent of Binford's and Ho's assessment that Zhoukoudian Locality 1 reveals "a noncultural form of adaptation that is strongly tool-assisted" (Binford and Ho, 1985: 429). The flaking of stone is not instinctive, but was taught and learned in a social context. How could there not be a social/cultural component?

Clark regards the units of culture history as "accidents of history" and so they are—not because Peyrony, Perrot, Breuil, or Bordes were in certain places at certain times, but because they are historically contingent. Scientists who investigate things that have changed through time have to deal with unique (historically contingent) events that often cannot be experimentally reproduced. This applies to the cultural and biological evolution of hominins as much as it does to the evolution of the universe or the evolution of fishes. It is not really problematic, since science is simply "systematic, empirical enquiry."

Clark further observes that ethnohistoric traditions have shorter lifespans than Palaeolithic units (an inevitable result of the shortness of history), but we have gone beyond seeing such traditions as fossilized remnants even of the Upper Palaeolithic world, much less the world of a different species of hominin. In short, I see no reason why Neanderthals could not have maintained the same, boring, tool-making tradition for some 40,000 years. From my own work in North Africa, I have no doubt that the stratified sequence of Tamar Hat (Algeria) records the maintenance by modern humans of a very specific, Late Palaeolithic, tool-making tradition for almost 6,000 years (Close, 1980–1981), a conclusion reaffirmed by a more recent and more detailed examination of the artifacts (Merzoug and Sari, 2008), and matched by the tradition of faunal exploitation (Saxon, 1975). Merzoug and Sari conclude quite reasonably that, "The perennial nature of knowledge and know-how of Tamar Hat Iberomaurusian peoples ... reflects good control of their environment (*sic*) resources" (2008: 71).

Having apparently spent most of a lengthy chapter comparing the virtues of behavioral ecology with the vices of culture history, Clark denies claiming that one is better than the other. The denial is honestly meant since he uses the analytical units of culture history to measure the variability within the Mousterian of western Eurasia (Tables 7.1 and 7.2), which he says might even exceed that of the early Upper Palaeolithic. This is not surprising, since the Mousterian, as he observes, covers some 200,000 years (at least), but the early Upper Palaeolithic lasted either no more than 15,000 years, or 20,000 years at the very most (depending on what the early Upper Palaeolithic is). Based on this (but not exclusively), Clark sees a temporal and spatial mosaic "that long precedes and long postdates the Middle-Upper Paleolithic transition." Considerable variability before and afterwards is not the same thing as continuity.

Neandertals, Agency, and the Other

I am very much in sympathy with the approach adopted by Soffer. The past was populated by self-interested individuals whose own needs varied and had to be continuously renegotiated with other members of the "group." These negotiations, particularly with those members who were physically present, shaped what the group actually did. It is the primate way of doing things (Thierry, 2008). Like Soffer, I regard our primate heritage as crucial, although I would interpret it somewhat differently. Not all primates are equally relevant to human behavior, and I believe our closest relatives—bonobos and chimpanzees—to be more informative than all the lemurs combined (who are of course excellent prosimians, as prosimians go).

Thus, while "most African primates" show a pattern of female philopatry (Soffer, this volume), I consider this outweighed by the facts that both bonobos and chimpanzees practice female dispersal, and that the long-term core of the group is composed of related males. This does not determine intrasex bonding: the core of a bonobo group is strongly bonded, unrelated adult females. It does, however, mean that allomothering cannot be done by grandmothers, since their daughters leave the group to breed elsewhere.

Consideration of bonobo and chimpanzee social relationships leads me to another difference from Soffer. I agree entirely that the socially defined "fault lines" of age and sex appear to be universal, but I would also add social inequality. The adults in bonobo and chimpanzee society consist, in essence, of mothers and their sons. The adult males—the sons—have clearly defined and maintained rankings among themselves, and a major factor in that ranking is the rank of the mother among the adult females (McGrew, 2004: 157–159). That is, in both species we see inherited inequality. I suggest that, for both *Homo* and *Pan*, socially constructed divisions by age, sex, and inherited rank are plesiomorphic (as is also female dispersal) and could have been seen in some guise even among Pliocene hominins.

Food-sharing, particularly of meat, is widely reported among bonobos and chimps, and bonobos have been observed to share plant foods. Cameron and Groves (2004: 75–77) also report that sexual division of labor is "incipiently present" in both *Pan* (one thinks of the Gombe males beating the bounds of their territory) and *Gorilla*; one may therefore infer it for all hominins.

Soffer's suggestion that the last Neanderthals were occupying what were, for them, desirable areas is novel (I believe) and intriguing. It has been easy to assume, since they are found in the spatial margins of Europe, that they had been pushed back into economically marginal areas. On a pan-European scale, the last Neanderthals and incoming moderns overlapped by more than 10,000 years (the modern human mandible from Oase is older than 40,000 [calendar] years, on the basis of radiocarbon and uranium-series dates and correlation with the GISP2 core (Zilhão et al., 2007)). One wonders why the moderns did not find the last Neanderthal territories desirable (I make the prejudiced assumption that moderns could have taken those areas if they had wanted to), or perhaps they occupied similarly desirable areas elsewhere.

A more material and more enigmatic part of the archaeological record is that which might be symbolic. Potential pigments occur in Middle Palaeolithic sites, but Soffer regards them as "dubious proxies" for symbolism because they can also have practical uses (Wadley et al., 2004); I believe she is correct but for different reasons. Hafting is the only serious contender as a practical use for ochre—its use as a preservative in tanning (as opposed to coloring) hide is confined to the laboratory. The pigments in African Middle Stone Age sites, known >280,000 years ago (McBrearty and Brooks, 2000), are worked pieces of *red* (occasionally brown) ochre. Hovers et al. (2003), discussing the deliberate selection of ochre in saturated reds for the burials in Qafzeh, note that humans universally respond to red, above all other colors. In contrast, most of the potential pigments in the European Middle Palaeolithic are *black* manganese oxides (Mellars, 1996: 369–370), and thus less likely to be of symbolic significance (assuming that Neanderthals responded to colors in the same way as we do).

Apart from pigment, Soffer essentially sees no other evidence for symbolism in the European Middle Palaeolithic and discounts the very few possibilities on the grounds that they are, indeed, very few. Since symbolism is shared among initiates, a single example cannot prove symboling.

Cultural Change Only

It was Straus's chapter that finally made me aware of how different the "European Middle-Upper Palaeolithic transition" looks when seen from south of the Mediterranean. Straus is at pains to show that several traits seen as typically Upper Palaeolithic are also found in the Middle Palaeolithic. Since the magisterial debunking of the European trait list by McBrearty and Brooks (2000; McBrearty, 2007), most (all?), Africanists no longer think in those terms. Of course, Neanderthals controlled fire! After a few years in the scavenging guild, Neanderthals are now firmly re-established as active hunters. In fact, given their specialization in mammoth and wooly rhinoceros (Bocherens et al., 2001, 2005), they can be ranked at the top of the carnivore guild. A few (that we know of) Neanderthals were deliberately buried, although to state that, "the [UP] situation does not seem to be radically different from that of the MP with respect to burial frequencies or practices" (Straus, this volume) seems to willfully ignore Skhul and Qafzeh (burials of modern humans earlier than any Neanderthal burials) with their shell beads and carefully selected fine red ochre (Hovers et al., 2003), not to mention the spectacular burials at Vestonice and Sungir. It is also true that "art" is not common in the Aurignacian, but the German figurines do exist, as does the cave of Chauvet. Finally, there are indeed changes and variety in the European Middle Palaeolithic. That is not the point.

Both Soffer and Straus are emphatic that we should not consider which hominin (*H. neanderthalensis* or *H. sapiens* [Straus adds a third one—"*Homo sapiens* (*sensu lato*)"]) was doing what. Soffer deals with "an end to a particular way of life," while Straus is concerned about "what was going on in the complex world of *cultural* change" (emphasis in the original). I am baffled by this. As an archaeologist, I am driven by an interest in what people were doing, not by my passion for backed bladelets (not completely). In a situation with two hominins on the ground, their identification in any particular instance seems to me to be crucial. I believe that Soffer would agree, or she would not have written about imagining The Other or the importance of differences between Neanderthal and modern bodies. Straus, however, regards this as a currently "unknowable question," and therefore irrelevant.

Ex Africa semper aliquid novi (Pliny)

Modern human beings (*Homo sapiens*) had evolved in Africa by 200,000 years ago (McDougall et al., 2005). Historically, as the appearance of moderns has become ever more clearly an African phenomenon, a distinction came to be made between "anatomically modern humans" and "behaviorally modern humans"—the fiercest proponent of this distinction probably being Richard Klein (who discussed it at some length in 1999). In retrospect, it seems an odd distinction to make (Marean, 2007), but it led to numerous attempts to define "modern behavior," centering on (Klein's) trait list. Since 2000, definitions have become more nuanced. Soffer (this volume) suggests "institutionalized interdependence," while others invoke symbolism in some way: "symbolically organized behavior: (Chase, 2003: 637); "fully symbolic *sapiens* behavior" (Henshilwood and Marean, 2003: 644 [which automatically excludes any other hominin]); and symbolic external storage (Donald, 1998, cited by Henshilwood, 2007).

Thus, symbolism seems to be a core part of modernity, and is also better defined than "modernity;" I shall therefore confine myself to symbolism only. Soffer sees no evidence for symboling by Neanderthals other than potential black pigment (see above); Straus (this volume) finds Neanderthal "art" only sporadically (except for the late Neandertals at Arcy-sur-Cure, who are a cottage industry unto themselves and beyond my charge).

"Personal ornaments," including beads, are generally seen as symbolic. In Africa (or Greater Africa, to use Klein's felicitous term), there are now *Nassarius*-shell beads discovered in material from early excavations at Skhul (Israel) and Oued Djebbana (Algeria) (Vanhaeren et al., 2006). The former is >100,000 years old and associated with modern humans; the latter, an Aterian site, could well be of comparable age and long postdates the appearance of moderns throughout Africa. It is significant that both were stored in museum collections for decades, but were not noticed until someone thought to look. The numerous (>65) *Nassarius* shell beads from Blombos (South Africa) (*ca.* 73,000–77,000 years ago) occurred in clusters of up to 17 beads, suggesting pieces of beadwork with up to 17 beads (Henshilwood, 2007: 126–127). Their discovery results from meticulous excavation and an open mind. The same two factors have led to the finding of engraved ostrich egg shells in the Middle Stone Age of Diepkloof (South Africa), which is a little later (Parkington et al., 2005).

Above, I briefly discussed the probable use of red ochre as pigment from a very early period in Africa. Blombos has also yielded two pieces of ochre with faces ground flat and then incised with very similar cross-hatched designs.

In sum, there is good evidence that anatomically archaic hominins, whose behavior was *not* symbolically mediated, occupied Europe for at least 150,000 years, while anatomically modern hominins, whose behavior *was* symbolically mediated, occupied Africa. This is not in any way dependent on our artificial constructs (Clark, Soffer, Straus) of Middle and Upper Palaeolithic, Middle and Late Stone Age, Châtelperronian, Aurignacian, "transitional industries," or any of those things. It depends on dating, hominin fossils, and some artifacts peculiar to Africa.

Some modern Africans left Africa and, by about 40,000 years ago, some of them appeared in Europe, which had been—and at that time still was—home to the Neanderthals for hundreds of thousands of years. Fifteen thousand years later, there were no Neanderthals. The hominin fossil evidence "supports a scenario of abrupt replacement," while the genetic evidence indicates that "even [a] very small Neanderthal contribution to modern human populations can be ruled out" (Hublin, 2007: 242). That is, the Middle-to-Upper Palaeolithic transition in Europe has a biological explanation: one hominin species completely replaced another. Material culture, the very stuff of archaeology, was made by human agents. When one human species is replaced by another, change in material culture has to be examined in that light.

We are the only occupants of the cognitive niche. This is a very recent thing in hominin evolution, having come about less than 30,000 years ago with the demise of the last Neanderthals (or perhaps 12,000 years ago if *H. floresiensis* existed). The earliest (African) hominins seem to have been quite speciose, and it would be delightful to suppose that the social brain grew to cope with other forms of hominins as well as conspecifics. Now, however, we are alone and apparently lonely.

An important reason—perhaps *the* reason—for our fascination with THE TRANSITION is that it was a period when modern humans (US) really did encounter the Other; and that the Neandertals (THEM) did not survive the encounter is not a surprise—but, for as long as they did exist, they were certainly the Other. "In Europe, the first modern humans met other humans displaying biological differences far beyond anything observed within Late Pleistocene and Holocene *Homo sapiens*" (Hublin, 2007: 244).

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Part II
Changes Within the Lower Paleolithic

From Nothing to Something: The Appearance and Context of the Earliest Archaeological Record

Michael J. Rogers and Sileshi Semaw

Abstract Before 2.6 million years ago (Ma), no archaeological record has been securely documented, and therefore there is no evidence of hominin tool use. Then, at 2.6–2.58 Ma, there is widespread evidence for tool manufacture and use at several archaeological sites, with undisputed stone tools and fossil fauna at Gona, Ethiopia. Additionally, the evidence from the earliest archaeological sites at Gona shows that the earliest stone tool makers were skilled flintknappers and were able to select high quality stone raw materials. The possible reasons behind this seeming abrupt transition from the absence of stone tools to the presence thereof include sampling biases, paleogeographic influences, gaps in the geological record, paleoenvironmental change, and changes in the record of hominin evolution.

Based on our observations at Gona, the earliest use of flaked stone tools is likely to be slightly older than 2.6 Ma. These stone tools represent a significant change in behavior that set the stage for subsequent hominin evolution. The paleogeographic and paleoenvironmental evidence points to the earliest use of stone tools in certain settings: usually (but not always) close to raw material sources, and ecotones between riparian woodlands and open grasslands. The earliest stone tool makers were proficient, selective, and flexible in their reduction strategies. The variability we see in Pliocene artifact assemblages has much to do with different raw material sources.

M.J. Rogers (✉)
Department of Anthropology, Southern Connecticut State University, New Haven, CT, USA

Keywords Early Stone Age • Paleoenvironments • Gona • Oldowan • Pliocene • Stone tools

Introduction

Twenty-five years ago, the earliest archaeological record was known primarily through several excavated sites at Olduvai Gorge (Tanzania) and Koobi Fora (Kenya). Dated to 1.9–1.6 Ma, the stone artifacts found at these sites served as the basis for what we knew about the Oldowan, the simplest known hominin technology. Archaeologists had excavated a handful of other Oldowan sites—including those that were thought to be slightly older in Members E and F in the Shungura Formation (Chavaillon 1976; Merrick et al. 1973), and in the Kada Hadar Member of the Hadar Formation (Corvinus 1975; Harris 1983; Roche and Tiercelin 1980, 1977)—but these were small sites, sometimes with imprecise dating and/or uncertain context, and were therefore either brought into question or omitted from discussion of the earliest human behavioral traces (e.g., Isaac 1984; Leakey 1981; Toth and Schick 1993). Research undertaken in the last decade has shown that the Oldowan archaeological record represented at Olduvai and Koobi Fora is in fact 700,000–900,000 years *later* than the earliest archaeological record, now documented at 2.6 Ma at Gona, Ethiopia (Semaw et al. 2003, 1997). Recent work has also shown that this early record is more widespread than previously known, as research

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projects at West Turkana and Kanjera in Kenya, and Middle Awash, Hadar, and Gona in Ethiopia have all added to the late Pliocene evidence. As additional sites have been securely dated to pre-2.0 Ma, there has been more interest in speculating about the timing and causes of the earliest hominin use of technology (e.g., de Beaune 2004; Foley and Lahr 2003; Panger et al. 2002), linking the earliest use of stone tools with climate change (often explicitly or implicitly tied to the emergence of the genus *Homo* [e.g., Bobe and Behrensmeyer 2004; Bobe et al. 2002; Harris 1983; Potts 1998; Stanley 1992; Vrba 1985; Wynn 2004]), and explaining the apparent variability of this early stone technology (e.g. de la Torre 2004; de Lumley et al. 2005; Delagnes and Roche 2005; Plummer 2004; Roche 2000; Semaw 2006, 2000).

In this paper, we review what is now known of the (still) sparse late Pliocene archaeological record, with particular reference to the paleogeographic and paleoenvironmental context of the earliest archaeological sites. Our own research at Gona is highlighted here because of its early age as well as its large number of localities that have been investigated. We also briefly explore the reasons behind some of the differences that have been noted among some of the late Pliocene artifact assemblages. This overview is not meant as a comprehensive review of the Oldowan archaeological record and ongoing theoretical debates surrounding it, as Plummer (2004) has provided recently, but as a succinct synthesis of the earliest archaeological record, with the hope that this will put future investigations into broad paleoecological and evolutionary perspective. We also hope that this brief discussion of arguably the most important archaeological transition—the transition from the apparent absence of a human/hominin tool-making tradition to the presence of such a tradition—will help to put all subsequent archaeological transitions described in this volume into broader perspective.

Summary of Archaeological Sites >2.0 Ma

As a means of highlighting the gaps in our knowledge and the sparseness of the late Pliocene archaeological record, in Table 1 we have placed the known excavated sites from primary contexts in chronological order within 100,000-year time intervals from 2.6 to 2.0 Ma.

Tables 2 and 3 present what is known of late Pliocene archaeological sites. Table 2 summarizes the material evidence found at the sites, and Table 3 focuses on the paleogeographic and paleoenvironmental data that derive from the sites themselves and/or the beds in which the sites are found, contributing to regional paleoenvironmental reconstructions.

Due to the paucity of sites, as well as the vagaries of site dates and dating precision, it makes some sense to consider these late Pliocene sites in three temporal periods: 2.3–2.0 Ma, 2.4–2.3 Ma, and 2.6–2.5 Ma.

Table 1 Excavated, primary context archaeological sites $\geq$ 2.0 Ma

2.6–2.5 Ma	2.5 Ma	2.4–2.3 Ma	2.3–2.2 Ma	2.2–2.1 Ma	2.1–2.0 Ma
Gona: EG 10, 12, 13, 24; OGS 7, 6 DAN 1 BSN 6	*Middle Awash:* Hata Mb	*Omo:* FtJi 2, Omo 123	*Gona:* DAN 2		*Kanjera South:* Excavation 1
		West Turkana: Lokalalei 1, 2C			*Gona:* OGS 3, (OGN 3)
		Hadar: AL 666, AL 894			
		Gona: WG 1			

Table 2 Summary of materials found at excavated Oldowan sites older than 2.0 Ma

Site	Locality	Age (Ma)	Material evidence	Stone Raw Materials*	Paleogeography	Associated Hominins	Source(s)
Gona	OGS-6a	2.6–2.55	Lithics, fauna	T, AL, R, B, La, VV, QL	Floodplain of paleo-Awash	None	Semaw et al. (2003); Quade et al. (2004); Stout et al. (2005)
	OGS-7	2.6–2.55	Lithics, fauna	R, AL, La, QL, VV, T, B	Bank of paleo-Awash	None	Semaw et al. (2003); Quade et al. (2004); Stout et al. (2005)
	EG-10	2.6–2.55	Lithics	T, R, B	Proximal floodplain of paleo-Awash	None	Semaw et al. (1997); Semaw (2000); Quade et al. (2004)
	EG-12	2.6–2.55	Lithics	T, R, B	Proximal floodplain of paleo-Awash	None	Semaw et al. (1997); Semaw (2000); Quade et al. (2004)
	EG-13	2.6–2.55	Lithics, fauna	T, R, La, AL, B, QL, VV	Proximal floodplain of paleo-Awash	None	Semaw et al. (1997); Stout et al. (2005); Quade et al. (2004)
	EG-24	2.6–2.55	Lithics	T, R, B?	Floodplain of paleo-Awash	None	Quade et al. (2004)
	DAN-1	2.6–2.5	Lithics	T, R, AL, La, VV, QL, B	Proximal floodplain of paleo-Awash	None	Stout et al. (2005); Quade et al. (2004)
	Kada Gona 2-3-4	2.6–2.5	Lithics	B, T	Bank of paleo-Awash?	None	Roche and Tiercelin (1980); Roche (1996)
	DAN-2d	2.5–2.2	Lithics, fauna	T, R, AL, La, VV, QL, B	Proximal floodplain of paleo-Awash	None	Stout et al. (2005)
	WG-1	2.5–2.3	Lithics, fauna	B, T	Proximal floodplain of paleo-Awash	None	Harris (1983); Harris and Capaldo (1993); Quade et al. (2004)
Middle Awash	Bouri, Hata Member	2.5	Cutmarked bones	None	Shallow lake margin	*A. garhi*	de Heinzelin et al. (1999)
Omo, Shungura	FtJi 1	2.34–2.3	Lithics, fauna	Q, C, L	Braided channel—derived context	*A. aethiopicus? Homo sp.?*	Merrick and Merrick (1976); Howell et al. (1987)
	FtJi 2	2.34–2.3	Lithics	Q	Proximal floodplain of meandering proto-Omo	*A. aethiopicus? Homo sp.?*	Merrick and Merrick (1976); Howell et al. (1987)

Table 2 (continued)

Site	Locality	Age (Ma)	Material evidence	Stone Raw Materials*	Paleogeography	Associated Hominins	Source(s)
	FtJi 5	2.34–2.3	Lithics, fauna	Q	Braided channel—derived context	*A. aethiopicus?* *Homo sp.?*	Merrick and Merrick (1976); Howell et al. (1987)
	Omo 57	2.34–2.3	Lithics	Q, C, L, Qt	Braided channel—derived context?	*A. aethiopicus?* *Homo sp.?*	Chavaillon (1976); Howell et al. (1987); de la Torre (2004)
	Omo 123	2.34–2.3	Lithics	Q, C, L, Qt	Proximal floodplain of meandering proto-Omo	*A. aethiopicus?* *Homo sp.?*	Chavaillon (1976); Howell et al. (1987); de la Torre (2004)
West Turkana	Lokalalei 1	2.33	Lithics, fauna	L	Floodplain of axial river, near ephemeral stream	*Homo sp.?*	Kibunjia (1994); Prat et al. (2005); Quinn et al. (2008)
	Lokalalei 2C	2.33–2.23	Lithics, fauna	P, B	Floodplain of axial river, near ephemeral stream	*Homo sp.?*	Roche et al. (1999); Delagnes and Roche (2005); Prat et al. (2005); Quinn et al. (2008)
Hadar	AL 666	2.33–2.36	Lithics, fauna	B, C	Levee of paleo-Awash; Crevasse splay of medial floodplain	*Homo sp.*	Kimbel et al. (1996); Hovers et al. (2002); Hovers et al. (2008)
	AL 894	2.33–2.36	Lithics, fauna	L	Levee of paleo-Awash; Crevasse splay of distal floodplain	*Homo sp.?*	Hovers (2003); Hovers et al. (2008)
Kanjera	Kanjera South, Excavation 1	2.1–2.0	Lithics, fauna	(A), B, C, F, Fen, I, Li, M, N, P, Q, Qt, R, S	Near braided streams at lake basin margin	None	Plummer et al. (1999); Plummer (2004); Braun et al. (2008)

*Lithic raw materials: A, andesite; AL, aphanitic lava; B, basalt; C, chert; F, felsite; Fen, fenites; I, ijolite; L, lava unspecified; La, latite; Li, limestone; M, microgranite; N, nephelinite; P, phonolite; Q, quartz; QL, quartz latite; Qt, quartzite; R, rhyolite; S, sandstone; T, trachyte; VV, vitreous volcanic.
Sources: Following Plummer (2004) and Potts (1991).

Table 3 Paleogeographic and paleoenvironmental context of excavated Oldowan sites older than 2.0 Ma

Site	Locality	Age (Ma)	Paleogeographic analogy/depositional environment	Fossil Fauna	Pedogenic carbonates	Other paleoecological data/regional reconstruction	Source(s)
Gona	OGS-6a	2.6–2.55	Open grass or ecotone near paleo-Awash	Cut-marked equid calcaneum on surface	Increase in % C_4 grass further from paleo-Awash	C_4 biomass averages 48% in 2.6–2.5 Ma time interval	Semaw et al. (2003); Quade et al. (2004); Levin et al. (2004)
	OGS-7	2.6–2.55	Riparian woodland adjacent to paleo-Awash	Fragments; bone flake; medium-sized upper leg midshaft	See above	See above	Semaw et al. (2003); Quade et al. (2004); Levin et al. (2004)
	EG-10	2.6–2.55	Riparian woodland or ecotone close to paleo-Awash	None	See above	See above	Semaw et al. (1997); Quade et al. (2004); Levin et al. (2004)
	EG-12	2.6–2.55	Riparian woodland or ecotone close to paleo-Awash	None	See above	See above	Semaw et al. (1997); Quade et al. (2004); Levin et al. (2004)
	EG-13	2.6–2.55	Riparian woodland adjacent to paleo-Awash	Persussion-marked medium-sized rib on surface	See above	See above	Semaw et al. (1997); Quade et al. (2004); Levin et al. (2004)
	EG-24	2.6–2.55	Open grass or ecotone near paleo-Awash	None	See above	See above	Quade et al. (2004); Levin et al. (2004)
	DAN-1	2.6–2.5	Riparian woodland or ecotone close to paleo-Awash	Not available	See above	See above	Quade et al. (2004); Levin et al. (2004)
	Kada Gona 2-3-4	2.6–2.5	Close to or in paleo-Awash	None		See above	Roche and Tiercelin (1980); Roche (1996)
	DAN-2d	2.5–2.2	Riparian woodland or ecotone close to paleo-Awash	Cutmarked bones on surface	See above		Quade et al. (2004); Levin et al. (2004)
	WG-1	2.5–2.3	Riparian woodland or ecotone close to paleo-Awash	fragments			Harris (1983); Harris and Capaldo (1993); Quade et al. (2004)
Middle Awash	Bouri, Hata Member	2.5	Open lake margin/deltaic	Cutmarked alcelaphine mandible and *Hipparion* femur and tibia midshaft; Abundance of alcelaphine antelopes			de Heinzelin et al. (1999)
Omo	FtJi 1	2.34–2.3	Secondary context—braided stream system				Merrick and Merrick (1976); Howell et al. (1987)
	FtJi 2	2.34–2.3	Distal edge of levee of meandering proto-Omo; behind gallery forest at edge of open savanna				Merrick and Merrick (1976); Howell et al. (1987)
	FtJi 5	2.34–2.3	Secondary context—braided stream system				Merrick and Merrick (1976); Howell et al. (1987)
	Omo 57	2.34–2.3	Secondary context—braided stream system				Chavaillon (1976); Howell et al. (1987); de la Torre (2004)

Table 3 (continued)

Site	Locality	Age (Ma)	Paleogeographic analogy/depositional environment	Fossil Fauna	Pedogenic carbonates	Other paleoecological data/regional reconstruction	Source(s)
	Omo 123	2.34–2.3	Distal edge of levee of meandering proto-Omo; behind gallery forest at edge of open savanna				Chavaillon (1976); Howell et al. (1987); de la Torre (2004)
West Turkana	Lokalalei 1	2.33	Alluvial plain of proto-Omo	Taxa include: *Theropithecus*, Colobinae, *Elephas, Hipparion, Notochoerus, Kolpochoerus, Antilopini, Aepycerotini, Alcelaphini, Reduncini*	Mixed vegetation with some gallery forest		Kibunjia (1994); Brugal et al. (2003); Quinn et al. (2008)
	Lokalalei 2C	2.33–2.23	Proximal floodplain near intersection of marginal channel with meandering proto-Omo	Taxa include: *Ceratotherium, Hipparion, Gazella*, Alcelaphini, Reduncini, Hippotragini	Mixed vegetation with some gallery forest	Open habitat with patches of bush and/or forest	Roche et al. (1999); Delagnes and Roche (2005); Brugal et al. (2003); Quinn et al. (2008)
Hadar	AL 666	2.33–2.36	Paleosol in medial floodplain, with open bush vegetation bordering paleo-Awash	Taxa include: *Theropithecus, Tragelaphus, Raphicerus, Gazella*, Muridae		Maka'amitalu Basin fauna: 33% of bovids are Alcelaphini or Antilopini, *Thryonomys*	Kimbel et al. (1996); Hovers et al. (2002); Hovers et al. (2008)
	AL 894	2.33–2.36	Paleosol in distal floodplain—with open bush vegetation bordering paleo-Awash			See above	Hovers et al. (2002); Hovers (2003); Hovers et al. (2008); Kimbel et al. (1996)
Kanjera	Kanjera South, Excavation 1	2.1–2.0	Lake margin, near channel	Abundant equids, alcelaphines	Wooded grassland to open grassland		Plummer et al. (1999); Plummer (2004)

2.3–2.0 Ma Sites

Kanjera South

Plummer and colleagues (Bishop et al. 2006; Plummer et al. 2001, 1999; Plummer 2004) have excavated the largest single site predating 2.0 Ma at Kanjera South, western Kenya. At Excavation 1, they uncovered about 4,500 stone artifacts, made from several different raw materials, associated with more than 3,000 fossil bone fragments, dated to sometime before the Olduvai Subchron, or about 2.1–2.0 Ma. Importantly, both the archaeofauna (with a high proportion of alcelaphine bovids and equids) and associated paleosol carbonates (with highly positive $\delta^{13}C$ levels translating into abundant C_4 grasses) indicate that the area was dominated by open grassland at the time hominins accumulated the stone debris and faunal remains. Also, the fossils found at Excavation 1 have a large number of small gazelle- and impala-sized individuals, prompting Plummer (2004) to suggest that this represents the hunting of small mammals. Ongoing analyses and future work at Kanjera will certainly add to our knowledge of hominin stone tool use, technology, ranging patterns, and foraging behavior.

Gona

OGS-3 (Ounda Gona South) from Gona is a small excavated site that is probably 2.1–2.0 Ma, but the lithic assemblage has yet to be analyzed. For this reason, it is included in Table 1, but not in Tables 2 or 3. Another site from this time interval at Gona is OGN-3, found in deposits exposed north of the Ounda Gona drainage. Tens of artifacts and fossilized fauna were found freshly exposed on the surface at the site, but it has yet to be excavated. The OGN-3 site is associated with a tuff dated to ~2.1 Ma (Table 1).

The DAN-2d (Dana Aoule North) excavation at Gona is included in the 2.3–2.2 Ma time interval, although it could be older. Dozens of artifacts and several cutmarked bones were found here—mostly on the surface, but some artifacts *in situ*—stratigraphically below a tuff dated to 2.27 ± 0.14 Ma (Quade et al. 2004). The assemblage has yet to be fully analyzed.

2.4–2.3 Ma Sites

Omo

It has been long known that the Shungura Formation in the Lower Omo Basin of southern Ethiopia contains some of the earliest archaeological traces (e.g. Chavaillon 1970; Merrick and Merrick 1976; Merrick et al. 1973). Howell et al. (1987) put these sites into geochronologic and paleogeographic context, firmly placing them in Member F (2.34–2.32 Ma). Of the five Member F sites confirmed by excavation, three of them (FtJi 1, FtJi 5, and Omo 57) were found in shallow braided channel in-fills with abraded and rolled faunal remains, probably in secondary context. The other two sites (FtJi 2 and Omo 123) were located in low-energy overbank deposits of a meandering proto-Omo. The artifacts at all these sites are predominantly quartz.

In de la Torre's (2004) recent review of the Shungura Formation archaeology, he confirms the secondary nature of the Omo 57 deposit, showing that most of the quartz pieces from that site are simply naturally rolled pebbles. That said, he also argues that a few of the artifacts from both Omo 57 and Omo 123 show remarkable flintknapping skill on the part of the hominin manufacturer, especially considering the small size and brittle nature of the quartz raw material. There are still questions about the integrity of the Omo 57 site, however, so for now only Omo 123 and FtJi 2 should be considered for any comparative purposes. Unfortunately, neither of these sites contained faunal remains. Future investigations in the Shungura Formation should help to clarify the stratigraphic and paleoenvironmental context of these Member F archaeological occurrences and may provide more definitive information on the existence of stone artifacts in Members C–E.

Hadar

Kimbel et al. (1996) have reported on a small archaeological occurrence discovered in the upper Kada Hadar Member of the Hadar Formation while excavating in sediments close to where an early *Homo* maxilla (A.L. 666-1) was found.

Dated to about 2.33 Ma, the A.L. 666 archaeological site, which was heavily eroded, yielded about 160 stone artifacts, both on the surface and *in situ* (Hovers 2001; Hovers et al. 2008). Another archaeological site, A.L. 894, has also been found nearby in the same basin and within the same stratigraphic interval, about 3–4 meters above a cobble conglomerate (Hovers 2003; Hovers et al. 2008). These two sites were deposited on the levee of the paleo-Awash river, although the A.L. 894 was probably slightly further from the paleo-Awash than A.L. 666 (Hovers et al. 2008). A larger excavation yielding 4,828 stone artifacts (but only eight cores), the A.L. 894 locality will likely prove to be more informative than A.L. 666 in terms of hominin behavior when the site is fully published.

West Turkana

The Lokalalei 1 (Kibunjia 1994; Kibunjia et al. 1992) and Lokalalei 2C (Roche et al. 1999) archaeological sites, found in the Kalochoro Member of the Nachukui Formation at West Turkana, are the earliest documented sites in Kenya (Harmand 2007; Roche et al. 2003). In the Lokalalei 1 excavation, dated to 2.33 Ma, Kibunjia (1994) recovered hundreds of stone artifacts and thousands of fragmentary faunal remains, from a wide variety of taxa indicative of a mixed environment, but with substantial grassland (Brugal et al. 2003). Recently, a single lower first molar was found 100 meters from the archaeological site, morphologically similar to early *Homo* (Prat et al. 2005). Kibunjia (1994) has argued that the stone artifacts at Lokalalei 1 reflect hominins' poor understanding of fracture mechanics, based on the high number of step fractures and small size of the flake scars on some of the cores.

Ironically, the lithic assemblage from Lokalalei 2C, a site only one kilometer from Lokalalei 1, has been described as one that demonstrates "greater cognitive capacity and motor skills than previously assumed for early hominids" (Roche et al. 1999, 57). A smaller site than Lokalalei 1, it also appears to be slightly younger (Brown and Gathogo 2002), dating to 2.33–2.23 Ma. However, its importance lies in the number of refitting pieces that have been found there (Delagnes and Roche 2005): 11% of the 2,614 stone artifacts from both the surface and the excavation have been conjoined to offer an unprecedented view of the steps taken and skill required by early hominins to create Oldowan stone flakes and reduce a core. In some cases, dozens of flakes have been refitted to their original core. Close to 400 faunal specimens were also found in association with the stone tools. The taxa represented include many that are indicative of open grasslands, though recent carbon isotope analyses on pedogenic carbonates suggest a mixed environment with significant gallery forest (Quinn et al. 2008). Both Lokalalei 1 and 2C were deposited within the floodplain deposits of a large axial (paleo-Omo) river.

2.6–2.5 Ma sites

Middle Awash

Like the A.L. 666 site at Hadar, the archaeological traces of the Hata Member (Bouri Formation), Middle Awash, were found as a result of a paleontological survey. However, the hominin taxon found in the ~2.5-Ma Hata deposits is not early *Homo,* but *Australopithecus garhi* (Asfaw et al. 1999). In addition, the deposits have not yet yielded *in situ* stone tools, only hominin-modified faunal remains. Several modified specimens were found, but only three have been reported *in situ* just above the Maoleem Vitric Tuff (MOVT), dated to ~2.5 Ma (de Heinzelin et al. 1999). These include an alcelaphine bovid mandible fragment with cut marks, a large bovid tibia midshaft with cut marks, chop marks, and percussion marks, and a *Hipparion* femur with cut marks. The marks on these bones indicate dismemberment, filleting, tongue removal, and marrow removal from a variety of large mammals.

Gona

Pliocene stone tools have been known in the Gona area for at least 25 years (Harris 1983; Roche and Tiercelin 1980), but the precise dating of the archaeological sites and the widespread distribution of early archaeological traces was not known until recently (Quade et al. 2004; Semaw et al. 2003, 1997). Since the Gona Paleoanthropological Research Project began in 1999, several new 2.5–2.6 Ma archaeological sites have been found and sampled through excavation. We now know that Gona is the site of both the earliest archaeological traces documented, as well as the most extensive Pliocene archaeological record, in terms of the number of known localities. All of the archaeological traces found at Gona are found within the recently designated Busidima Formation (previously the upper Kada Hadar Member of the Hadar Formation), with dates constrained between 2.7 and <0.16 Ma (Quade et al. 2008, 2004). This change in nomenclature makes sense in terms of the great amount of time represented by the stratigraphy and the significant changes in lithology seen after the 2.9–2.7 Ma disconformity.

Few of the early archaeological sites at Gona have yielded faunal remains, but the small sample that has accumulated is significant. Bone fragments in the OGS-7 excavation (Semaw et al. 2003) have documented the earliest clear association of stone tools and animal remains. Also, several faunal specimens found on the surface, but clearly from 2.6 – 2.1 Ma sediments, have shown hominin modifications such as cut marks and percussion marks (Domínguez-Rodrigo et al. 2005).

All of the Gona localities have a consistent paleogeographic setting: they are all closely associated with the paleo-Awash River, which provided the cobbles from which the stone tools were made (Quade et al. 2004; Stout et al. 2005). While some localities were located on the bank or near a channel bar of the paleo-Awash (e.g., OGS-7), others were located up to a few hundred meters from the river in the adjacent edaphic grasslands (e.g., EG-24, OGS-6a) (see Levin et al. 2004; Quade et al. 2004). Pedogenic carbonates in vertisols have revealed both a regional trend towards increased grassland between 3.0 Ma and the present day (in particular between 3.0 and 2.5 Ma) (Quade et al. 2004), and increasing grassland contribution to the vegetation with increased distance from the paleo-Awash (Levin et al. 2004). The combination of these studies has led to the paleogeographic and habitat reconstructions for each Gona locality listed in Table 3.

The small excavated site of BSN-6 (Busidima North) is also located in the same paleogeographic context as the other earliest sites at Gona and is included in Table 1. However, the lithic assemblage from the site has yet to be analyzed, and we feel that the stratigraphic placement needs verification; therefore, the site is not included in Tables 2 and 3.

The excavated locality of WG-1 (west of the Kada Gona drainage) was originally thought to be about 2.5 Ma (Harris 1983), but now seems to be slightly higher stratigraphically, dating to about 2.5–2.3 Ma (Quade et al. 2004).

General Observations of Recent Discoveries

From the summary above, we make the following general observations, followed by brief discussions of the toolmakers themselves and the paleoenvironmental context of the earliest archaeological traces, including the influence of raw material availability on technological variability.

(1) Fifteen years ago, there were arguably only four excavated archaeological localities in primary context predating 2.0 Ma (WG-1, FtJi2, Omo 123, and Lokalalei 1). That number is now approaching 20, with most of the recent additions coming from Gona, but with important additions from Middle Awash, West Turkana, Hadar, and Kanjera.

(2) Even with this dramatic increase in archaeological evidence, the record of the first c. 700,000 years of hominin stone technology is scarce. Gona is the only place with a confirmed record of stone tools that predates 2.36 Ma. This may be partly—but not entirely—due to the rarity of deposits in the 2.8–2.3 Ma time range in Africa. Furthermore, given the extent of the archaeological record at Gona at 2.6–2.55 Ma, it seems odd that this is the only place with stone tools of this age. We predict that this situation will change in the future as more attention is paid to late Pliocene deposits.

(3) The first hominin-manufactured stone tools will likely be discovered >2.6 Ma, but probably <2.9 Ma. At Gona, there is a gap in the stratigraphic record between 2.9 and about 2.7 Ma. Soon after Busidima Formation deposition

begins—with the first of a series of paleo-Awash channel cuts and subsequent fining-up sequences—we find the first stone tools. This coincidence of a visible archaeological record with the onset of a particular depositional regime implies that stone tool manufacture began earlier than the first visible archaeological locality at Gona (Quade et al. 2004). Future research at Gona and elsewhere may identify earlier archaeological traces.

(4) The Lokalalei, Hadar, and Omo sites are all dated to about 2.33–2.35 Ma. This coincidence may partly be explained by the existence of the same tuff (Tuff F-1 = Elkalalei tuff, dated to 2.34 Ma) being deposited in the Turkana Basin at both Lokalalei and the Member F sites of the Shungura Formation. The BKT-3 tuff found near A.L. 666 at Hadar is dated to 2.33 Ma, but has yet to be found elsewhere (Campisano and Feibel 2005). Future work may be able to sort out whether this temporal coincidence, and the 250,000-year gap between the Gona sites and these 2.33-Ma sites, is due to small sample size, different depositional histories among different study areas, and/or factors related to hominin adaptation and evolution. The occurrence of early *Homo* at both Hadar and West Turkana close to the 2.33-Ma archaeological sites may prove to be important.

(5) Kanjera is the only confirmed archaeological site in primary context dated between 2.3 and 2.0 Ma, aside from the small sample at OGS-3 at Gona. Both Kanjera and OGS-3 are probably 2.0–2.1 Ma; therefore, there are no archaeological sites that can be confidently dated to 2.1–2.3 Ma. Future investigations at Gona and elsewhere will add to the sample in this time range, but this observation underscores the problems in drawing too many conclusions about the nature of the archaeological record, and hominin biocultural evolution, before 2.0 Ma.

Who Made Stone Tools in the Pliocene?

This question is easy to answer, but the answer is problematic: We don't know. The candidates include early *Homo, Australopithecus garhi,* and *Au. aethiopicus*. *Au. garhi* has been found in the same Hata Member deposits as hominin-modified bones at Bouri in the Middle Awash (Asfaw et al. 1999), and no other hominin has been found there. On the other hand, the A.L. 666-1 maxilla found next to stone tools at Hadar has been classified as early *Homo,* perhaps *Homo habilis* (Kimbel et al. 1996). In addition, a molar found close to Lokalalei 1 at West Turkana has also been classified as early *Homo* (Prat et al. 2005).

Both *Au. aethiopicus* and early *Homo* have been identified in the Member F deposits in the Shungura Formation (Suwa et al. 1996), but not in direct association with the archaeological localities. Hominin remains have yet to be found at Gona or Kanjera in the same deposits encasing the early archaeological sites.

While it is possible to suppose that *Au. garhi* made the earliest 2.6–2.5 Ma stone tools and then evolved into stone tool-making early *Homo* by 2.35 Ma, we feel that the situation was probably more complex than this scenario suggests. Although there is no reason to exclude any 2.5-Ma hominin from the capability of making stone tools, the suggestion that *Au. aethiopicus/Au. boisei* made the earliest stone tools because of the coincidental stability of both this hominin lineage and Oldowan technology from 2.6 to 1.6 Ma (Wood 1997) fails to convince us from both logical and evidential points of view.

Regardless of the taxonomic resolution of the earliest stone tool makers, it is possible that the paleoanthropological record in the late Pliocene will eventually tell another story of (1) mosaic evolution in hominin evolution, this time decoupling the origins of stone tool manufacture from the origins of marked encephalization, and/or (2) multilineal hominin evolution, this time with respect to behavior.

Paleoenvironmental Context of the Earliest Sites

Since identifying the manufacturer(s) of the earliest stone tools is problematic, it is also difficult to address questions related to the paleoecology of the earliest stone tool makers. However, by examining the paleogeographic and paleoenvironmental contexts of the earliest archaeological sites, we may begin to generate hypotheses related to the adaptive significance of the first stone tool use and the environmental constraints and opportunities that were important for the earliest stone tool makers.

Table 3 summarizes what is known of the paleoenvironmental context of the Pliocene archaeological record by listing the contextual data by category: (1) paleogeographic reconstruction gleaned from depositional environment and sedimentology, (2) fossil fauna found in direct association with the archaeological material (or *is* the archaeological material), (3) pedogenic carbonates found at the archaeological locality or within the same stratigraphic interval as the site, and (4) other paleoecological data, which could include palynology or other regional reconstructions based on faunal remains, isotopes, and/or stratigraphy. By presenting the data this way, we emphasize the piecemeal nature of the paleoenvironmental information we have and the need for multiple lines of evidence in order to increase confidence in our paleoenvironmental inferences. All of the sites in Table 3, except the Omo localities, have more than one line of evidence to support their paleoenvironmental reconstructions.

In general, archaeological sites >2.0 Ma are found in mixed environments with a strong component of open grassland. Small sample size does not allow for an assessment of temporal change or lack thereof, although the paleoenvironmental settings seem fairly consistent from one site to another. The primary differences among sites relates to paleogeographic setting. The sites that are associated with a large axial river system, whether it be paleo-Awash or paleo-Omo (i.e., Gona, Hadar, Omo, West Turkana), all have somewhat mixed environments, probably because the rivers themselves are providing a certain amount of riparian woodland along their banks. The two lake margin sites (Middle Awash and Kanjera), on the other hand, are dominated by open grasslands and seem to have minor woodland components (de Heinzelin et al. 1999; Plummer 2004). The paleogeography of the Gona sites, however, provides a reminder of the dangers in inferring general patterns from single localities.

At Gona, the Oldowan localities are consistently located in association with a large, perennial paleo-Awash River, which provided the source of the stones for flintknapping (Quade et al. 2004). Some localities were located immediately adjacent to the paleo-Awash (e.g., OGS-7, EG-12, and EG-13), while others were located up to a few hundred meters away from the river (e.g., OGS-6a, EG-24). Using the modern Awash River as an analog, the riverbank localities were probably located in riparian woodlands, while others were set in open edaphic grasslands. Pedogenic carbonates sampled laterally from the paleo-Awash in the lower Busidima Formation support the paleoenvironmental reconstruction of more grassland as one moves further from the paleo-Awash channel (Levin et al. 2004). Excavation of a single site, or even of a few sites, at Gona could give the mistaken impression of a narrow geographic setting for stone tool-making, whereas a larger sample has shown that archaeological traces were left in a variety of settings. However, this variety is constrained by the paleo-Awash and its active floodplain.

Presumably, the Hadar localities were located in similar paleogeographic settings to those at Gona, since both localities were found in paleosols (Hovers 2003) within similar fining-up sequences to those seen at Gona, with cobble conglomerates at the base (Kimbel et al. 1996). The setting of the A.L. 666 locality seems analogous to the floodplain localities of EG-10 and EG-12, whereas the A.L. 894 locality may be more distal (Hovers et al. 2008), similar to the settings of EG-24 and OGS-6a. The fauna at A.L. 666 is representative of a mixed grassy/woodland environment, and seems similar to the overall faunal assemblage from the Maka'amitalu basin at Hadar.

The Omo and West Turkana localities were all deposited within fluvial sediments associated with the paleo-Omo river. Howell and colleagues (1987) placed the archaeological sites of the Shungura Formation in the proximal floodplain of either a meandering (in the case of FtJi 2 and Omo 123) or a braided (FtJi 1, FtJi 5, Omo 57) paleo-Omo. The context of both FtJi 2 and Omo 123, then, is similar to what we see at Gona. However, the raw materials for stone tool-making at these localities do not seem to come from the paleo-Omo, but from some distance to the east, as the quartz was brought from the basin margin by small alluvial channels. Similarly, the raw materials for the West Turkana sites came from high energy basin margin streambeds from the west, not far from the sites themselves.

As mentioned, the Kanjera and Middle Awash lake margin sites have the strongest evidence for open grassland environments, although the archaeofauna sample size at Bouri is small (de Heinzelin et al. 1999). The open grassland signatures of these sites are perhaps due to the paucity of extensive riparian woodlands nearby, unlike the other sites discussed here. These two sites also have evidence for substantial transport of stone. At Bouri, the lack of stone tools and raw material sources nearby indicates that hominins transported stone to the lake margin setting. The stone tools at Kanjera were made from a variety of raw material sources, some local and some at least 10 km away (Braun et al. 2008). Raw material selection and transport will be discussed in more detail below.

The overall evidence for late Pliocene hominins using stone tools in environments with substantial open grassland is strong. Where there is evidence for woodland/forest in the paleoenvironmental reconstructions of early archaeological sites, this could be due simply to the pull of stone raw material sources in riverbeds with riparian forest (at Gona and Hadar) and/or fresh water supplied by a perennial river (Gona, Hadar, Omo, West Turkana). On the other hand, there is also strong evidence for the preferential use of environmental ecotones—habitats that are at the junction of woodland and grassland—that would have provided access to a variety of woodland and grassland resources. The evidence is consistent with the idea that early stone tool use was an adaptation that enabled the exploitation of resources in open grasslands *and* woodlands, with emphasis on the former, probably as a way of diversifying their diets. However, at present we cannot distinguish between early stone tool use as an adaptation to accessing resources in open grassland habitats versus accessing resources in a wider variety of habitats, including open grasslands.

The specific paleoenvironmental context alone may not be the most important factor in site location; tool function probably played a significant role as well. For example, if the earliest stone tools were made in order to access animal resources, and if hominins had more animal resource encounters in ecotones and open grasslands (as opposed to in woodlands and forests), then you would expect the paleoenvironmental pattern that we have observed. The hominin-modified bones found at Bouri, Gona, Lokalalei, and Kanjera (Plummer 2004) are consistent with this idea.

There are problems with these paleoenvironmental interpretations, however, that need to be addressed, including: (1) The discussion of faunal evidence here has been limited to the analysis of presumed environmental preferences of certain taxa, whereas a taxon-free, functional morphological approach would increase confidence in the results. (2) All the paleoenvironmental data are time-averaged to varying degrees, so that we cannot know exactly what the specific habitat was like at the time of tool manufacture and use. The use of multiple lines of evidence helps in this regard. (3) Any analysis of habitat preference is also subject to the problem of negative evidence. That is, the absence of archaeological sites in heavily forested environments is not necessarily an indication that hominins did *not* use stone tools in those habitats; it could be that those environments have yet to be sampled by the known geological and paleoanthropological records. (4) Small sample sizes, as noted above, can influence our ideas of where sites are placed on paleolandscapes. (5) Finally, there is no reason to assume that the adaptational significance of stone tool use remained constant throughout the 600,000 years of time considered here. It is possible, for example, that paleogeographic location was more constraining on stone tool use behavior at 2.6 Ma at Gona than it was at 2.33 Ma at Lokalalei or at 2.1–2.0 Ma at Kanjera (see, for example, Rogers et al. [1994] for further discussion of the influence of paleogeography on Oldowan site distribution).

Origins of Stone Tool Use and Global Climate Change

Many scholars have argued or speculated that the origins of stone tool use, and/or the origins of our genus *Homo,* are causally linked with a global cooling and drying event in the late

Pliocene, sometime around 2.8–2.4 Ma. The general argument is that this global climatic event (or series of events) had the effect of reducing forest cover and expanding grassland in the African tropics, profoundly influencing the evolution of African terrestrial mammals, including hominins.

More specifically and relevant to this review, paleoanthropologists have presented several different scenarios within this broad framework relating the origins of stone tool use to climate change (e.g., Behrensmeyer 2006; Behrensmeyer et al. 1997; Bobe and Behrensmeyer 2004; Bobe et al. 2002; Harris 1983; Levin et al. 2004; Plummer 2004; Potts 2007; Quade et al. 2004; Stanley 1992; Vrba 1995; Wynn 2004). Most simply, the first use of stone tools is seen as a direct result of exploiting the expanded grasslands in East Africa. A corollary to this basic idea is that the earliest stone tools allowed hominins to expand their diet to include food items that were found in open habitats, but not to the exclusion of other habitats. Other environmental hypotheses of human evolution in the late Pliocene emphasize a change in environmental variability that hominins had to confront over the short-term (seasonality) or long-term (variability selection). Recent reviews have emphasized the complexity and difficulty in linking environmental change with evolutionary effects (e.g., Behrensmeyer 2006; Kingston 2007).

It is not our intention here to test or apply the savanna hypothesis to the origins of stone tool use, but to point out that sorting through various environmental hypotheses will be a significant challenge. Indeed, while it may appear at first glance that the paleoenvironmental settings of the earliest archaeological sites support the idea that stone tool-making was, at least in part, an adaptation to open grasslands (created by a late Pliocene global cooling event), we see problems with this argument, including:

(1) We still do not know if the origin of stone toolmaking and global cooling are linked temporally. The earliest stone tools found at Gona are dated close to 2.6 Ma, but the disconformity in the stratigraphic record there suggests that the beginnings of stone tool use should eventually be found in the 2.6–2.9 Ma time range. Also, there is considerable discussion about when exactly global cooling occurred and how this translated into ecological change on the African continent. Clearly, though, if a global cooling event is documented at, say 2.52 Ma, then this event is too late to have spurred the beginnings of stone tool use. Of course, we could also ask why *this* particular drying/cooling event? Why didn't a previous drying/cooling in the early Pliocene—e.g., the apparent expansion of grassland in the KH-2 submember at Hadar after 3.1 Ma (Campisano and Feibel 2007)—lead to stone tool manufacture? Why not a later one?

(2) Temporal correlation is not causation (e.g., Hill 1987; White 1995). Even if we can establish that the first stone tools appear at approximately the same time as a global climatic event, this does not mean that stone tool use was caused by such an event. First, it is difficult to establish a clear causal link between the global event and African terrestrial ecosystem change, and the studies that have attempted to assess this have indicated a complex interaction, with sometimes conflicting results. The key to the argument is in this complex interaction, though, since even if global climate change can be successfully tied to African environmental change, there still needs to be a causal mechanism that explains how a change in environment led to a change in hominin behavior (see, e.g., Kingston 2007).

(3) The *lack* of temporal correlation does not necessarily mean a *lack* of causation. For instance, if the earliest stone tools are eventually dated to 2.8 Ma, and the evidence for a late Pliocene global cooling event suggests that this cooling happened in stages, but beginning at 2.7 Ma, this does not mean that global climate change had *no* role in influencing the evolution of early stone tool use. This is due, in part, to the complexities of global/regional interactions and the incompleteness of the geological record. However, it is also possible that an initial cultural/technological innovation (stone tool use) that was mediated by local/regional environmental conditions could subsequently be reinforced or sustained by later, global climatic changes.

(4) In our view, in order to address adequately the issue of how climate and/or environmental

change influenced the origins of stone tool use, we need fine-grained paleoenvironmental data throughout the 2.9–2.3 Ma time interval from several different depositional basins, some with archaeological sites and some without (but with available raw material). Although progress has been made to fill this sampling gap, much additional work from many different sites will be required. It is also worth noting that accumulating the relevant data will require time-consuming survey and geological sampling of areas that do not appear to contain an archaeological record. Significant progress in this regard has been made recently in a few study areas (e.g., Campisano and Feibel 2007; Kingston et al. 2007).

Raw Material Transport and Selection

Raw material availability, along with the hominin selection, transport, and use of raw material for stone tool manufacture, is intimately tied to the paleoenvironment, as noted above, and seems to us a primary determinant in the appearance and characteristics of the earliest archaeological record. At Gona, an analysis of the types of raw materials available in the paleo-Awash and found at the archaeological sites has demonstrated that hominins were quite discriminating in their selection of stone type for tool manufacture, preferentially choosing higher quality raw materials (Stout et al. 2005). Raw material selectivity has also been observed at other sites such as Lokalalei and Kanjera.

Ongoing raw material investigations at Gona will examine how the raw material, shape, and size of the original cobbles may have influenced reduction strategies at different sites (e.g., EG sites versus OGS-7). It is our view that any discussion of Oldowan variability must first be informed by an in-depth knowledge of the types of stones available and the types chosen for tool manufacture. Once this is appreciated, then higher order explanations of technological variability can be explored. For example, many of the well-struck technical blades from OGS-7 at Gona were made from a fine-grained vitreous volcanic raw material (Stout et al. 2008). At West Turkana, the remarkable refitting of dozens of artifacts at Lokalalei 2C has shown a certain skill level in organizing flake reduction, but it is also acknowledged that the more refined flaking is done on a higher quality phonolite (Delagnes and Roche 2005). Work at Kanjera has also explored this issue (e.g., Bishop et al. 2006; Braun et al. 2008).

Conclusions

The summary of the evidence from the Pliocene archaeological record is consistent with the idea that early stone tools were made and used to take advantage of open grassland settings, and probably a variety of settings. As we continue to expand our knowledge of the late Pliocene archaeological record, there is no reason to assume that there will be uniformity in this record. Variability in archaeological traces can be interpreted in a variety of ways (e.g., raw material availability and use, function of stone tools, different depositional settings, social learning patterns and abilities, different hominin species), but we are still trying to assess the nature and extent of this variability with regard to the earliest archaeological record. Testing higher order inferences regarding this variability remains a challenge.

The evidence shows that there is a significant sampling bias in the geological record 2.9–2.6 Ma, and that the earliest manufacture and use of stone tools may date to this time interval. However, hypotheses relating the appearance of the earliest stone tools simply to changes in the visibility of this record (cf. Panger et al. 2002) are not supported at this time, since we are in fact finding both low and high density occurrences at Gona. Hypotheses that relate the beginnings of stone tool use to throwing, pounding, and/or digging may be likely, but are not supported; at the moment, the evidence clearly suggests that the purpose of the earliest flintknapping was mainly to produce sharp flakes used for processing animal resources.

Future investigations of the evolutionary significance of the earliest use of stone tools will require filling in the many temporal and spatial gaps of the Pliocene archaeological record. Not only will we need to find more sites from different time intervals, but we will also need to examine closely the geological, paleontological, and paleoenvironmental records of sites and regions that do *not* have stone tools and/or modified bones, but do have available stone raw material sources. We suspect that issues related to sampling and negative evidence may have a bearing on hypotheses concerning archaeological transitions from many different time periods, not just the first one from "nothing" to "something."

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The Oldowan-Acheulian Transition: Is there a "Developed Oldowan" Artifact Tradition?

Sileshi Semaw, Michael Rogers, and Dietrich Stout

Abstract The phrase "Developed Oldowan" (DO) was originally coined by M. Leakey to describe a technologically "advanced Oldowan" artifact tradition, that preceded the Acheulian Industry. M. Leakey further identified three stages of the DO which she labeled as the DOA, DOB and DOC. The DO (*sensu lato*) has been generally recognized as transitional to the Acheulian, but the status of the DOB and the DOC remains unclear. In addition to a lack of clarity in terms of classification, the DO also suffers from a lack of secure radiometric dates, even at Olduvai where it was first identified. Despite such shortcomings, archaeologists still assign assemblages into the DO, as supposedly "intermediate" or transitional between the Oldowan and the Acheulian. However, a closer look at the DO assemblages from Olduvai Gorge and other sites in Africa and the Middle East shows that the artifacts assigned into this tradition are not technologically drastically different from the preceding Oldowan. Probably the flaking characteristics of the raw material types (e.g., quartzite and limestone, and to a lesser extent basalt) and the original shape of the cobbles used by hominins may have played a major role in the final shape of the "distinctive" artifact types (such as spheroids/subspheroids) used for assigning assemblages into the DO. Further, both the DOB and the Acheulian appeared ~1.7 million years ago (Ma) in the archaeological record, making it unlikely that the DO is a transitional artifact tradition that preceded the Acheulian. Our preliminary evaluation of the archaeological record at Gona, Ethiopia and elsewhere suggests a fairly abrupt appearance of the Acheulian after a temporally rapid transition from the Oldowan.

Keywords Oldowan • Developed Oldowan • Oldowan-Acheulian transition • Early Acheulian

The Oldowan and Acheulian entities appear to have been separated by a comparatively rapid change dependent on a single technical step which by its very nature could not have been taken gradually (G. Ll. Isaac 1969, 21).

Introduction

The appearance of Acheulian (or Mode II [Clarke 1969]) handaxes in the archaeological record is often heralded as a significant development in human cultural/technological evolution, relative to the preceding Oldowan industry. While the earliest appearance of the Acheulian has long been considered to occur 1.7–1.5 Ma (e.g., Clark 1970; Klein 1999), until recently the earliest *in situ* occurrence has been difficult to document securely. Although details have yet to be published, Konso in Southern Ethiopia (Beyene 2003, 2004, 2008; Beyene et al. 1997) and probably Kokiselei in West Turkana, Kenya (Roche 2005; Roche et al. 2003) document

S. Semaw (✉)
Stone Age Institute and CRAFT Research Center, Indiana University, Gosport, IN, USA

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the earliest Acheulian occurrences dated to ~1.7 Ma. At Gona we have recently excavated Early Acheulian artifacts estimated to at least 1.6 Ma, but details of the associated geology/geochronology have yet to be worked out (Quade et al. 2004, 2008; Semaw et al. 2008 [in prep]).

Based on current investigations, the Oldowan, the earliest ancestral hominin stone tool tradition, appeared in the geological record by ~2.6 Ma, although it is possible that the use of flaked stones may have begun as early as 2.9 Ma (Quade et al. 2004; Rogers and Semaw [this volume]; Semaw et al. 1997, 2003 [in press]). This simple core-flake technology persisted in the archaeological record with little change until the emergence of the Acheulian Industry by ~1.7 Ma (Beyene 2008, 2004, 2003; Roche 2005). What was the nature of the Oldowan-Acheulian transition, and are there clear transitional artifacts in the archaeological record? Several Early Pleistocene artifact assemblages have been categorized as belonging to a transitional industry called the "Developed Oldowan," often based on a subjective typology. One result of the uncertain chronology, as well as the use of subjective "transitional" tool types, is that the Oldowan-Acheulian transition is, paradoxically, poorly understood. We hope to clarify some of these issues in this paper.

It is widely held among Paleolithic archaeologists that the Developed Oldowan, the stone tool tradition coined by M. Leakey (1971), marks a significant transition between the Oldowan and the Acheulian industries (e.g., Clark 1970; Klein 1999). Based on analysis of the Early Pleistocene lithic assemblages from Olduvai Gorge Bed I–Bed IV, M. Leakey proposed three stages of the Developed Oldowan, which she labeled from the oldest to the youngest, as the Developed Oldowan A, B, and C (DOA, DOB, and DOC, for short). The assemblages classified into the DOA (~1.7–1.6 Ma) contain cores/choppers and flakes, major elements of the Oldowan tradition, but are differentiated mainly by the preponderance of spheroids/subspheroids, and artifacts identified as "protobifaces." The DOB (~1.5–1.4 Ma) contains crudely-worked small bifaces (the majority made on cobbles) along with "light duty tools" including "awls, burins, and *outils écaillés*," (tool types also identified within the Oldowan and the DOA, but in much smaller numbers). Well-made large bifaces (on large flakes) that are similar to the Early Acheulian were also found in the DOB, but in smaller proportions. DOB-type assemblages are also known higher up in the Olduvai Gorge stratigraphic sequence in Bed IV, but are labeled as Developed Oldowan C simply by virtue of their more recent date (but see Jones 1994). Therefore, we will henceforth include the DOC into the DOB for the purpose of our discussion.

Following M. Leakey, the so-called "Developed Oldowan" (also sometimes referred to as "Evolved Oldowan") was widely accepted, and archaeologists have assigned Early Pleistocene assemblages from Africa and the Levant to this tradition (e.g., Bar-Yosef 1994; Chavaillon et al. 1979; Clark and Kurashina 1979; Piperno et al. 2004a, 2004b). Subsequently, Stiles (1991, 1979a, 1979b, 1979c) questioned M. Leakey's interpretations, and addressed the Developed Oldowan/Early Acheulian dichotomy in a series of papers (see also Jones 1994), and the same issue was recently discussed by de la Torre and Mora (2005), who express uncertainty by criticizing the status of the DO as a valid artifact tradition. Based on the study of some of the excavated assemblages from Olduvai Gorge, Stiles concluded that the DOB should be dropped as a valid category, because the variations seen in the bifaces of the two assemblages were mainly a result of differences in the flaking quality of the raw materials used. Although Jones' analyses showed his uncertainty about the status of the DOA and the DOB, he seems to favor the validity of the DOC in Beds III and IV.

Although archaeologists have classified some Early Pleistocene lithic assemblages into the "Developed Oldowan," it is often unclear or unstated as to which stage (A or B) of this tradition the materials should be assigned. Further, it is unclear in the archaeological literature whether the DOA or DOB (or both) should be considered transitional between the Oldowan and the Acheulian industries. Thus, it is important to have a closer look at lithic assemblages from Olduvai Gorge to assess the validity of the DOA and the DOB as justifiable artifact traditions, and to evaluate whether the two stages can be accommodated in either the Oldowan or the Acheulian industries. To that end, this paper examines earlier studies of

Olduvai Gorge Bed I and Bed II assemblages, as well as other Early Pleistocene lithic assemblages in Africa, in order to determine whether or not artifact tradition(s) existed that can be unambiguously characterized as intermediate between the Oldowan and the Acheulian, and to what extent the term “Developed Oldowan” helps in understanding cultural/technological changes during the course of human evolution (see also de la Torre and Mora [2005] for detailed discussions of their revisions of the Olduvai Gorge Bed I and II materials).

Part of the inspiration behind this paper comes from our years of survey and excavations of Plio-Pleistocene archaeological sites at Gona, Ethiopia. At Gona, we have not found lithic assemblages that can be assigned to the Developed Oldowan, even though there are deposits dated to 1.7–1.5 Ma. It was interesting to us that this “artifact tradition” existed at some sites (e.g., Olduvai Gorge, Ain Hanech, and Melka Kunture, etc.) but not at Gona or other well-investigated Plio-Pleistocene archaeological sites.

Based on our investigations at Gona, experimental work conducted by other researchers (e.g., Sahnouni et al. 1997; Jones 1994; Schick and Toth 1994), and assessment of the existing Early Pleistocene archaeological literature, we argue here that the DOA appears to be technologically similar to (if not the same as) the Oldowan. While the “DOA” includes a variety of heavily-worked artifacts identified as spheroids/subspheroids and “protobifaces,” the techniques employed for the manufacture of these artifacts do not show drastic departures from earlier practices, either conceptually or in craftsmanship. Hence, we do not see a need to posit a different stone tool tradition for such assemblages other than the Oldowan (e.g., Sahnouni et al. 2002; Sahnouni and de Heinzelin 1998). In addition, we do not see anything “transitional” in the DOA, and therefore suggest that the DOA be subsumed within the Oldowan Industry (see also de la Torre and Mora 2005).

Although by no means exhaustive, our assessment also supports Stiles’ conclusion that the DOB should be dropped, and be subsumed under the Early Acheulian because the lithic assemblages identified into both “traditions” consist of artifacts that are clearly Early Acheulian in character. Further, both lithic industries appeared at the same time (~1.7–1.6 Ma), and overlapped for at least a million years up to ~0.5 Ma. The variations seen between the DOB and the Early Acheulian assemblages at Olduvai Gorge, particularly the workmanship of the bifaces, could have resulted from differences in the raw materials used, and their flaking quality (Stiles 1991, 1979a, 1979b, 1979c, 1981; see also Jones 1994). The makers of the “DOB” appear to be skilled and capable of making large bifaces (on large flakes) identical to some of those excavated at Early Acheulian sites. Further, the presence of bifaces made on large flakes in the Developed Oldowan (although in much smaller proportion compared to the Early Acheulian) is indicative that the same hominin species may have been responsible for the two traditions.

One further result of our review is that the Oldowan-Acheulian transition may in fact mark several interrelated transitions, and that the traditional notion of the Acheulian beginning with the first appearance of handaxes may be too simplistic. During this transition we may see some variability depending upon paleogeography; availability, size, and type of raw materials used; and possible hominin “experimentation,” i.e., alternative technological responses to a range of selective pressures.

The Oldowan, a Brief Overview

In the 1930s Louis Leakey began archaeological surveys of the deposits exposed at Olduvai Gorge, in Tanzania, and discovered stone artifacts characterized by cores/choppers and flakes, which he named the Oldowan after Olduvai Gorge (Leakey 1934; see Gowlett [1990] for details on the history of early explorations). During the following decades, M. Leakey undertook systematic archaeological investigations and excavations at Olduvai Gorge. She conducted large scale excavations and carried out years of meticulous work analyzing the Olduvai Gorge materials, thereby revealing a wealth of information on the stone tool behavior of Early Pleistocene hominins in Africa.

The Olduvai Gorge Bed I stone artifacts were dated to 1.9–1.8 Ma, and at the time represented the earliest stone artifacts documented in the world (Leakey 1971). Bed I was the focus of much of the geological investigations because of the archaeological riches and important hominin fossil discoveries made in the late 1950s and the 1960s; hence, Bed I is the best dated section of the entire sequence (Hay 1976; Tamrat et al. 1995; Walter et al. 1991). At Olduvai Gorge, upper Bed I and lower Bed II contain artifacts attributed to the classic Oldowan, i.e., assemblages characterized primarily by cores/choppers, and flakes and flaking debris, the hallmark of the Oldowan Industry or Mode I of Clarke (1969). M. Leakey believed that the cores/choppers were the actual tools that the hominins sought, and she named tool types based on their shape and assumed functions. She identified a variety of choppers (side, end, pointed, etc.), as well as specimens identified as discoids, polyhedrons, spheroids, awls, burins, and so forth (Leakey 1971, 1976a). Additional specimens included stones with pitting marks identified as hammerstones, and "manuports," i.e., unmodified cobbles that hominins transported to the sites (but see also the recent revisions by de la Torre and Mora [2005]). Even though Louis Leakey named the earliest lithic industry, it was M. Leakey, the archaeologist, who excavated, described, and clearly defined the Oldowan stone tool tradition.

The Leakeys' work brought unparalleled enthusiasm and attention to the prehistory of East Africa. Following their success, a number of international projects began systematic fieldwork during the 1960s and 1970s, primarily in Kenya and Ethiopia. The multidisciplinary research initiated and pioneered by the late F.C. Howell was instrumental for the discovery of Late Pliocene stone artifacts at Omo in Southern Ethiopia. American and French teams undertook years of excavations at Omo, and recovered stone artifacts (mainly made of quartz) within the Shungura Formation in the deposits dated to 2.4–2.3 Ma, almost 0.5 Ma older than the artifacts earlier excavated from Olduvai Gorge (Chavaillon 1976; Howell et al. 1987; Merrick 1976; Merrick and Merrick 1976). In the 1980s and 1990s, field investigations at Lokalalei, in Kenya, revealed the presence of stone artifacts made of basalt and phonolite dated to 2.4–2.3 Ma (Delagnes and Roche 2005; Kibunjia 1994; Kibunjia et al. 1992; Roche et al. 1999). Archaeological work at Kanjera South, also in Kenya, has led to the recovery of Late Pliocene stone artifacts estimated to ~2.0 Ma (primarily based on paleomagnetic profiles) (Bishop et al. 2006; Plummer 2004).

In Ethiopia, geological work by Maurice Taieb in the 1960s and 1970s opened up the venue in the Afar, an unexplored paleoanthropologically-rich area with ancient fossils and stone artifacts exposed in the deposits straddling the Awash River (Johanson et al. 1982; Taieb and Coppens 1975; Taieb et al. 1972). Systematic field investigations carried out later in the 1990s, and subsequent research by the Gona Palaeoanthropological Research Project, resulted in the discovery of 2.6-Ma excavated stone artifacts at East Gona (mainly made on trachyte and rhyolite), and cut-marked bones and a hominin named *Australopithecus garhi* in the Middle Awash (Asfaw et al. 1999; de Heinzelin et al. 1999; Semaw 2000, 2005, 2006; Semaw et al. 2003, 1997 [in press]). Continued investigations of the Late Pliocene deposits exposed at Ounda Gona to the south have yielded stone artifacts and associated fragmented fossil fauna (with cut-marked bones also found on the surface) that were also radiometrically dated to 2.6 Ma (Domínguez-Rodrigo et al. 2005; Semaw et al. 2003). At Hadar, Oldowan stone artifacts (made on trachyte and ignimbrite) associated with an early *Homo* maxilla and dated to 2.3 Ma were excavated in the early 1990s (Kimbel et al. 1996). To date, the Late Pliocene sites in both Ethiopia and Kenya have not yielded artifacts identified as spheroids/subspheroids, protobifaces, awls, burins, etc. All of these sites contain cores/choppers and flakes that are typical of the Oldowan Industry.

During the Early Pleistocene (~1.9–1.5 Ma) a large number of archaeological sites were documented all across Africa, including Melka Kunture, Gadeb, Middle Awash, Konso, and Fejej in Ethiopia (Asfaw et al. 1992, 1991; Chavaillon et al. 1979; Clark and Kurashina 1979; Clark et al. 1994; de Lumley et al. 2004; Kurashina 1987; Piperno et al. 2004a, 2004b); Koobi Fora in Kenya (e.g., Isaac and Harris 1997); Nyabusosi in Uganda (Texier 1995); Olduvai Gorge and Peninj in Tanzania (de la Torre et al. 2008; Domínguez-Rodrigo et al. 2001 [in press]; Isaac et al. 1974; Leakey 1971); Ain Hanech and El Kherba in Algeria (Sahnouni et al. 2002; Sahnouni and de Heinzelin 1998); Sterkfontein, Kromdraai, and Swartkrans in South Africa (Brain et al. 1988; Field 1999; Kuman 1994a, 1994b, 1998; Kuman et al. 1997). Spheroids/subspheroids were identified at some of the sites, such as Ain Hanech, Melka Kunture, Gadeb, and Sterkfontein.

Of these sites, Melka Kunture, Gadeb, and Sterkfontein were reported to contain artifacts assigned to the Developed Oldowan. Interestingly, the artifacts from a majority of the other Early Pleistocene sites were classified into the Oldowan Industry or its "variants."

The evidence from all of these sites indicates that Oldowan artifacts were simple cores and flakes, made mainly with the hand-held percussion technique (sometimes with the bipolar technique). At about 2.6 Ma, the hominin toolmakers had a superb understanding of conchoidal fracture on stones, and they selected relatively high quality and fine-grained raw materials that were suitable for making sharp-edged implements (Rogers and Semaw [this volume]; Semaw 2006, 2000; Semaw et al. 2003, 1997; see also Stout et al. [2005]). Evidence of cut-marked fossil bones from Gona and the Middle Awash indicate that ancestral hominins at 2.6 Ma had already begun incorporating meat into their diet (de Heinzelin et al. 1999; Domínguez-Rodrigo et al. 2005). From our conservative perspective, the technology of Late Pliocene/Early Pleistocene stone tool manufacture—both conceptually as well as in workmanship—remained the same until the advent of the Acheulian Industry, described below.

The Developed Oldowan A

At Olduvai Gorge, artifacts assigned to the "DOA" come from Lower and Middle Bed II (including FLK North and HWK East), where spheroids/subspheroids and light duty tools (primarily made of chert) become more abundant compared to Bed I. Also, "protobifaces" and heavy duty tools become relatively numerous here. M. Leakey believed that the preponderance of spheroids/subspheroids and the light duty components within the Lower and Middle Bed II assemblages signaled the appearance of an advanced stone tool tradition that she labeled the "Developed Oldowan," and later modified to the Developed Oldowan A ("DOA"). Although Bed II contains important archaeology as well as hominin fossils, it is poorly dated and still awaiting refinement on the age of the tuffs. Based on a combination of $^{40}Ar/^{39}Ar$ (including K/Ar) and paleomagnetic calibrations, the lower part of Bed II is dated to ~1.71 Ma, and the topmost Bed II to approximately 1.1 Ma (Hay 1976; Manega 1993; Stollhofen et al. 2008; Tamrat et al. 1995; Walter et al. 1991). Thus, the ages of the materials assigned to the DOA are estimated to 1.7–1.6 Ma.

It is important here to briefly examine some of the elaborate artifact types identified by M. Leakey, all of which formed the basis for classifying the Lower-Middle Bed II assemblages into the "DOA" tradition.

Spheroids/Subspheroids

Artifact forms labeled as spheroids/subspheroids, sometimes also referred to as "bolas," have been recovered from several Lower Paleolithic sites such as Olduvai Gorge, Ain Hanech, Gadeb, Melka Kunture, Chesowanja, and relatively younger sites such as Isimila, Isenya, and Olorgesailie, all from East and North Africa (Chavaillon et al. 1979; Clark and Kurashina 1979; Gowlett et al. 1981; Howell 1961; Isaac 1977; Kurashina 1987; Leakey 1971; Roche 2000; Sahnouni 2006, 2005, 1993; Sahnouni et al. 2002, 1997; Sahnouni and de Heinzelin 1998; Willoughby 1985); and from "Ubeidiya" in Israel (Bar-Yosef 1994; Bar-Yosef and Goren-Inbar 1993). Since the primary artifacts of the Oldowan tradition were simple cores and flakes, experimental replication studies have shown that hominins were mainly after sharp-edged cutting implements (Bunn 1981; Bunn et al. 1980; Keeley and Toth 1981; Potts and Shipman 1981; Toth 1987, 1985). However, archaeologists have long wondered about the function of spheroids and subspheroids and how they were made (Sahnouni et al. 1997; Schick and Toth 1994; Willoughby 1985).

Roche and Texier (1995, see also Roche [2000]) suggest that spheroids and (polyhedrons) show more sophistication in technology due to the deliberate shaping and consecutive flaking technique necessary to produce these forms. This contrasts with the simple and contiguous flaking seen in other Oldowan core types. Willoughby (1985) suggests that they could have been used for pounding/processing plant foods or as missiles, but does not rule out that they were simply the natural result of quartz being used as hammerstones/percussors. Schick and Toth

(1994; see also Sahnouni et al. [1997]) tested this idea by conducting experiments demonstrating how the Olduvai Gorge spheroids/subspheroids may have been produced. The experimental knapping study of quartz by Schick and Toth (1994, 446) indicated “that the simplest explanation for the artifact classes of subspheroids and spheroids is that these forms are hammerstones that have been used for an extended length of time for flaking cores.” Thus, among the most plausible explanations for the preponderance of spheroids/subspheroids from Bed II times are “early hominins shifting their preference of raw materials from lava to quartz over time” (Schick and Toth 1994, 446; see also Jones 1994). Schick and Toth (1994) concluded that “repeated use of quartz chunks or exhausted cores as percussors would naturally produce battered artifacts that would formally be classed as subspheroids and spheroids without any necessary intent or premeditation on the part of the hominids to produce these forms” (Schick and Toth 1994, 442). Experimental study conducted on limestones also showed that continuous heavy flaking of this raw material results in forms identified as spheroids/subspheroids, similar to several of the artifacts known from Ain Hanech dated to 1.8 Ma (Sahnouni et al. 1997; see also Sahnouni 1993). Thus, it is likely that the spheroids/subspheroids at Olduvai Gorge were derived from increased hominin use of quartz as the preferred raw material, both for cores as well as hammerstones. Also, Jones’ (1994) analysis indicated that the pieces identified as spheroids/subspheroids at Olduvai Gorge were consistently made on quartz. However, Schick and Toth do not rule out the possibility that such specimens could have been used for other functions once the spherical shapes were attained through extensive percussion.

Are spheroids/subspheroids, then, really evolved forms compared to the core/choppers, discoids, etc., of the Oldowan tradition? Do they show technological sophistication demanding more skill for making them? It depends on what we interpret as being intentional, which is difficult to demonstrate from the archaeological record. The simplest explanation is that these forms were probably a byproduct of simple flaking, made by the hand-held percussion technique similar to earlier artifacts of the Oldowan tradition, and were conditioned by the raw materials used (e.g., quartz at Olduvai Gorge, limestones at Ain Hanech). Therefore, for now, the workmanship does not appear to be related to an advanced technical skill drastically different from the techniques of manufacture employed for making Oldowan artifacts. In this regard, it is interesting to note that the lithic assemblages at Ain Hanech contain relatively numerous spheroids/subspheroids, and the site is dated to ~1.8 Ma, but the materials are still classified into the Oldowan rather than the “Developed Oldowan” (see Sahnouni et al. 2002; Sahnouni and de Heinzelin 1998).

Protobifaces

According to M. Leakey, “protobifaces” are specimens that are “intermediate between a biface and a chopper” (M. Leakey 1971, 5). These specimens “are always rare and are restricted in time span from Upper Bed I to the Sandy Conglomerate, the lowest horizon of Middle Bed II. They do not conform to any particular pattern or technique of manufacture but appear to represent attempts to achieve a rudimentary handaxe by whatever means was possible” (M. Leakey 1971, 266). A closer look at some of the specimens identified as “protobifaces” shows that these are cores/choppers that are heavily-reduced through intensive bifacial flaking. As clearly shown in the illustrations provided in M. Leakey’s volume (1971, 79, 80), the specimens identified as “protobifaces” from FLK North, Lower Bed II, are actually heavily-worked cores/choppers (Fig. 1). Such specimens are rare even at Olduvai Gorge, and are among the tool types unlikely to have been deliberately designed with a template of a biface in mind (see also de la Torre and Mora 2005). Therefore, it is difficult to envision that hominins manufactured such tool forms in the anticipation of creating future proper bifaces. One can argue that the hominins could have made bifaces if they desired to do so, but the idea of a proto-form/pre-form at this stage appears to be unlikely. Interestingly, there are also instances of artifact types that could be identified as “protobifaces” even among the excavated specimens from Gona dated to 2.6 Ma, although smaller in size (see Fig. 2), but the identification of such heavily-worked pieces as “protobifaces” at this early date

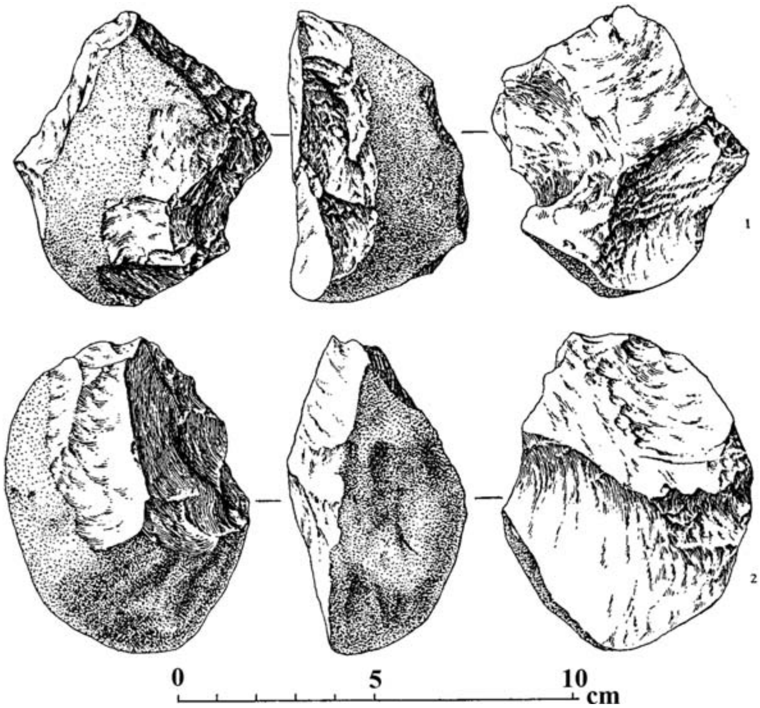

Fig. 1 FLK North, "protobifaces" on lava, levels 1–2, after M. Leakey (1971)

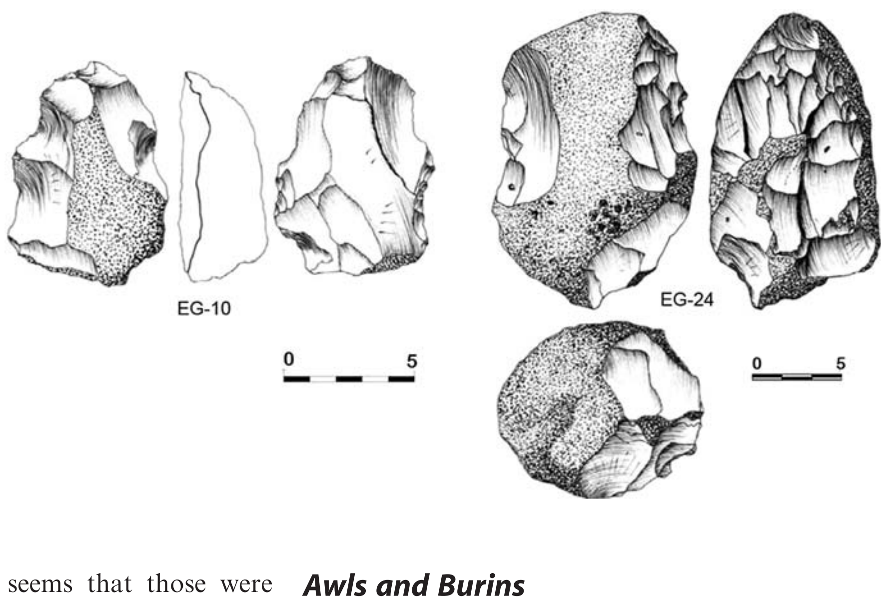

Fig. 2 Heavily-flaked cores, EG & EG24, Gona, 2.6 Ma

cannot be meaningful. It seems that those were heavily-worked cores/choppers that have attained such shape through continuous bifacial flaking, and most likely not made, as suggested by M. Leakey (1971), through the intentional shaping by hominins to produce "protobifaces" by any means possible.

Awls and Burins

Like the "protobifaces," the so-called "awls" and "burins" are probably accidental (Potts 1991), and according to de la Torre and Mora (2005, 43) some of the pieces identified as burins are actually "knapping fractures." It seems hard to justify that these pieces were made intentionally by Early Pleistocene hominins to be used as "awls" and "burins" (*sensu stricto*), as their names imply. Further, the number of such artifacts was insignificant even at Olduvai Gorge, and difficult to grasp if the "tools" were indeed part of the tool repertoire of Early Pleistocene hominins. Therefore, the pieces identified as "awls" and "burins" probably were not deliberately made to be used for elaborate functions as implied. It is also interesting to note that such elaborate tool types did not make the list of artifacts recovered from any other Early Pleistocene sites in Africa.

Choppers

As archaeologists, we tend to associate assemblages that primarily consist of choppers and flakes with the Oldowan industry (Mode I). Observations in the field at Gona (and elsewhere, e.g., Koobi Fora) have shown that crudely made cores/choppers and flakes, the hallmark of the Oldowan, actually are ubiquitous during the Early and Middle Stone Age, and persisted well into the Late Pleistocene. Hominins probably made crude-looking choppers/cores throughout the Paleolithic to produce sharp-edged flakes used as "expedient tools." Choppers/cores were produced in large numbers during the Oldowan, and continued to be made, although in fewer numbers, well into the Acheulian and later times (e.g., Clark et al. 1994). Researchers place much emphasis on "artifact types" and "tool frequency" to determine the technological/cultural affinity of archaeological materials, and usually without due regard to the role that the variable flaking qualities of different raw materials (not to mention initial raw material sizes and shapes) may have played in influencing artifact forms, as discussed above (see Jones 1994; also Stiles 1979a, 1979b, 1979c). Also, different activities (e.g., carcass processing vs. plant processing) probably had a significant impact on Early Stone Age assemblage composition. Therefore, the naming of a variety of artifact traditions based solely on "tool frequency" (for example, based on the proportion of choppers vs. spheroids/subspheroids), without due consideration to the role that raw material variability may have played in assemblage composition, may not carry much weight, particularly for the Early Pleistocene. Studies have clearly shown the effect of access (or lack thereof) to good quality raw materials impacting artifact forms (e.g., Stout et al. 2008). Therefore, investigations of the paleogeographic and paleoenvironmental settings of Early Pleistocene sites are critical for understanding ancestral human stone tool manufacture and use behavior, as are studies of the flaking quality and influence of raw materials (for example, their proximity and availability), before assigning assemblages into different "cultural traditions." M. Leakey (1971) initially believed that the various "chopper" forms were the desired tools, but knapping and butchery experiments have shown that these were probably byproducts generated as a result of the production of sharp-edged cutting flakes (Isaac 1984; Toth 1987, 1985).

The Developed Oldowan B

At Olduvai Gorge, assemblages assigned to the "DOB" began in Middle Bed II, and the earliest occurrences may date to ~1.5–1.4 Ma. Here, hominins continued making the same classic Oldowan artifacts (cores/choppers, *débitage,* and manuports), but also some crude bifaces, signaling the emergence of a more "advanced" stone tool tradition. The light duty tools including scrapers, burins, awls, *outils écaillés*, and laterally trimmed flakes were also present in the "DOB" throughout Bed II up to Bed III. This same lithic tradition also persisted, with some additions, into Bed IV times, and was named the "Developed Oldowan C," although it is unclear to us how it differs from the assemblages assigned to the "DOB." Nevertheless, both the DOB and the Early Acheulian are found in Beds II–IV and the Masek Beds, and were penecontemporaneous for over 1.0 million years.

M. Leakey noted that the bifaces found in the Developed Oldowan show "unskilled workmanship," whereas Early Acheulian bifaces were larger in size and well-struck, and the makers appeared to have "full mastery of their materials." Thus she argued that those two traditions should be separated. According to M. Leakey, the "Developed Oldowan" is contemporary with, but distinct from, the Acheulian: "...the factor that distinguishes the two traditions is an inability to detach large flakes in the Developed Oldowan—as in the Oldowan itself—whereas from Bed II onwards the Acheulean bifaces were generally made on large flakes" (M. Leakey 1975, 484–486). It is our impression that in the past a majority of archaeologists have generally agreed with M. Leakey's observations on the differences between "Developed Oldowan" and the "Early Acheulian" (e.g., Barham 1997; Klein 1999).

The Early Acheulian

M. Leakey (1971) excavated, discovered, and described the Acheulian at Olduvai Gorge, but Kleindienst (1962) set the criterion that an assemblage should contain 40–60% bifaces to be classified as Acheulian. Although Leakey did not oppose Kleindienst's definition, she pointed out that the term "Acheulian" should also be applied to the contemporary assemblages where a low percentage of bifaces is found in an industry otherwise characteristic of the "Developed Oldowan" (1976a, 447). According to M. Leakey, Early Acheulian bifaces tend to be larger and more numerous compared to those in the "DOB." Further, the spheroids/subspheroids that dominated the DOA assemblages become relatively few in the Acheulian.

It can be argued that M. Leakey (1971) did not clearly define the differences/similarities between the DOB and the Early Acheulian. Initially she classified some of the Bed II Assemblages (MNK and the Lower Floor at TK) to the Developed Oldowan, and later reclassified them into the Acheulian.

> It now seems possible that the industries from two sites in Bed II (MNK and the Lower Floor at TK), that were first classed as Developed Oldowan, should probably be included in the Acheulean, since the bifacial tools are Acheulean in character and technique of manufacture, although they are exceedingly rare. These two industries were originally classified as Developed Oldowan on the basis that a proportionate abundance of bifaces was a diagnostic character of the Acheulean (Kleindienst 1962), and that an industry should have 40% or more to qualify as Acheulean. More detailed work on the Acheulean and Developed Oldowan indicates that other features are perhaps more important, in particular the technique of manufacture evident in the bifaces. (M. Leakey 1976b, 31)

Part of Leakey's difficulty with the Oldowan-Acheulian transition was the initial acceptance of Kleindienst's arbitrary 40% threshold (and later reconsideration), but other problems had to do with uncertain dating and vague ideas of what exactly is changing during this transition, summed up in the somewhat subjective type of "biface." In their revision of the Olduvai Gorge artifacts, de la Torre and Mora (2005) illustrate that some of the so-called "bifaces" are not even artifactual. Thus, we are still uncertain of the answers to such simple questions as: What exactly marks the end of the Oldowan and signals the beginning of the Acheulian? When did the Oldowan end and the Acheulian begin? How long did the transition last? Why is the Developed Oldowan considered to be transitional? Further research is needed, especially on the functions of the Acheulian stone tools and their paleoenvironmental settings to be able to answer some of these questions conclusively.

Discussion

The Developed Oldowan A

Did the Oldowan evolve into the "Developed Oldowan"? Why do we have artifacts classified as "Developed Oldowan" at some sites but not others? Despite years of extensive and systematic field surveys undertaken in the Early Pleistocene Gona deposits, the archaeology team has found no artifacts that can be identified as protobifaces, spheroids/subspheroids, awls, burins, etc., the hallmark of the "Developed Oldowan" tradition. In addition, no other Late Pliocene site in East Africa has yielded artifacts identified as these types. Crudely made handaxes and cleavers found from Early Pleistocene deposits at Gona have been associated with Oldowan (Mode I) choppers and flakes. Gona is not an exception in this regard, and several other sites in Africa that contain Oldowan artifacts (either Late Pliocene or Early Pleistocene) have not yielded lithic assemblages that can be identified as Developed Oldowan (*sensu stricto*). For example, artifact forms such as spheroids are unknown at Koobi Fora, Lokalalei, Omo, etc.

Spheroids and subspheroids have been found at Ain Hanech, Algeria, and date to 1.95–1.77 Ma (Sahnouni et al. 2002; Sahnouni and de Heinzelin 1998). The site is contemporary with Olduvai Gorge Bed I, and is certainly older than the Developed Oldowan levels at Olduvai Gorge. Sahnouni believes that artifact manufacture here follows the norms of Oldowan technology, and he has classified the Ain Hanech artifacts into the Oldowan. The spheroids/subspheroids, the main artifact types of the DOA, were not universal during the Early Pleistocene, and existed only at sites where quartz and limestone were the raw materials accessible for ancestral toolmakers (e.g., Sahnouni et al. 2002, 1997; Sahnouni and de Heinzelin 1998; Willoughby 1985).

Kurashina (1987) compared the Developed Oldowan assemblages from Gadeb, Ethiopia, with 64 Oldowan, Developed Oldowan, and Acheulian assemblages from sub-Saharan Africa. The results of his analyses, based on the "tool frequency," showed that the Developed Oldowan clusters well with the Oldowan, and Kurashina concluded that the Developed Oldowan represents an activity facies within the Oldowan. Gowlett (1988) sees the DOA as "simply a somewhat evolved form of Oldowan, in which bifacial working is increased, but in which there are no radical new departures" (p.14). Following a more detailed study of the Olduvai Gorge archaeological materials, de la Torre and Mora (2005, 228) conclude that "…there is no such thing as the Developed Oldowan."

So, is there an artifact tradition attributable to the Oldowan-Acheulian transition? As far as Leakey's DOA is concerned, the answer is no. The Olduvai Gorge spheroids/subspheroids are simply a result of extensive flaking and/or use of quartz as percussors/hammerstones, and the so-called "protobifaces" probably have very little (if anything) to do with a plan of making bifaces. Instead, Leakey's "protobifaces" are actually pieces that would be identified as exhaustively reduced cores (bifacially-worked side-choppers following M. Leakey's typology, see Fig. 1). The existence of burins and awls during the Early Pleistocene (Oldowan and the DOA) is also hard to justify (see de la Torre and Mora 2005; Potts 1991). While some of these pieces may formally be assigned to these types (based on their shape), it is difficult to conceive of the need by Early Pleistocene hominins for such tools, and if indeed those pieces were used as such. In sum, the DOA is not technologically different enough from the Oldowan to merit a different tradition. Therefore, it seems appropriate for the DOA to be dropped, and be subsumed within the Oldowan Industry.

The Developed Oldowan B

Why were the DOB and the Acheulian penecontemporaneous for almost one million years? M. Leakey argues that the two represent different cultural traditions or the assemblages were crafted by two different hominin groups (species?). Clark (1970) suggests that the two contemporary traditions may represent activity variants, i.e., artifacts made for differing functions. Gowlett (1988) also seems to favor the idea that differences in function may explain the variations in the Developed Oldowan/Acheulian. Isaac (1984) indicated preferred hominin habitats, with the Bed I and Bed II Oldowan sites located close to the lake, whereas the Acheulian toolmakers ranged widely away from the lakeside floodplain, a point which is also elaborated upon by Hay (1990).

Stiles (1979b) argued that the use of different raw materials was responsible for the variations seen in the DOB and the Early Acheulian. He carried out statistical tests on bifaces and large flakes recovered from two Early Acheulian (EFHR and TK Lower Floor [TKLF]) and two DOB (TK Upper Floor [TKUF] and FC West Floor [FCWF]) sites from Olduvai Gorge. His results showed that there were indeed statistical differences in the bifaces and the whole flakes of the two "traditions," and that the DOB assemblages had significantly higher frequencies of quartz compared to lava (see also Jones

1994). Stiles argued that "raw material rather than cultural tradition accounts for the differences between the bifaces of the two industries" (1979b, 129), and concluded that "... the observed differences can be explained by differences in the raw materials and primary form of the bifaces, there being no need to call on separate cultural traditions as an explanation" (p. 29). Hence, Stiles (1979b) urged that the DOB be dropped. Davis (1980) argues against the raw material explanation provided by Stiles, but offers no plausible explanation for the differences in the two assemblages.

According to Jones:

> ... there is a small but definite overlap between the two types of collection in that 5 to 10 per cent of the Developed Oldowan samples consist of bifaces that are identical to the majority at many Acheulean sites, and less than 5 per cent of several Acheulean collections consist of small bifaces which are morphologically and technologically similar to the majority at Developed Oldowan sites. (Jones 1994, 272)

It is problematic to accept Kleindienst's criterion that an assemblage should contain at least 40% handaxes to be classified into the Acheulian tradition. It is clear that the hominins responsible for the DOB assemblages already had the technological competence and the capability to make bifaces. Therefore, other factors may explain why the "tool frequencies" in the two assemblages differed. The most plausible explanation is that the differences in the flaking-quality, proximity, size, shape, and availability of raw materials may have influenced assemblage composition of the artifacts of the two "traditions" (Jones 1994; Stiles 1979a, 1979b).

> Other differences include the very variable morphology of the Developed Oldowan biface sample, as compared to the general consistency of the Acheulean samples. The sample sizes of the Developed Oldowan occurrences are generally lower than most Acheulean samples; and while the Acheulean collections from any one site will tend to be dominated by one maybe two materials, the Developed Oldowan collections will preserve roughly equal numbers of each material. Quartzite, however, has a notably lower occurrence at Developed Oldowan sites than at Acheulean sites, where it tends to be the dominant raw material for bifaces. (Jones 1994, 273)

Other explanations for the differences between the DOB and the Acheulian include the use of different paleohabitats by the makers of the two assemblages. R. Hay (1976) pointed out that the Developed Oldowan sites were located within 1 km of paleo-lake Olduvai Gorge, whereas the Acheulian sites were >1 km from the lake. Compared to the Oldowan, we see more or less similar habitats (mainly open grasslands/stream channels) occupied by the makers of the DOB and Early Acheulian artifacts. Most of the DOB and Early Acheulian sites are found in more open settings and located near channels. According to Jones (1994), the sources for both phonolite and quartzite were localized, and hominins (both DOB and Early Acheulian toolmakers) would have had equal access to stone resources for creating blanks on which to make large bifaces. Thus, the makers of both the DOB and Early Acheulian probably started with the same blank sizes. Jones (1994, 296) states that there are "...two very important similarities between these two samples of bifaces: first, both samples are made in roughly the same manner, i.e. using the same basic set of techniques, to the same basic plan shape. Second, both samples are made in the same range of raw materials."

Jones (1994) also points out a number of possible explanations for the differences between the DOB and Early Acheulian, and he seems to think

> ...that the bulk of the Developed Oldowan bifaces started out as typical Acheulean handaxes, but through use and the need to renew edges, or a general need to produce small flakes, they were flaked to their present shapes and discarded. This applies well to the phonolite and quartzite samples, but not to the basalt and trachy and esite collections. There is no evidence that the blanks for the Developed Oldowan quartzite and phonolite bifaces started out small; the bifaces in these two materials started out at the same size. This is further borne out by re-sharpening experiments on typical Acheulean bifaces. After three or four phases of re-sharpening, I was left with what could only be classified as a typical Developed Oldowan handaxe. (Jones 1994, 274)

According to Jones, "the majority of the Developed Oldowan sample consists of re-sharpened and re-flaked Acheulean handaxes" (Jones 1994, 296). Compared to the Acheulian, the DOB contains more variety of tool types and a higher percentage of *débitage*, and Jones concluded that the DOB sites represent activity areas for maintaining artifacts, whereas the Acheulian sites represent discard areas after use. In sum, the DOB seems technically similar and appears to be contemporary with the Early Acheulian, and such assemblages with crudely made Acheulian handaxes, choppers, heavy duty tools, and *débitage* should be subsumed under the Early Acheulian.

Is There a Transitional Industry Between the Oldowan and the Acheulian?

The main task of Oldowan toolmakers was selecting fine-grained cobbles with good flaking quality for making sharp-edged flakes needed for processing carcasses and other cutting needs. The flakes were struck from cores with the hand-held percussion technique. In contrast, Early Acheulian toolmakers were concerned with selecting large cobble blanks and/or boulder cores of sufficient size for the removal of large flake blanks (>10 cm). Ethnographic (Stout 2002; Toth et al. 1992) and experimental (Toth 2001) evidence strongly suggests that the latter would have been done with the core supported on an anvil or the ground, rather than in the hand. Large flake production in the Early Acheulian thus involves different objectives, different raw materials, and different means of support, as well as much greater force, possibly involving different percussive techniques such as throwing (Toth 2001). This mode of flaking is qualitatively different from the production of Oldowan flakes and clearly represents a novel technological invention. The challenges of properly positioning and supporting larger cores, and of delivering larger amounts of percussive force to precise targets further reflect an increase in required motor skill over Oldowan flaking.

Early Acheulian toolmaking further differs from the Oldowan in the subsequent shaping of the flake or cobble blank. This introduces an additional stage in tool production as well as an additional level of hierarchical action organization. Flake removals must be organized with respect to an overarching goal, and properly related to one another on this larger spatiotemporal scale if success is to be achieved. Early Acheulian bifaces are quite crude compared to later forms, yet examples from Gona clearly show the deliberate creation of bifacial cutting edges and shaping of distinct points. This is true of bifaces on large cobbles as well as flake blanks, and reflects invariance at a higher level of hierarchical organization.

Whereas the neural demands of Oldowan toolmaking pertain primarily to sensorimotor coordination (Stout and Chaminade 2007; Stout et al. 2008), the higher-level organization of Acheulian toolmaking places demands on the prefrontal cortex (Stout et al. 2008), a region generally thought to play a central role in coordinating flexible and goal-directed behavior (Ridderinkhof et al. 2004). Late Acheulian toolmaking in particular is associated with activation of the right hemisphere homologue of Broca's area, a region implicated in language processing as well as the more general coordination of actions as subordinate elements within ongoing, hierarchically-structured action sequences (Koechlin and Jubault 2006). Broca's area has been a focus for hypotheses relating to manual object combination, hierarchical action organization, and language evolution (Greenfield 1991). The earliest paleoneurological evidence of expansion in this region comes from KNM-ER 1470 (Holloway 1999), dating to ~1.9 Ma.

In sum, qualitative technological, behavioral, and cognitive differences between the industries make a "transitional" industry difficult to envision. Essential neural, somatic, and behavioral preconditions must have been in place to afford the invention of this new technology; however, the technology itself represents a clear discontinuity. In addition, at Olduvai Gorge, the "Developed Oldowan" persisted side-by-side with the Acheulian industry for about one million years (1.5–0.5 Ma). The contemporaneity of the Developed Oldowan and the Acheulian itself casts doubt on the validity of the Developed Oldowan as a transitional industry.

Outside of Olduvai Gorge, the Karari Industry at Koobi Fora has been described as similar to the DOA (Isaac and Harris 1997). Emerging at about 1.6 Ma, the "Karari" is a distinctive artifact tradition with a preponderance of single platform cores that overlapped with the "Developed Oldowan" at Olduvai Gorge, Early Acheulian at West Turkana, and other sites. Given its standardized form and technique of manufacture, "…it would seem probable that the idiosyncratic features of the Karari industry are best regarded as due to stone-working *habits* that were adjusted to local raw material forms" (Isaac 1984, 164–165 [original emphasis]). In the final analysis, it seems likely that the Karari Industry will prove to be an alternative technological response to some of the same behavioral changes (e.g., different habitats, increased mobility [Braun and Harris 2003; Rogers et al. 1994]) that prompted the invention of the Acheulian, rather than a "transitional" industry in the conventional sense.

It is probable that hominin behavior does change in the Early Pleistocene, but it is difficult to equate these changes to a transitional stone tool industry. For example, compared to the Late Pliocene, stone tool use became more "habitual" and sites were repeatedly occupied during the Early Pleistocene. By 1.8 Ma, intensive flaking of cores, a larger number of retouched pieces, and high density concentrations of artifacts were documented across many sites in Africa, as well as more cutmarked bones in the archaeological record (Toth et al. 2006). However, the same techniques of Oldowan artifact manufacture (hand-held/bipolar technique) lasted for about a million years (2.6–~1.7 Ma). Major changes in the hominin plan and aim of stone tool manufacture, i.e., the conceptual and physical ability to remove large flakes from boulder cores and impose form and symmetry—tasks that demand complex operational sequences—emerged with the Early Acheulian ~1.7 Ma.

Isaac, years ago, suggested that:

> ...the seemingly abrupt initiation of the early Acheulian may relate to the discovery of how to strike large flakes consistently. What is not yet clear is whether bifaces at the moment of innovation represented *new tools* for performing long lasting tasks (such as butchery) or whether *new tasks* were added to the behavioural, adaptive repertoire. To resolve this we will need better information on function before, during, and after the beginning of the Acheulian. (Isaac 1984, 50 [original emphasis])

Better information is now accumulating, albeit slowly, as discussed below.

The Emergence of the Acheulian

The earliest appearance of the Acheulian has long been considered to occur 1.7–1.5 Ma (e.g., Clark 1970; Klein 1999), but the earliest *in situ* occurrence has been difficult to document securely, leading to some confusion in the literature. For example, while Klein (1999) cites West Turkana as documenting the earliest Acheulian site (from Roche 1995), Clark et al. (1994) cites Konso (from Asfaw et al. 1992), Lieberman and Bar-Yosef (2005) refer to Peninj (from Domínguez-Rodrigo et al. 2001), and Klein (2006) cites Kokiselei at West Turkana (from Roche et al. 2003) and Gona (from Quade et al. 2004). Despite these various hints, full reports of the artifacts, their age, and context have yet to be published. At Konso, Early Acheulian artifacts that are ~1.7 Ma have been reported by Beyene (2008, 2004, 2003; see also Beyene et al. 1997; Suwa et al. 2007), but this should await a full report by the researchers. Roche et al.'s (2003) brief report indicates the presence of an Early Acheulian Industry at Kokiselei (KS4), West Turkana, Kenya, dated to ~1.65 Ma. The artifacts consist "of handaxes or proto-handaxes, picks, and of flakes, some of them very large, as are some of the cores" (Roche et al. 2003, 665). Some technologically complex Oldowan stone tools are also reported from Peninj dated between 1.6 and 1.4 Ma (de la Torre et al. 2003), but these assemblages lack bifaces and the large blanks known to occur at this time. Although for a long time the Early Acheulian from Peninj was believed to be ~1.4 Ma, recent publications by de la Torre et al. (2008) and Domínguez-Rodrigo et al. (in press) have reported an age around 1.2 Ma for both the Oldowan and the Early Acheulian of Peninj.

Systematic survey of the newly designated Busidima Formation at Gona (Quade et al. 2004, 2008) has yielded Early Pleistocene Oldowan, and Early-Late Acheulian, Middle Stone Age, and Late Stone Age archaeological sites (Semaw et al. [in prep.]). A number of these sites have been excavated, yielding stone tools *in situ*. The presence of a more than 100 meter-thick Plio-Pleistocene sequence in the Busidima Formation has provided an opportunity to assess whether any lithic assemblages existed to mark the Oldowan-Acheulian transition. Our recent fieldwork at Gona has shown the presence of abundant Early Acheulian crudely-made bifaces and picks estimated to be ~1.6 Ma (Quade et al. 2004, 2008; Semaw et al. 2008 [in prep.]). However, there are no lithic assemblages that are attributable to the Developed Oldowan, and the evidence from Gona appears to favor a rapid technological transition from the Oldowan (Mode I) to the Acheulian technology (Mode II), much in the same way that the earliest sites at Gona mark an abrupt transition from no archaeological record to the presence of an archaeological record (see Rogers and Semaw [this volume]).

Our continued archaeological field investigations at Gona show that the main artifact types found in the Early Pleistocene deposits (i.e., in addition to the typical Oldowan cores/choppers and flakes) include crudely made Early Acheulian handaxes, picks, and cleavers. These are the new artifact types unknown in the Late Pliocene/Earliest Pleistocene stone assemblages of the Oldowan tradition. The Early Acheulian assemblages consist of numerous large flakes (blanks) and crude bifaces that were made on large cobbles as well as on large flakes >10 cm (e.g., Fig. 3). Interestingly, a common form at these early sites (e.g., OGS-12 and BSN-17) is a pick (sometimes trihedral) made on large cobbles, perhaps similar to the early sites at Konso.

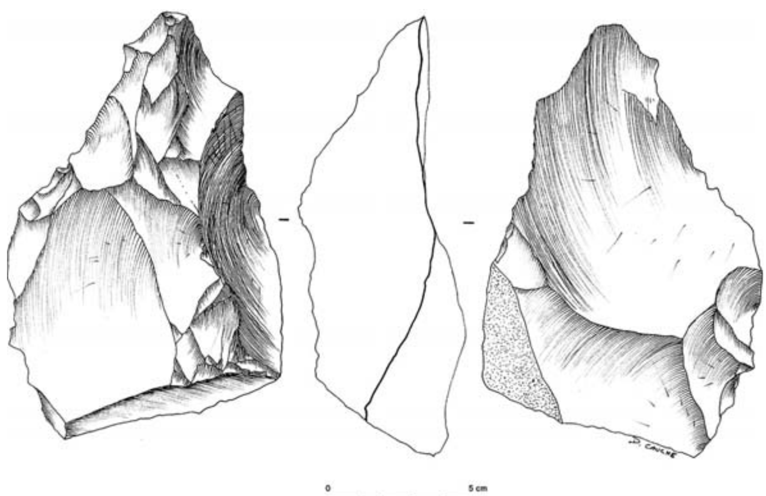

Fig. 3 Early Acheulian biface excavated from OGS-12 (Gona), ~1.6 Ma

Although the Acheulian is usually associated with *Homo erectus* (and *Homo ergaster*), their first appearance datum (FAD) not contemporaneous. Fossil hominins in Africa attributed to *Homo erectus* date from at least 1.65 Ma (see recent review in Suwa et al. [2007]), and the earliest Eurasian hominins from Dmanisi (Republic of Georgia) and Java (although with less-secure chronological placement) are also known with dates of ~1.8 Ma (Gabunia et al. 2001; Larick et al. 2001; Lordkipanidze et al. 2007, 2005), although Acheulian artifacts are absent from these localities. The relationship between the appearance of *Homo erectus* and the origin of the Acheulian tradition is unclear; from the present evidence these events may be separated by at least 100,000 years.

Hominins c. 1.7 Ma began producing crude bifaces and picks (and probably cleavers as well) from large cobbles and large flakes. The making of large flakes (>10 cm) was cognitively and technically different from the production of the simple sharp-edged cutting flakes produced during the Late Pliocene, the main purpose of which was probably for processing carcasses. As stated by Isaac (1969), the discovery of how to knock off large flakes (blanks) used for making bifaces appears to be the novel strategy that heralded the appearance of the Acheulian Industry. Substantial differences exist in the entire cognitive processes involved in the two traditions. Late Pliocene hominins were primarily after fine-grained cobbles used for the production of small sharp-edged cutting flakes. Preliminary observations indicate that during the initial stage, Early Acheulian toolmakers (e.g., at Gona) were after large size raw materials irrespective of their fine-grained nature. This does not mean that hominins were not interested in fine-grained raw materials, but simply that clasts that were large as well as fine-grained were quite scarce, and the hominins utilized whatever large cobbles/boulders were accessible for producing large blanks. Such considerations likely explain the recently noted (Sharon 2008) tendency for Large Flake Blank tools to be made on relatively coarse-grained materials throughout the temporal and geographic range of the Acheulian. At Olduvai Gorge, Oldowan, "Developed Oldowan," and Acheulian toolmakers occupied different paleogeographic landscapes, i.e., close to paleo-lake Olduvai Gorge during Bed I times, and more inland later; the composition of the raw materials also changed from lava during Bed I to quartzite during later times (see review in Kyara [1999]).

The case regarding the quality of raw materials used at Olduvai Gorge, according to de la Torre and Mora (2005, 209), may be different from Gona, with the hominins selecting (e.g., at TK) for "large quartz blocks without irregularities that could be turned into large cutting tools, anvils, etc." This contrasts with Bed I sites where small lava cobbles of "irregular quality" quartz fragments were used for making the Oldowan artifacts. During the Late Pliocene small, sharp-edged cutting (Oldowan) flakes were produced by hand-held percussion, throwing, or bipolar techniques, but the large blanks produced by the makers of the Early Acheulian would have been difficult to produce using these hand-held percussion methods. The large implements produced by Early Acheulian toolmakers are known to be effective for cutting, digging, and woodworking, but these tools' functions are not yet clear.

It is arguably more difficult to make a handaxe from a cobble than from a large flake; therefore, we cannot consider those made of cobbles as primitive or less advanced. Flaking and shaping a large cobble into a pick or biface may be difficult, and experimental work should throw light on this issue. Nonetheless, both types (bifaces on cobbles as well as on large flakes) were made by the makers of the Early Acheulian, and most likely hominins had figured out that first obtaining a large flake makes it easier for making handaxes and cleavers.

The timing and circumstances of the technological leap from the Oldowan to the Acheulian stone tool tradition in Africa is still among the most important but least understood questions in the field of paleoanthropology. Why the Acheulian $\sim$1.7 Ma? While there is some evidence of African climate change about 1.8–1.7 Ma (Cerling 1992; deMenocal 2004), there is no clear link between environmental change and the origins of *Homo erectus* or the Acheulian. The Oldowan-Acheulian transition is important because it marks the first time that our ancestors created tools (handaxes, cleavers, and picks, among others) that probably required a preconception of form before their manufacture—tool forms that persisted for over 1.3 million years. This transition is poorly understood, though, because of the paucity of well-dated Acheulian archaeological sites that are older than 1.4 Ma. As we have discussed, some preliminary investigations in East Africa suggest that the Acheulian appeared in the geological record about 1.7 Ma, and probably coincided with the expansion of *Homo erectus* into areas unoccupied by earlier hominins (Beyene 2008, 2003; Beyene et al. 1997; Roche et al. 2003). However, the emergence of the Acheulian at $\sim$ 1.6–1.7 Ma has yet to be unambiguously demonstrated both archaeologically and geologically. The timing of the appearance of the Acheulian is geologically poorly constrained by only a few sites, and the environmental background for the behavioral changes in hominins near the Pliocene/Pleistocene boundary is poorly understood.

With regards to the "transition" between the Oldowan and the Acheulian, Isaac long ago stated that

> the sharp distinction between these new Acheulean Industries and the Oldowan or Developed Oldowan is related to the appearance in the former of large flakes which formed the blanks on which tools were made. A "quantum" jump or "invention" may well have been involved in this changeover. (Isaac 1972, 409)

His suggestions still hold, and we agree with his conclusions, although we feel the "invention" may, in fact, be more complex than it sounds, as we suggest below.

Conclusion

A long held consensus view among archaeologists is that the "Developed Oldowan" is transitional between the Oldowan and the Acheulian, but this is not apparent in the archaeological record. For Paleolithic archaeologists, having a clearly transitional stone tool tradition seems orderly and convenient, but that does not appear to be the case with the "Oldowan–Developed Oldowan–Acheulian" transition, and the relationship of these three "traditions" actually appears to be more complex. Current evidence suggests that the so-called DOA/DOB and the Early Acheulian began at about the same time, i.e., ~1.7 Ma. Hence, even if they were considered to be viable traditions, the DOA and the DOB cannot both be precursors to the Acheulian, and they cannot be transitional between the Oldowan and the Acheulian. Further, the DOB and the Acheulian at Olduvai Gorge appeared at the same time and then overlapped for about one million years (1.5–0.5); therefore, both traditions are contemporary. Further detailed research on the age and paleoenvironmental settings of these occurrences is warranted to sort out the meaning of the differences in these traditions. Most archaeologists seem to accept the validity of the "Developed Oldowan" as a stone tool tradition, but at this stage it seems to us reasonable to assign the DOA to the Oldowan, and the DOB to the Early Acheulian, as others have suggested before.

Moreover, our discussion above and our work at Gona have led us to consider that the way the "Oldowan–Developed Oldowan–Acheulian" transition has traditionally been conceived may be conflating separate cultural/technological/ecological changes occurring in the Late Pliocene/Early Pleistocene that may or may not be interconnected, such as: (1) the ability to knock off large flakes, (2) the ability to flake invasively and shape tools purposefully with predetermination or preconception of form, (3) the standardization of tool shape and/or technique, (4) changing diet and ranging patterns, (5) possible changes in group size and/or organization, and (6) possible changes in learning styles and abilities. Early Pleistocene hominins may have "experimented" with these developments initially until all elements came together with the classic Acheulian. For example, in our opinion, the Karari Industry at 1.6–1.5 Ma definitely shows the ability to knock off large flakes and standardization, but lacks clear evidence for predetermination of form or shaping or invasive flaking (such as seen in later handaxes). Early Acheulian artifacts such as those found at OGS-12 at Gona may demonstrate all of the technical factors except invasive retouch and perhaps standardization (we would need a larger sample to identify true standardization). The evidence from Kokiselei 4 and from Konso may also be consistent with this idea, although we await full analytical reports on the Acheulian assemblages from these sites. The major point here is not that the Karari or other assemblages are transitional, but that at the very beginning of the Acheulian we expect to find some variability depending upon paleogeography, availability, and size and type of raw materials, as well as what appears to be some "experimentation" (although this "experimentation" need not have been conscious), that is, alternative technological responses to similar selective pressures. More research will be needed to discern what this variability means (what these selective pressures were) and whether or not the earliest Acheulian forms, again in Isaac's words, "represent *new tools* for performing long lasting tasks (such as butchery) or whether *new tasks* were added to the behavioral, adaptive repertoire" (Isaac 1984, 163). Given the initial variability in the Early Acheulian record, we suspect the latter.

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Lower Palaeolithic Transitions in the Northern Latitudes of Eurasia

Jan Michal Burdukiewicz

Abstract The northern latitudes of Eurasia were inhabited temporarily, during favorable, warmer periods since 1 Ma ago with a considerable transition from Mode 1 (Oldowan) or Mode 2 (Acheulean) to microlithic technology and introducing new and more effective composite tools. Until recent years, archaeologists believed that such technology occurred almost exclusively during the Mesolithic and Late Palaeolithic (Mode 5), in the form of small stone inserts held by wooden or bone hafts, producing composite tools. A significant spatial, chronological and ecological variability of Lower Palaeolithic microlithic assemblages suggests that they developed as a result of the adaptation to local environment, possibly temperate and wooded, in different areas from North-Eastern China to Northern Europe, parallel to Mode 1 and Mode 2 in southern and western part of Eurasia.

Keywords Acheulean • Lower Palaeolithic • Microlithic technocomplex • Oldowan • Composite tools

Introduction

The Lower Palaeolithic Period covers the longest time span in human history, rich in numerous changes in the widening of inhabited areas as well as in technological development. Archaeologists usually distinguish two main technologies of the Lower Palaeolithic: Pebble Tool Technocomplex (called usually Oldowan or Mode 1) and Technocomplex (called Acheulean or Mode 2). Both these technocomplexes originated in Africa and dispersed to southern parts of Asia and Europe. The climate of Africa was warm enough for early hominins to survive. Southern Asia and Europe offered more or less similar environmental conditions. This way technological equipment in these areas was sufficient to exist and important transitions are not visible in the archaeological data. Northern latitudes of Eurasia had very changeable climatic conditions during the Pleistocene period.

According to recent research, the first inhabitants in Northern Eurasia appeared c. 1 Ma ago. The earliest colonization of northern latitudes (around the 60th parallel) is connected with a considerable transition from Mode 1 or 2 to microlithic technology. Such sites are known in Eurasia, Central Europe, and China, and span from c. 1 Ma to 300 ka BP, far to the north from the Movius Line indicating the northern border of the presence of Mode 2.

It is supposed that forested areas, especially the northern zone of Eurasia, were settled because early hominin groups carried out transitions to microlithic technology, which meant introducing new and more effective composite tools. Northern latitudes of Eurasia were inhabited temporarily, during favorable, warmer periods. These inventories are characterized by the domination of microlithic technology in lithic production (average length of artifacts c. 15–30 mm), which were most probably hafted. Such invention in human history is usually seen as very sophisticated and characteristic for Mode 5. Until recent years, archaeologists believed that such technology occurred almost exclusively during the Mesolithic and Late Palaeolithic (Mode 5), in the form of small stone inserts held by

J.M. Burdukiewicz (✉)
Institute of Archaeology, University of Wroclaw, Wroclaw, Poland

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wooden or bone hafts, producing what is known as composite tools. Finally they came to realize, however, that small lithic tools, often no larger than a fingernail and hard to hold using only fingers, started to be produced much earlier, by hominin groups inhabiting northern latitudes of Eurasia in the Lower Palaeolithic.

The Earliest Settling of Eurasia—Modes 1 and 2

The earliest colonization of northern Eurasia is now connected with the oldest archaeological site of Dmanisi in Georgia, dated to c. 1.8 Ma (Vekua et al. 2002). The artifacts of Dmanisi as well as other older sites in Eurasia are connected with the Pebble Tool Technocomplex. It should be mentioned further that sites with pebble tool technology have similar tool-making techniques regardless of raw material differences. The Oldowan appeared c. 2.6 Ma ago (Semaw et al. 2003; Stout et al. 2005). The most important feature of Oldowan artifacts is the low degree of standardization (Wynn and Tierson 1990). The most diagnostic forms for such assemblages are core tools and flakes with one or more sharp edges or points. In other words, Mode 1 (Oldowan) can be characterized by simple lithic processing techniques with one, two, or more flaking directions (Plummer et al. 2001; De la Torre and Mora 2005). Sometimes centripetal flaking can also be seen. These flakes were modified by the application of simple retouch, and were frequently notched or denticulated. At archaeological sites from this period simple unmodified manuports and hammerstones are common.

Further expansion to the north is connected with the Acheulean technology, Mode 2, or more neutral handaxe technology, which appeared c. 1.6 Ma ago in Africa (Dominguez-Rodrigo et al. 2001). Such technology was more sophisticated and standardized (Mc Pherron 2000; Mc Nabb et al. 2004) compared to the Oldowan. Handaxes, cleavers, and picks are frequently seen as "preferred products" (Bordes 1968, 64; Debenath and Dibble 1994, 130, etc.), "cores for flake extraction" (Davidson and Noble 1993), or "individualized memic constructs" (McNabb et al. 2004). Anyway, the handaxes are alike all through their spatial and temporal allocation, although they show a variety of shapes as well. Bifaces from Europe and Asia are almost the same as African ones. However, cleavers in Europe are much rarer than in Africa or South Asia.

From an archaeological point of view bifaces are interpreted as a wide taxonomic unit, with recurring "mental templates" held by the knappers sharing similar cultural principles (Wynn and Tierson 1990). In another explanation, technological and morphological similarity did not reflect a taxonomic unit, in opposition to the idea that it was the convergent result of knapping techniques and the use of the artifacts (Wynn 2004, 674). This way bifacial technology was convergently invented in different local traditions, and handaxes were made in various ways by individual manufacturers, depending mostly on raw material.

Majority of archaeologists prefer to see the Acheulean as a general taxonomic unit with several spatial and temporal variations. The northern border of early handaxe distribution is indicated by the Movius Line, with some recent modifications like Bose Basin in China (Hou et al. 2000). The oldest sites with handaxes in Western Asia appeared c. 1.4 Ma ago in Ubeidiya (Bar-Yosef 1987; 1998) and Gesher Benot Ya'aqov in Israel aged 0.8 Ma (Goren-Inbar and Saragusti 1996). In South Asia, the early Acheulean site of Isampur (India) is tentatively dated to 1.2 Ma (Paddayya et al. 2002; Chauhan 2004). In Eastern Asia the oldest handaxes are lastly known from Bose Basin in Southern China, and are dated to 0.8 Ma (Hou et al. 2000).

In Europe Mode 2 appeared later, probably 600 ka ago, as indicated by the oldest sites with handaxes, like Venosa Notarchirco in Southern Italy, Carrière Carpentier in Northern France, and Boxgrove in southern England. Much more numerous are slightly younger lithic concentrations from La Galeria in Atapuerca (Carbonell et al. 2001, 267–271).

Lower Palaeolithic Microlithic Sites in the Levant

In the northern latitudes of Eurasia there are lithic assemblages which are quite unlike the two mentioned above. They are characterized by core/flake technology and by the very small size of the artifacts. These artifacts are frequently called microliths because of their small dimensions, like typical Mode 5 tools (Figs. 1, 2, 3, 4, 5, 6, 7, 8, and 9).

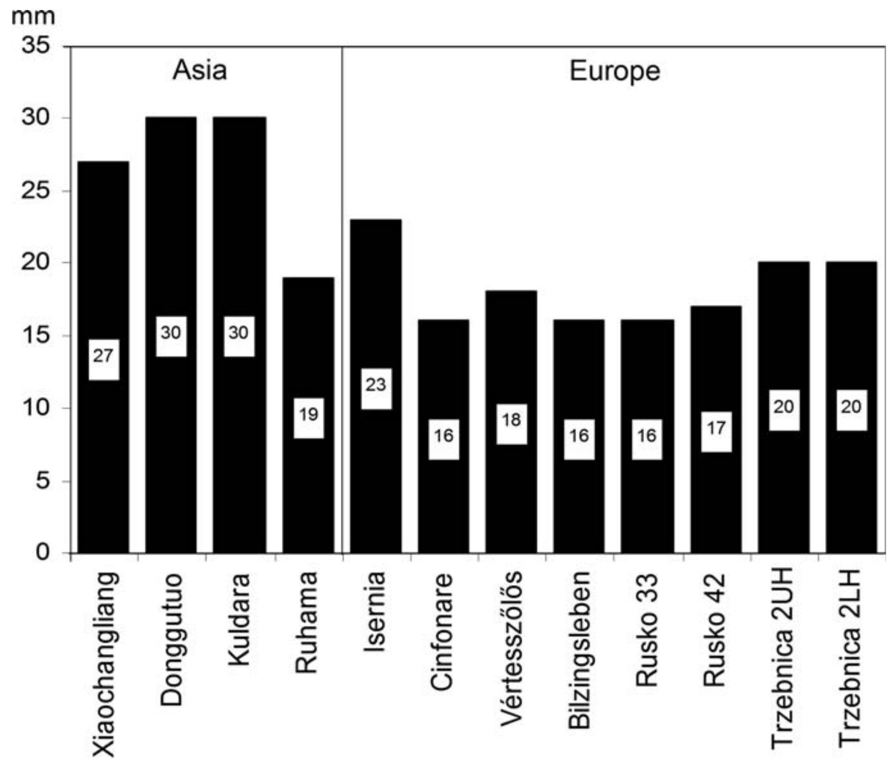

Fig. 1 Mean length of artifacts from the main Lower Palaeolithic microlithic sites in Eurasia

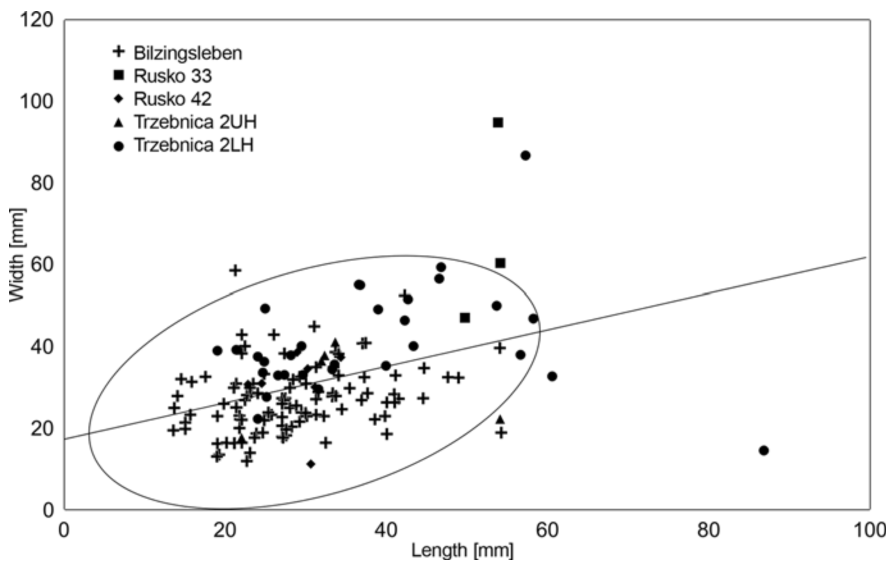

Fig. 2 Lower Palaeolithic microlithic sites in Central Europe: Scatter plot of core length and width

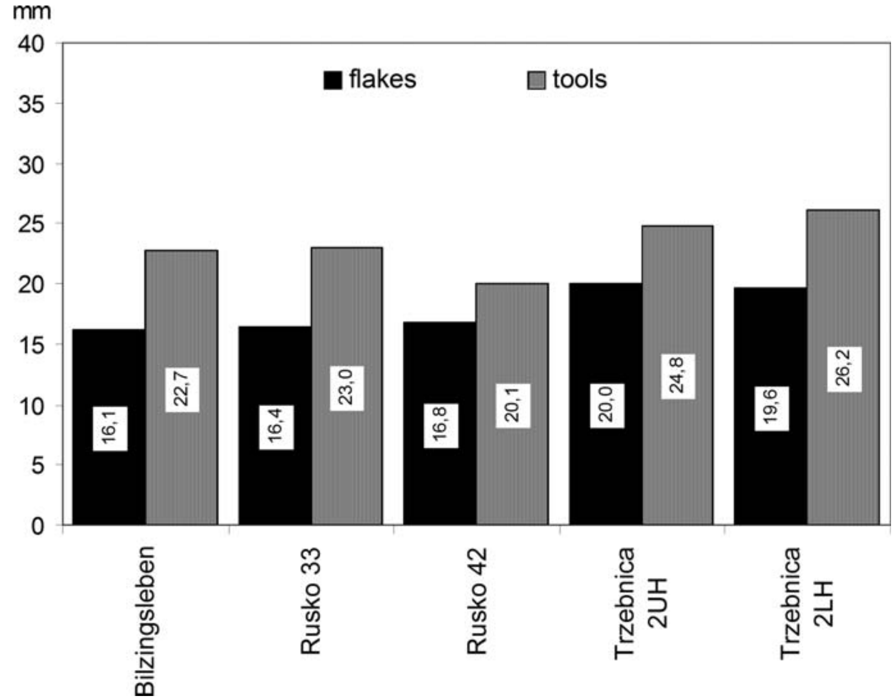

Fig. 3 Lower Palaeolithic microlithic sites in Central Europe: Mean length of flakes and tools

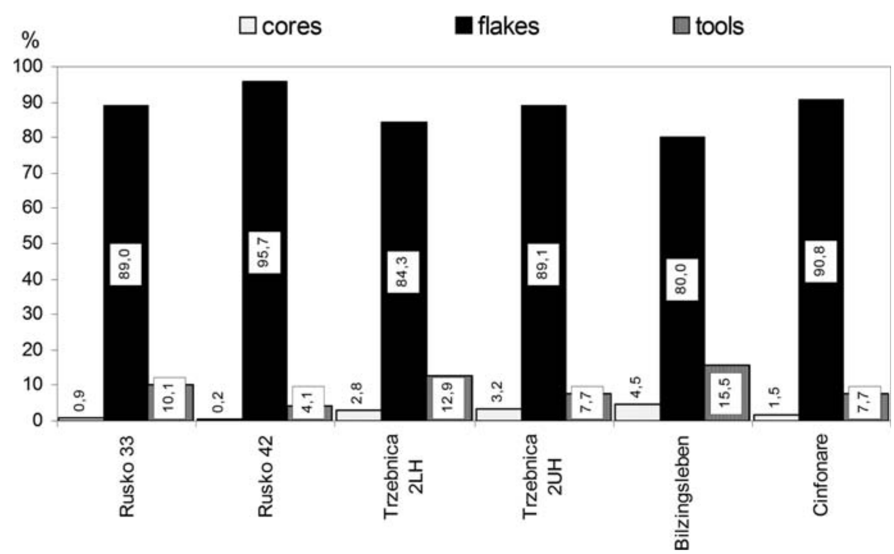

Fig. 4 Lower Palaeolithic microlithic sites in Central Europe: Frequency of main groups of artifacts

Nevertheless, they do not have frequent regular geometric shapes like Mesolithic ones. Sometimes they are associated with larger tools, like choppers, which make them somewhat similar to the Pebble Tool complex.

The oldest Lower Palaeolithic microlithic assemblages known at present appeared around 1 Ma BP in the Levant. A unique microlithic site is Ruhama near Ashqelon, in the border zone between the coastal plain and the Negev Desert (Ronen et al. 1998; Burdukiewicz and Ronen 2000; Zaidner et al. 2003). At Ruhama, flint artifacts are numerous and homogenous in size. Mean lengths of cores, flakes, and tools are smaller than 3 cm (Fig. 1). The most numerous are single platform cores, but double platform cores and items

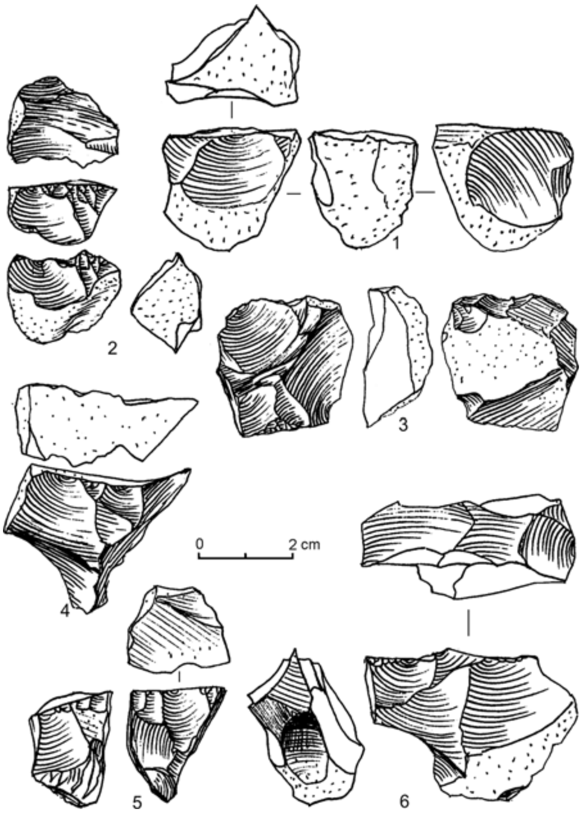

Fig. 5 Bilzingsleben in Thuringia (Germany): Microlithic cores

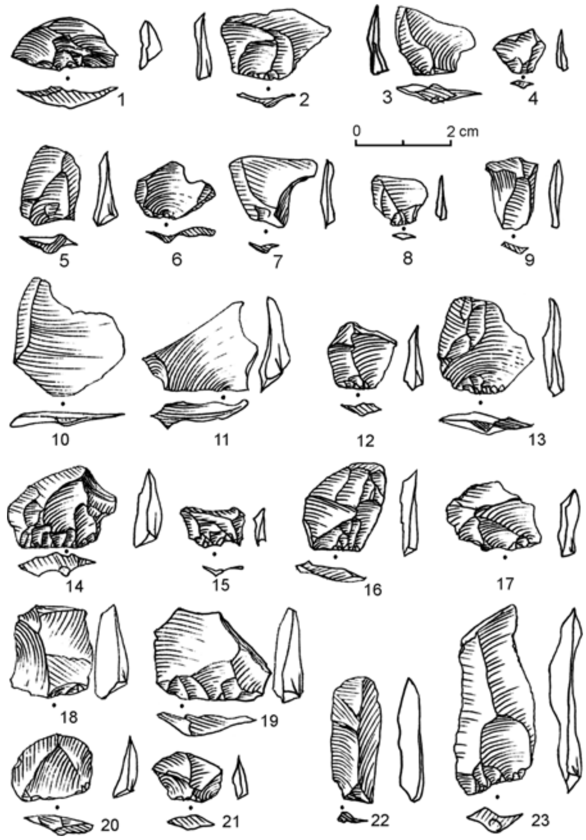

Fig. 6 Bilzingsleben in Thuringia (Germany): Noncortical flakes

with changed orientation are also present. The retouch techniques are usually scalar, denticulated, or notched. Bifacial retouch is also present but rare, and some points are reminiscent of very small handaxes, which are also microlithic. It should be an indication of a transition from Mode 2 technology. The presence of warm-region fauna (bovids, horses, and hippopotamuses) broadly indicates the climatic conditions.

Another site, Evron-Quarry, is located in the western Galilee coastal plain c. 2.5 km from the Mediterranean shore and 20 m above sea level, slightly east of the major sandstone ridge along this coast. The inventory includes three components: (1) 20 handaxes, (2) cores, flakes, and tools of "ordinary" size, and (3) small size cores and debitage (Ronen 2003). The presence of such small artifacts is exceptional for the Lower Palaeolithic assemblages in the Levant. At Ruhama, only small artifacts are present, but at Evron-Quarry, there are two separate components: a large one with handaxes and a small one showing a complete technological process, from small core processing to small retouched tools (Ronen 2003). In the Evron-Quarry case, it is not clear if the "small-tool component" was fashioned by the same hominin group or another one, which used the same place in different periods.

Lower Palaeolithic Microlithic Sites in Central and Eastern Asia

Other sites with microlithic artifacts, dated roughly to 1 Ma ago, are recorded at Donggutuo and Xiaochangliang in northeast China (Keates 2003, 149). At the present stage of research it is thought that deposits with microlithic artifacts date from a period somewhat before the Jarmillo event, i.e.,

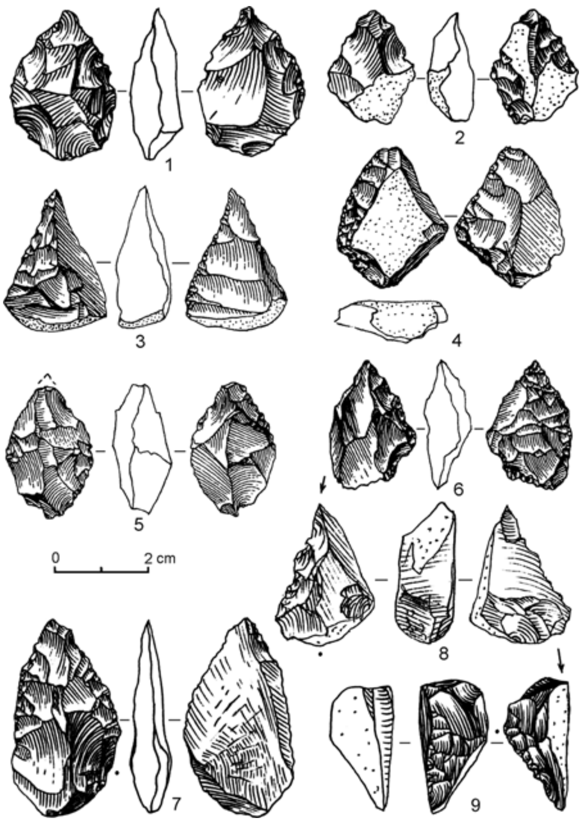

Fig. 7 Bilzingsleben in Thuringia (Germany): Bifacial points: 1–6, elongated points: 7, burins: 7–8

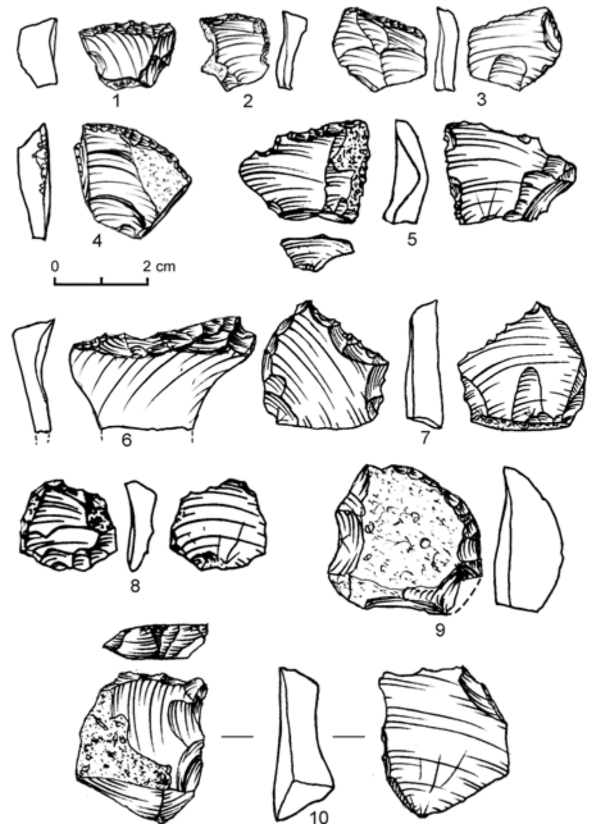

Fig. 8 Trzebnica 2LH in Silesia (Poland). Side scrapers

their dating is somewhat before 990 ka BP. Xiaochangliang in the Nihewan Basin is rich in microlithic artifacts with warm-region fauna (forest elephants, hippopotamuses, horses, red deer, gazelles, and small mammals) and plant remains of birch and elm (Zhou et al. 2000; Keates 2003). Similar artifacts were found in Donggutuo, located on loess upland 1.5 km from Xiaochangliang. There were several archaeological horizons with over 10 thousand artifacts and numerous bone fragments of warm-region fauna. Lithic artifacts, like cores, flakes, and retouched tools, at both sites are very small (Fig. 1). Keates (2003, 149) suggests that these dimensions resulted from the poor quality of local raw material like chert, vein quartz, quartzite, basalt, or sandstone.

The best known site with microlithic artifacts in China is Zhoukoudian locality 1—a large cave 140 m long and up to 40 m broad. There were 17 layers connected with 5 climatic cycles (Zhou et al. 2000). Cycle 1 (layers 14–13) was cold and should be linked with OIS 18–19. Cycle 2 (layers 12–9) was rather warm; and layer 10, with a lower archaeological horizon, dense ash, and remains of animals from forest and steppe environments, was recently dated c. 670 ka BP (Zhou et al. 2000, 105). Cycle 3 (layers 8–6) originated in a warm climate and was closed by the collapse of the cave roof; it is correlated with OIS 13–12. The warmest was cycle 4 (layers 5–3), when the travertine originated. From a layer dated by the TMS method to c. 400 ka BP, come traces of fireplaces and the youngest hominin remains (Zhou et al. 2000, 108). The top layers 2 and 1 come from cycle 5, which originated during the cold climate of OIS 11–10. In the cave were found over 100,000 lithic artifacts, numerous animal remains, as well as bone fragments of 45 individuals of *Homo erectus pekinensis*. Forty-four various types of rocks had been transported from a distance of up to 5 km (Zhou et al. 2000; Keates 2003, 151). The main raw material (over 88%) was

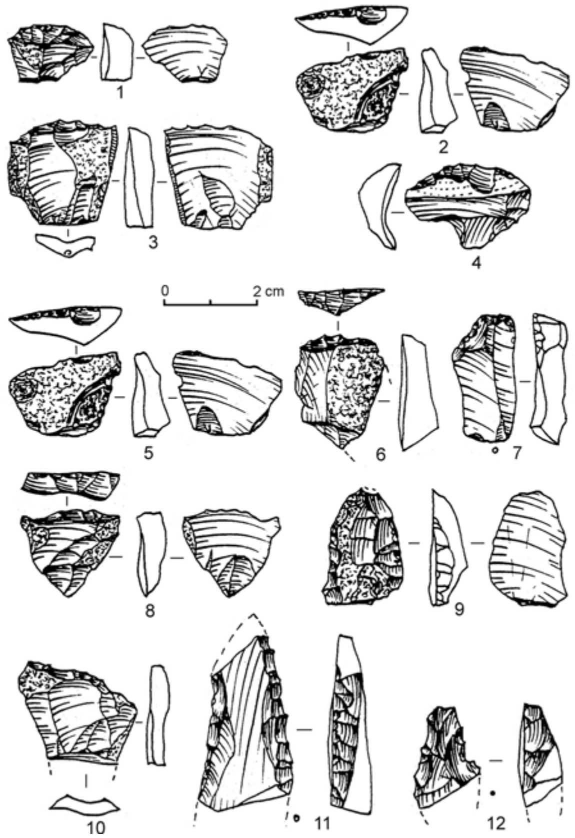

Fig. 9 Rusko 42 in Silesia (Poland). Side scrapers: 1–10, point fragments: 11–12

vein quartz represented by cores, flakes, and tools in the range of 1.9–7.3 cm, but over 75% of the tools were smaller than 4 cm. There were numerous pebble tools as well.

In China these sites are included in the "small tool tradition," also called the "Donggutuo-Zhoukoudian-Xujiayao-Salawusu" tradition (in chronological sequence), with slightly larger tools (mean length c. 27–30 mm) made of a variety of lithic raw material, such as chert, quartz, basalt, and others. They are juxtaposed with the macro-tool tradition "Kehe-Lantian-Sanmenxia-Dingcun," with choppers, picks, and spheroids (Keates 2003). However, the most complicated aspect of such a division is the inseparability of several collections. Several researchers believe that the usage of wood and bamboo was very important (Keates 2003, 156).

A similar number of artifacts is characteristic of Kuldara in Tajikistan, Central Asia. This site is considered at present as the oldest in the region. Its age, based on soil stratigraphy, is correlated with OIS 23 or 25, i.e., c. 900 ka BP (Ranov and Dodonov 2003). In Central Asia, microlithic assemblages are known from recent research in Kazakhstan, at sites like Koshguran and Shoktas, which are dated to c. 500 ka BP (Derevianko et al. 2000).

Lower Palaeolithic Microlithic Sites in Europe

In Europe microlithic sites are known from Italy, Hungary, Germany, and Poland. The oldest are Italian sites, which are dated from 0.7 to 0.3 Ma BP. Isernia La Pineta in Central Italy was excavated in 1978. Three archaeological layers were recognized (Peretto 1994). The richest was horizon 3a, which yielded over 10,000 artifacts and rich faunal and floral collections. This horizon showed a K/Ar date of c. 730 ka and a similar age estimation by paleomagnetic method (Cremaschi and Peretto 1988). However, age estimation according to *Arvicola* chronology by T. van Kolfschoten is 200 ka younger (Roebroeks and van Kolfschoten 1995). Organogenic data enable reconstruction of the ecological setting as an open landscape with relatively warm climatic conditions.

The small lithic artifacts were made of local flint with small crystalline intrusions, and much less numerous macro-tools were made of dolomite chalk. For example, in sector II of the site 4589 artifacts were collected: 2.2% cores, 70% flakes, and almost 28% retouched tools. The mean length of the flakes was 23 mm and the tools were slightly longer—31 mm (Crovetto 1991). The main goal of flint processing in Isernia La Pineta was the production of flakes with sharp edges, which were used as functional tools; the retouch seems to have been accidental damage rather than intentional reshaping (Peretto 1994, 460).

Similar small artifacts like those at Isernia La Pineta were also found at other Italian sites: Venosa-Loreto (Basilicata), Quarto delle Cinfonare (Latina), and Visogliano near Trieste. In Venosa-Loreto the most important is horizon A, dated to Late Cromer Complex and previously interpreted as Tayacian (Crovetto 1991); however, it is much older than traditional Tayacian in France. Nearby in Venosa the important Acheulean site Notarchirico has several archaeological horizons, and is dated to the Middle Pleistocene (Piperno 1999). Quarto delle Cinfonare yielded only microlithic artifacts. The team which excavated the site believes that it should be compared with Fontana Ranuccio nearby, which is also characterized by the presence of small artifacts associated with bone handaxes (Peretto et al. 1997, 613). In the Visogliano cave, a small collection of microlithic artifacts was found to be associated with a few pebble tools and forest/steppe fauna dated to OIS 13 or 11 (Cattani et al. 1991).

The next region which has produced early microlithic assemblages is Central Europe. The oldest are Mauer in Southern Germany and Vértesszőlős in northern Hungary, which originated probably 0.6 Ma BP. Vértesszőlős was inhabited several times, probably up to 0.3 Ma BP. Additional sites, Bilzingsleben and Schöningen in Central Germany, were inhabited several times in the period 0.45–0.3 Ma . These sites yielded unique organogenic finds made of wood, bone, and antler. Trzebnica and Rusko in southwestern Poland are the most northern, and, like Schöningen in Germany, they were covered by Scandinavian inland ice at one time.

The lower deposits at Mauer in Baden-Württemberg include redeposited microlithic artifacts and a jaw of *Homo heidelbergensis*. These small lithic artifacts and remains of temperate fauna were for a long time overlooked because of their post-depositional replacement (Beinhauer et al. 1992, 46). Pollen analysis indicates that *Homo heidelbergensis* here lived in a forested environment (Urban 1992).

Occupation at Vértesszőlős is documented in nine layers with lithic artifacts, a skull fragment, and two teeth of *Homo erectus* seu *sapiens palaeohungaricus,* spanning from around 600 to 300 ka BP in changeable climatic conditions, from Mediterranean to cold forests of *Pinus montana* (Kretzoi and Dobosi 1990). Over this long duration its archaeology witnessed little transformation, despite evident changes in the natural environment. At Vértesszőlős, almost 8,900 lithic artifacts in several horizons were documented, and are characterized by the presence of numerous small pebble and flake tools made of flint (66%), quartzite (31%), and limestone (3%).

Other microlithic sites are recorded in Lower Silesia in Poland. Several years ago the brickyard at Winna Góra in Trzebnica and the open cast kaolinite mine at Rusko near Strzegom produced four microlithic assemblages, relatively dated on geological grounds to OIS 13 and 11. The most interesting is the lower horizon from Trzebnica (OIS 13), which included almost 1,500 lithic artifacts (Fig. 8) and several remains of forest and steppe fauna. Other assemblages: Trzebnica upper horizon, Rusko 33, and Rusko 42 from OIS 11 contained almost exclusively small lithic artifacts (Fig. 9). The richest inventory was from Rusko 42, with almost 3,800 lithic artifacts (Burdukiewicz 2003).

Another very rich site is Bilzingsleben, excavated over 30 years by D. Mania (Mania and Mania 2003), which delivered 140,000 artifacts (Figs. 5, 6, and 7). Seventy-five per cent of these artifacts were made from Nordic flint. Among these 120,000 flint artifacts there are about 30,000 retouched tools. Several pebble tools were present, made of large pieces of crystalline rocks, and rare bifacial tools made from flint similar to miniature Acheulean handaxes (Fig. 7; Brühl 2003, 51). Exceptional are the rare bone handaxes of normal size (Brühl 2003, 52). These artifacts were associated with 3 or 4 individuals of *Homo erectus bilzingslebenensis* and a very rich warm ecological context represented by thousands of floral and faunal remains (Mania and Mania 2003).

An extremely interesting discovery was made at Schöningen in Lower Saxony, where H. Thieme identified seven assemblages, of which only three were published in detail. Schöningen produced a number of truly exceptional wooden objects in association with lithic artifacts: namely, several spears, a throwing stick, and small handles—hafts for microlithic stone tools (Thieme 2003). The findings from Schöningen have shed new light on the more poorly preserved wooden artifacts discovered at Bilzingsleben.

The microlithic assemblages recently recorded in Central Europe cited above apparently jointly represent a distinct taxonomic complex, sharing a number of common attributes, which are analyzed in the coming section. Most probably, the complex in question developed as a result of adaptation to the conditions of the moderate climate in a woodland zone, with some elements of a Mediterranean climate in the southern region. In the north, certain boreal elements are observed, as evidenced by finds of spruce and fir wood objects recorded at Schöningen (Fig. 10).

Fig. 10 Possible reconstruction of the Lower Palaeolithic composite tool (c. 20 cm-long fir stick with diagonal groove and inserted pointed flint) according to finds more than 400 ka old from Schöningen 12 (Germany)

Lithic Artifacts

Analysis of lithic artifacts is usually limited to general descriptions of cores and flakes and more detailed classification of retouched tools. Therefore, the size of the artifacts and the peculiarities of the microlithic assemblages were not perceptible. The author prefers a morphometric approach, showing a technological and three-dimensional analysis. Experience was gained from the study of other Palaeolithic assemblages (Schild 1980) and formulated as a dynamic technological analysis. A list of all artifact categories and attributes was designed in the form of a hierarchical sequence of production of all artifacts (including waste and broken pieces) classified with several levels from each category into main groups, keeping with the technological sequences and statistics: I—raw material procurement, II—preparation and early core exploitation, III—advanced core exploitation, IV—final core exploitation, and V—tool production (Table 1).

Intentional selection of raw stone material is the first important factor, which indicates the users' familiarity with the properties of the rocks. For example, at Bilzingsleben lithic tools were made mainly from flint nodules and chunks. Chert and hornstone were used less often. Only in areas with limited flint deposits, such as Vértesszőlős, were the dominant materials quartz and quartzite. Flint accounted for more than 90% of the inventories. The early stage of core exploitation is represented by initially struck cores and by cortical or cortical-natural flakes. A comparison of average flake length in Lower Palaeolithic microlithic inventories shows them to have an astounding similarity of between 16 and 23 mm (Fig. 1).

The more advanced stage of working is represented by cores with more than three removals and

Table 1 Lower Palaeolithic microlithic sites in Central Europe: Dynamic technological sequences of lithic artifacts

	Rusko 33		Rusko 42		Trzebnica 2LH		Trzebnica 2UH		Bilzingsleben	
Technological sequences	N	%	N	%	N	%	N	%	N	%
I. Raw material procurement	0	0.00	0	0.00	376	25.67	57	26.76	1388	22.21
II. Preparation and early core exploitation	31	8.93	133	3.58	132	9.01	10	4.69	306	4.90
III. Advanced core exploitation	88	25.36	411	11.05	158	10.78	15	7.04	1174	18.78
IV. Final core exploitation	193	55.62	2822	75.86	601	41.02	102	47.89	1808	28.93
V. Tool production	35	10.09	354	9.52	198	13.52	29	13.62	1574	25.18
Total	347	100.00	3720	100.00	1465	100.00	213	100.00	6250	100.00

flakes partially covered by cortex on the dorsal face or noncortical flakes (Fig. 5; 6). Altogether they account for 7–25% of all products (Fig. 4). Some difficulty for classification is posed by flake fragments, which form one of the largest categories of flints in all assemblages. The set of cores analyzed with the DTA method shows interesting tendencies. Slightly over half of the pieces were produced during the sequence of core exploitation. Preparation of core platforms played an important role in microlithic assemblages of the Lower Palaeolithic. Other procedures, including preparation of distal end and side edges, are less frequent. The techniques of core exploitation show an evident and recurrent tendency. In Lower Palaeolithic microlithic assemblages, early exploitation started generally from single- or double-platform cores (Fig. 5). Change of flaking direction was the main technique of adjusting the angle of core exploitation—used frequently, as indicated by the 65% of cores showing changed orientation in the group of advanced cores, and their equally high percentage in the group of residual cores.

Another indication that the process of core exploitation involved core platform preparation or change of direction are flake butts. There are no evident differences in the percentage proportion of flake butts from sequences II and III in all the analyzed inventories. In Sequence III there was a slightly decreased ratio of corticated to natural butts and a decrease in the percentage share of punctiform butts. At the same time, paradoxically, sequence II showed a higher share of facetted and dihedral butts than in sequence III (Fig. 6).

Microlithic assemblages from the Lower Palaeolithic show a greater similarity in the percentage participation of butts. Next to percussion cones, scars and wavy rings are considered a diagnostic feature of core exploitation technique. Other features taken into account in determining flake shape include transverse and longitudinal cross-section. Once the flake shape is defined, the next step is to assess the degree of modification during tool production (Fig. 3).

The main attribute used in defining flakes is their shape; along with flake proportions, it is an important feature helping distinguish blades among the flakes. The basic categories are represented by irregular flakes, considered as the most characteristic for early lithic industries, followed by parallel, diverging, converging, oval, and segmented flakes. Contrary to recurring views, the flaking technique during the Lower Palaeolithic was not random.

Final core exploitation is documented by a group of residual cores, core fragments, and fragments of rejected flakes, partly cortical or entirely without cortex. Cores in this sequence are typically small in size and show a marked degree of exploitation. The high percentage of fragmented cores and diverse residual forms is most probably the effect of using the direct technique of percussion with a hard hammer, and the bipolar technique, which do not allow for proper control, resulting in a substantial quantity of waste (Table 1).

All tools and production wastes are taken into consideration in this sequence. We defined as tools all specimens showing evidence of retouch, i.e., flakes, cores, and chunks. Many tools were only partly retouched, repaired, and damaged. In keeping with the principles of DTA, the degree of modification of the debitage was determined together with the statistical extent of this modification.

In comparison to the preceding stages, sequence V is represented by only a small number of artifacts. In the study of Palaeolithic assemblages, it is common to calculate the ratios between tools, cores, and flakes (Fig. 4). In the examined Lower Palaeolithic microlithic assemblages, tools made up no less than 15% all lithic artifacts at Bilzingsleben, nearly 13% at Trzebnica 2LH, 10% at Rusko 33, 8% at Trzebnica 2 UH and Quarto delle Cinfonare, and a mere 4% at Rusko 42 (Burdukiewicz 2003a, 2003b, 2006).

The criteria of flake selection for tool production are less easily understood. Analysis was made of the relationship between core, flake, and tool size and of the change in the frequency of flakes and tools in terms of their form and their transverse and longitudinal cross-sections. Statistical analysis determined important differences in the size of cores, flakes, and tools. In all of the analyzed microlithic assemblages, length, width, and thickness medians were higher for tools than for flakes. A particularly great difference between tools and flakes could be noted with regard to the thickness median.

Next to the criterion of size, which was evidently taken into consideration when selecting flakes for tool production, there may have been a preference for flakes of a specific form. Certain differences were observed in the frequency of specimen forms. Flake form modification by means of retouch, or even the very selection of flakes of a preferred form, testifies to the deliberate selection of preforms (Fig. 3).

On the basis of the percentage of tool forms, inventories could be divided into two broad groups. One includes material from Bilzingsleben and Rusko 33, dominated by tools with converging edges. Rusko 42, and Trzebnica 2LH and 2UH, on the other hand, registered an obvious domination of forms with diverging edges. Participation of tools having parallel or oval shape is quite different than in the case of flakes. As follows from the above discussion, differences in the amounts of flakes and tool forms in each assemblage are clearly visible. Therefore, retouch led to the modification of shapes, and consequently the distribution of flakes and tool form participation is completely different. This shows that the view proposed by C. Peretto and his team, that retouched tools generally represent waste, is hardly justifiable (Peretto 1994). The demonstrated intentionality of raw material selection and methods of retouch is evidently inconsistent with the supposedly "opportunistic" approach of early hominins to stone working.

The study of microlithic assemblages using the DTA and statistical methods has made it possible to detect the earliest indication of standardization in stone working during the Lower Palaeolithic. Obviously it was less developed than in the Levallois or blade production techniques, but all the same, observable in larger statistical samples. Also evident is the considerable similarity of technological sequences from Bilzingsleben and both levels at Trzebnica (Table 1). Inventories from Rusko 33 and Rusko 42 are slightly different, but this may be due to the influence of postdepositional processes which led to the redeposition of artifacts and are responsible for removing heavier forms from sequence I and for the low representation of sequence II. In view of the above discussion, the Lower Palaeolithic microlithic assemblages described here may best be defined as technocomplexes in the sense proposed by D. Clarke (1968).

Organic Artifacts

Organic artifacts during the Palaeolithic are rarely preserved anywhere in the world, chiefly because organic material tends to perish shortly after having been discarded by its users or later, as a result of the destructive action of postdepositional processes. At Vértesszőlős almost all bone artifacts were discovered in level 1 of Vértesszőlős site I. Most were fashioned from the long bones of large mammals like *Bovidae, Cervidae, Equidae,* and *Proboscidae*. The hunters from Vértesszőlős apparently preferred herbivores, which accounted for as much as 92.5% of animal remains, whereas in a natural faunal spectrum nearly 1/3 were predators.

At Bilzingsleben the main source of raw material for bone tool production was definitely *Palaeoloxodon antiquus,* which represented only 12% of general faunal inventory. It is noteworthy that juvenile individuals with milk teeth (60%) outnumbered mature and aged individuals (40%). Substantial variability of forms, numerous incomplete or damaged individuals, coupled with the as yet incomplete publication of the site, all make a more detailed classification quite difficult. D. Mania uses functional terms, applied to stone artifacts, such as side scrapers, points, cleavers, chisels, hammers, etc. (Mania and Mania 2003). Another group of organic objects featured in large number at Bilzingsleben is comprised of deer antler. Based on careful analysis, Mania was able to identify the process of antler working, distinguishing many antler tools.

Unusually favorable post-depositional conditions at Schöningen and Bilzingsleben assisted the survival of a great number of worked wooden objects. The oldest of these are four wooden pieces discovered at Schöningen 12 on the fossil lake shore, in association with numerous flint artifacts. All were fashioned from silver fir and had lengths of 12, 17, 19.1, and 32.2 cm. The shortest of these pieces had diagonal grooves at both ends, the other three only a single such groove (Thieme 2003). Most probably, its purpose was to hold flint inserts, forming a tool combining two types of raw material (Burdukiewicz and Ronen 2003).

In 1995 excavation of level 4 at Schöningen 13 II–4 uncovered finely preserved wooden spears. The objects rested within a level of organic mud, covered by a layer of peat—the dried out littoral zone of a flat channel lake. The same area furnished 30,000 faunal remains, including 17 well preserved skulls of young horses (*Equus mosbachensis*), some of them with cut marks. Numerous plant remains and abundant mollusk fauna indicate a boreal climate, continental in character, with coniferous forests (Thieme 2003).

The spears were recovered on the whole from a 25 by 10 m zone of the largest concentration of finds. The first three were discovered by H. Thieme; by 2003 five more had been recorded (Thieme 2003). The spears weighed around 500–600 g. Their average length and weight—about 230 cm and 600 g, respectively—are similar to those of modern women's Olympic equipment. Experiments have shown that the maximum distance achieved with this type of spear is as much as 75 m, but an experienced spear thrower is able to achieve an accurate throw over a distance of up to 35 m. A large number of diverse pieces of worked wood were discovered at Schöningen 13 II–4, but they still await publication. Although Bilzingsleben produced a greater variety of wooden tools, their function is not easy to establish because of substantial damage as a result of pos-tdepositional processes.

Pioneer Settlers of Northern Latitudes of Eurasia—Technological Transitions and Adaptations to Wooded Environment

From the time of the first investigations made at Vértesszőlős by Vértes (1965), microlithic assemblages have continued to pose a problem for archaeologists concerned with the Lower Palaeolithic, because they did not fit easily into the traditional culture scheme adopted at the time. Eventually, a considerable number of similar assemblages were recorded in Eurasia, ranging from Central Europe to China, spanning the period from c. 1 Ma to c. 120 ka BP. According to the current state of research, sites with microlithic artifacts appeared in Eurasia in the following chronological order: the Levant, the Middle and Far East, the Apennine Peninsul, and Central Europe (cf. Derevianko et al. 2000; Burdukiewicz and Ronen 2003). A new site with small lithic flakes was lastly found in Parkfield (Suffolk, United Kingdom) in Cromerian layer dated 0.7 Ma ago (Parfitt et al. 2005; Roebroeks 2005).

Given their substantial spatial, temporal, and ecological variability, the most reasonable explanation is that microlithic assemblages emerged from Pebble Tool or Handaxe Technocomplexes, more or less autonomous of each other, as a result of adaptation to specific environmental conditions. In several sites with microlithic artifacts, larger tools like choppers or rare handaxes are more or less frequently present, in particular in the southern zone, like Evron-Quarry, in the vicinity of Quarto delle Cinfonare or Bilzingsleben in the north. In Northern China, these associations are still less clear.

The principal motivation for their increase was possibly the abundance of organic material, wood in particular, which came to be used as the main raw material. Wooden and bone tools are easier to produce, but they are rather less effective. Innovation of composite tools, made of wood or bone with lithic inserts (Fig. 10), seems to be the most effective way of tool production during the Stone Age. However, until recently, wooden, bone, or resin hafts are known in very limited numbers. New evidence from Schöningen and Bilzingsleben offers sufficient proof that composite tools were used during the Lower and Middle Palaeolithic in Northern Eurasia around 60° north latitude. The presence of several microlithic assemblages in this zone supports such a concept. A similar concept was developed entirely independently in the Far East, where the functioning of microlithic assemblages was probably associated with the widespread use of bamboo (Keates 2003). It seems correct to assume therefore that the Euroasiatic Microlithic Technocomplexes developed in other environmental conditions continuing a relationship—unspecified as yet—with communities of Pebble Tool or Acheulean Technocomplexes. Whatever may have been the case, the assemblages in the two regions are partly parallel to each other chronologically.

The situation of microlithic assemblages is remarkable, in that their decline was multistage in character. They are recorded during warmer and wetter periods with prevailing woodland vegetation, and apparently disappear during cooler periods, the time of the development of steppe or tundra landscape. The first period of microlithic assemblage decline is noted at the close of the Holsteinian interglacial (OIS 11), around 300 ka BP, a time of expansion in Europe of Acheulean handaxes and flake tools of larger dimensions. The second period of development dates to OIS 7, 5, and 4, i.e., stages of the Middle Palaeolithic. Finally, microlithic industries developed fully towards the end of the Pleistocene and during the early Holocene.

Final Remarks

The study of the Lower Palaeolithic, the earliest stage of human history, has made important progress during the latter half of the 20th century. The discovery of numerous hominin fossil remains and new archaeological sites has furthered our knowledge of palaeoecological conditions and climatostratigraphic changes. Evidence newly recovered in Europe and northeastern China has made it necessary to distinguish two or three taxonomic units, defined as the Lower Palaeolithic Microlithic Technocomplexes in the Levant, Eastern Asia, and Europe. Their assemblages are characterized by the domination of microlithic technology in lithic production and the use of microliths as inserts in composite tools. Such invention in human history is usually seen as very sophisticated and characteristic for Mode 5.

An important role was apparently played also by tools from organic materials: wood, bone, and antler in particular. Substantial spatial, chronological, and ecological variability of microlithic assemblages suggests that they developed as a result of adaptation to the conditions of the local environment, the adaptation processes presumably following their individual courses in different areas. Further research is needed on the mobility of hominin groups who as early as around 1.8 Ma appear to have been able to travel over substantial distances in a relatively short time, as indicated by new discoveries at Dmanisi (Georgia), several thousand kilometers from southern and eastern Africa.

The Microlithic technocomplexes could have developed in relative isolation from each other as well as from other technocomplexes like Pebble Tools (Mode 1) or Acheulean (Mode 2) in the southern zone of Eurasia. In any case, these assemblages are partly parallel to each other chronologically. In Europe, microlithic assemblages occur in an environment with a climate ranging from the Mediterranean to the boreal, but always in association with woodland or woodland-steppe vegetation. No assemblages of similar type are recorded for colder periods.

Another interesting group of issues relates to the beginnings of a cultural organization of the microenvironment, the domestication of fire, and the emergence of hunting. Spears discovered at Schöningen and surviving evidence of selective hunting now make it possible to discard the hypothesis of the long-lived persistence of scavenging. Exceptionally favorable conditions for subsistence, offered by springs in travertine areas (Bilzingsleben, Isernia), enabled some hominin groups to occupy a single site over a long period or to return frequently to the same area (Vértesszőlős; Schöningen 13–4). Travertine and bog settlements, due to their exceptional properties favoring preservation of organic materials, have conserved traces of such occupation to this day.

The production of small artifacts, that were not easy to hold and use with the fingers, is not easy to explain. It is worth stressing the presence of some bifacial tools bearing various links with Mode 2 technology. Recent excavations of worked wooden objects in Schöningen (Lower Saxony, Germany) and wooden sticks with diagonal grooves at the ends suggest that they were handles to hold stone inserts, forming tools combining two types of raw material.

As opposed to the early assemblages from Africa and Southern Eurasia in northern latitudes, the usage of microliths as inserts in composite tools seems to be the most important feature. It is difficult to explain why early forager groups changed their lithic technology. The most possible transition process can be explained as an adaptation to new conditions of the local environments, where technological innovations provided survival and demographic success.

The primary motivation for the transition to a new lithic technology seems to be the abundance of organic material, wood in particular, which came to be used as the main raw material for the production of composite tools. Until recently, our record included only a very limited number of wooden finds, but evidence offers proof that microlithic assemblages indeed functioned during the Lower and Middle Palaeolithic in Northern Europe. A similar concept was developed independently in northeastern China and Central Asia, where the functioning of microlithic assemblages was probably associated with the widespread use of bamboo and wood.

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Hominin Adaptability and Patterns of Faunal Turnover in the Early to Middle Pleistocene Transition in the Levant

Miriam Belmaker

Abstract The Levant is one of the key regions to document hominin dispersal from Africa into Eurasia. The number of dispersals, continuity of populations within the region, and the role of the region as a corridor or as a 'cul de sac' are focal questions in understanding the scenario of early hominin adaptability in the Lower Paleolithic, and specifically, during the transition between the Early and Middle Pleistocene.

Mammalian taxa differ in their ability to respond to ecological change. While some have a low threshold for climatic and environmental change, others can tolerate a wide range of habitats. Humans are highly adaptable to a wide range of habitats. Nonetheless, local distribution of populations and settlement patterns may be affected by environmental change. To understand transitional patterns in early hominin populations, we must place them within the context of the environment in which they lived. This paper describes the faunal turnovers that occurred during the Early to Middle Pleistocene transition of the Levant and discusses the relationship between these changes and the distribution of human populations in the region.

The presence-absence of fauna at ten Levantine archaeological sites was analyzed using the range through method. A sharp faunal turnover is apparent at the Brunhes-Matuyama boundary (0.78 Ma). Minor turnover events may be present at the Jaramillo paleomagnetic episode (1.1 Ma) and at the mid-Brunhes climate event (0.43 Ma).

Despite variability in lithic assemblages among sites, all Early Pleistocene lithic traditions are within a similar cultural *milieu* (Levantine Acheulean). However, following the faunal turnover of 0.78 Ma, there is an appearance of a novel cultural tradition, which is associated with a new dispersal event out of Africa and the local disappearance of earlier Levantine Paleolithic cultures. This suggests that while local populations of hominins were able to withstand small level climate shift (i.e., the Jaramillo and Mid-Brunhes), populations may not have adapted as well to the environmental changes that coincided with the Matuyama-Brunhes Boundary faunal turnover.

This study exemplifies how early hominins may have tolerated low and medium level environmental changes but not larger ones. The continued presence of hominins in the Levant during the early Pleistocene was a process of several dispersal events, rather than a long continuous occupation.

Keywords Biochronology • Southern Levant • Pleistocene • Environmental change • Biozones

Introduction

During the Early Pleistocene and Early to Middle Pleistocene transition, hominins dispersed from Africa into higher latitudes. This dispersal event, named 'Out of Africa I' (Stringer and Gamble 1993), includes several expansions dated to c. 1.8 Ma and to c. 0.8 Ma (Schick and Toth 1993; Gabunia and Vekua 1995; Larick and Ciochon

M. Belmaker (✉)
Department of Anthropology, Peabody Museum, Harvard University, Cambridge, MA, USA

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1996; Bar-Yosef 1998a; Potts 1998; Arribas and Palmqvist 1999; Bar-Yosef and Belfer-Cohen 2001; Antón et al. 2002; Potts 2002; Antón and Swisher III 2004; Martínez-Navarro 2004). The biological adaptation which facilitated long range dispersal (Bar-Yosef and Belfer-Cohen 2001), as well as Acheulean stone tool technology, predate the earliest dispersal event by more than 0.5 Ma and therefore do not appear to be the sole impetus for the dispersal event (Antón et al. 2002). Thus the drive for the dispersal must be sought elsewhere, either in a climatic shift or in a change in the ability of early hominins to compete for preoccupied niches (Potts 1998).

Our ability to test these hypotheses rests on untangling the relationship between the response of fauna and climate change. Modern ecological studies indicate that taxa respond to environmental change in one of several ways: adapt to the new habitat, disperse to a different region, or become extinct (Bennett 1997; Barnosky et al. 2003). Since niches are usually occupied by other species, new dispersing species must compete in the new location (Krebs 2001). To successfully colonize a new region, newly arriving taxa must be better competitors than the present occupiers of the niche. To understand the forces which were a possible impetus for dispersal of the genus *Homo,* one should study the correlations between global and local climatic events of the hominin ecological *milieu,* such as evidence of the changes in the composition of the mammal community.

The Levant constitutes a biogeographic corridor between Africa and Eurasia. In the west, it is bordered by a fertile Mediterranean region, which rapidly subsides eastwards to the semiarid steppes of the Syrian and Arabian deserts. In the north it is bounded by the Zagros and Taurus mountains and in the south by the isthmus of the Suez (Yom-Tov and Tchernov 1988; Tchernov and Belmaker 2004). Since the onset of the Neogene, the Levant was a geographic corridor between Africa and Eurasia. During different time periods, geological changes (i.e., tectonics, climate, and sea level changes) altered the 'permeability' of this land bridge. Thus, during certain times, the region allowed for animals to disperse from one region to another, as opposed to other periods in which it served as an ecological barrier (Yom-Tov and Tchernov 1988; Tchernov and Belmaker 2004). Climate changes may have had profound implications for the dispersal ability and colonization success of terrestrial taxa in general and hominins in particular (Dennell 2003).

Previous analyses of mammalian successions in the Levant have suggested that the tempo, mode, and correlation of climate change with faunal turnover events between the Early and Middle Pleistocene are not clear (Tchernov 1981, 1984, 1988). However, since the publication of these studies, recent excavations have resulted in the wealth of new faunal materials, a revision of taxonomic lists, and new biostratigraphic methods which may allow us to increase the resolution and clarification of paleobiogeographical processes.

In this paper, I analyze faunal turnovers in the terrestrial ungulate community in the Levant during the Early Pleistocene and across the Early to Middle Pleistocene transition boundary. Results are discussed in light of possible dispersal events and the cultural entities in the Levantine Lower Paleolithic.

The Time Frame

The geomagnetic constraints for the stratigraphy of the Quaternary are a matter of debate (Haq et al. 1977; Horowitz 1979). The basis for the division of the periods, i.e., the division between the Pliocene and the Pleistocene as well as subdivisions within the Pleistocene are based on biostratigraphic data and paleomagnetic events. These have been often correlated with major climatic shifts and changes in the size of the carbon reservoirs, ice sheet volume, and subsequent wind and ocean current regimes, temperatures, and precipitation.

Dates for the Pliocene-Pleistocene transition vary between 1.6 and 2.4 Ma (Haq et al. 1977). In this paper I use the dating of the onset of the Pleistocene to c. 1.8 Ma which is correlated to the beginning of the Olduvai event (Napoleone et al. 2003). The Matuyama-Brunhes Boundary (MBB) is dated to 0.78 Ma. This marker is widely used to define the Early and Middle Pleistocene boundary. Within the Middle Pleistocene, the Mid-Brunhes climatic shift is dated to c. 0.43 Ma (Wang et al. 2003) and is used to distinguish between the Early Middle Pleistocene and Late Middle Pleistocene. The Middle to Late Pleistocene boundary has also been widely debated, but it is commonly placed at the base of OIS 5 c. 0.13 Ma (Gibbard 2003).

In this paper, I include sites within the Early and Middle Pleistocene that have been assigned to the Lower Paleolithic, roughly between 1.8 and 0.2 Ma. These include the Oldowan, Levantine Acheulean, and Acheulo-Yabrudian cultural entities (Bar-Yosef 1995). I have excluded the Levantine Mousterian sites from this analysis.

The Early and Middle Pleistocene Fossil-Bearing Archaeological Sites

Eight sites are known in the Early Pleistocene and Early Middle Pleistocene of the Levant (Fig. 1) and exhibit both faunal and lithic assemblages in well-dated contexts. ‘Ubeidiya, Bitzat Ruhama, Evron, and Latamne predate 1 Ma, Gesher Benot Ya‘acov is dated to the MBB, and Holon, Revadim Quarry, and Qesem postdate the Mid-Brunhes event but are older than 0.2 Ma. I have also included the site of Dauqara, Jordan. Although not well dated, it includes an Early Pleistocene faunal assemblage.

Fig. 1 Location of Early and Middle Pleistocene sites mentioned in the text

There are many other archaeological sites with lithic assemblages assigned to this time period that did not yield fossil assemblages (e.g., Mayyan Baruch, Nahal Zihor) as well as paleontological sites, which are not associated with lithic assemblages (e.g., Bethlehem, An Nafud). However, as the faunal transitions are analyzed in relation to cultural ones, it is beyond the scope of this paper to present in detail the Levantine Lower and Middle Paleolithic paleoanthropological sites without both lithic and faunal assemblages.

'Ubeidiya

The site of 'Ubeidiya lies about 3 kilometers south of the Sea of Galilee, on the flanks of the western escarpment of the Jordan Rift (Stekelis et al. 1960; Picard and Baida 1966a, 1966b; Stekelis et al. 1969; Bar-Yosef and Tchernov 1972; Bar-Yosef and Goren-Inbar 1993). The lithic assemblage has been identified as Developed Oldowan and Levantine Acheulean (Stekelis et al. 1960; Stekelis 1963, 1965, 1966a, 1966b; Stekelis et al. 1969; Bar-Yosef and Goren-Inbar 1993). A rich faunal assemblage ($n \approx 3500$) (Haas 1966, 1968; Tchernov 1986; Belmaker 2006) and scant human remains (Tobias 1966a, 1966b; Belmaker et al. 2002) have also been identified at the site. Paleomagnetic studies of the 'Ubeidiya Formation have indicated reversed polarity (Opdyke et al. 1983; Braun et al. 1991; Verosub and Tchernov 1991), suggesting that it predates the MBB. Recent paleomagnetic analysis indicated a R-N-R-N-R sequence (Sagi et al. 2005). The normal episodes have been attributed to the Gilsa (1.575–1.567 Ma) and Cobb Mt. (1.215–1.190 Ma) (Sagi et al. 2005; Sagi 2005). Comparison of the lithic assemblage to an East African site such as Olduvai Upper Bed II dated to c. 1.53–1.27 Ma (Gowlett 1979; Cerling and Hay 1986) also suggest an Early Pleistocene age (Stekelis et al. 1969; Bar-Yosef and Goren-Inbar 1993).

Evron Quarry

Evron Quarry (Tchernov et al. 1994; Ron et al. 2003) is located near Kibbutz Evron on the coastal plain of the Western Galilee, Israel. Paleomagnetic and ESR studies have suggested a date c. 1.0 Ma (below the 0.78 Ma MBB) for the archaeological bearing strata (Porat et al. 2002; Ron et al. 2003). The site has yielded Acheulean deposits that include quartz/limestone pebbles and flint artifacts (Gilead and Ronen 1977). Handaxes collected from the quarry were associated with the assemblage (Ronen 1991). A small faunal assemblage was retrieved ($n = 36$) (Tchernov et al. 1994).

Bitzat Ruhama

Bitzat Ruhama is located in the eastern part of the southern coastal plain of Israel (Ronen et al. 1998). The site is estimated between 0.99 and 0.85 Ma based on magnetostratigraphy and thermoluminescence dating methods (Laukhin et al. 2001; Ron and Gvirtzman 2001). The site exhibits a large and highly variable lithic assemblage with no bifaces dominated by notches and denticulates (Zaidner 2003a, 2003b). There is only a small faunal assemblage ($n = 36$) with a high abundance of *Equus* cf. *altidens* (Ronen et al. 1998).

Latamne

Latamne is located c. 40 km north of the village of Hamma, Syria, on the terrace system or floodplain zone of the Orontes River (Bridgland et al. 2003). It consists of a 'living floor' with large lithic and faunal assemblages (Clark 1967). The date of the site was estimated as c. 0.7 Ma based on faunal correlations (Guérin et al. 1993), but the presence of the arvicolid *Lagurodon arankae* (Tchernov 1994) and typotechnological affinities of the lithic assemblage suggest a date c. 1.0 Ma (Tchernov 1994).

Dauqara

The site of Dauqara (Copland 1998) is located near Sukhne, Jordan, at the River Zarka/Wadi Dhulail confluence. This site is represented by 22 artifacts that include bifacial choppers, six cores, and large flakes. The small faunal assemblage includes a tooth of *Mammuthus meridionalis, Equus* cf. *tabeti* (*altidens*), and *Bos primigenius* (Parenti et al. 1997). Based on the faunal and lithic evidence, it has been suggested that this site may date to 1–0.78 Ma. However, it should be considered that the lithics and fauna might not be contemporaneous or form a mixed assemblage (Besançon et al. 1984).

Gesher Benot Ya'acov

Gesher Benot Ya'acov is located in the northern Dead Sea rift valley, 4 km south of the Hula Valley, Israel. The site has yielded scant hominin remains, a wealth of lithic remains, a large faunal assemblage, and a unique botanical assemblage (Goren-Inbar et al. 2000, 2004). The Acheulean industrial complex suggests technological affinities with some African evidence and has been interpreted as evidence for a second dispersal event (Goren-Inbar et al. 1991, 1992a, 1992b; Goren-Inbar 1992; Goren-Inbar and Saragusti 1996). The site preserves the MBB and thus has been dated to 0.78 Ma (Goren-Inbar et al. 2000).

Qesem

Qesem Cave is located 12 km east of Tel Aviv, Israel. Excavation in the cave revealed rich lithic and fauna assemblages. Uranium series dates have suggested an age bracket of 0.4–0.2 Ma (Barkai et al. 2003). The lithic assemblage has been assigned to the Acheuleo-Yabrudian and Amudian cultures (Gopher et al. 2005; Lemorini et al. 2006). The rich faunal assemblage ($n = 1780$) is dominated by medium-sized cervids (Stiner et al. 2004; Gopher et al. 2005).

Holon

The site of Holon is located in the southern coastal plain of Israel (Yizraeli 1967; Chazan and Kolska Horwitz 2007). ESR and OSL dating methods have suggested an age of 0.205 Ma (Porat et al. 2002; Chazan and Kolska Horwitz 2007). The lithic assemblage includes handaxes, choppers, cores, and flakes and has been attributed to the Late Acheulean (Chazan 2000a, 2000b). A well-preserved faunal assemblage ($n = 572$) was found at the site (Chazan and Horwitz 2006; Chazan and Kolska Horwitz 2007).

Revadim Quarry

Revadim Quarry is located on the southern coastal plain of Israel, north of Kibbutz Revadim. Paleomagnetic dates suggest a normal polarity, indicating an age younger than 0.78 Ma. OSL dates suggest a minimum age bracket of 0.3–0.2 Ma. (Marder et al. 1998; Gvirtzman et al. 1999). The lithic assemblage at the site suggests a high frequency of flake tools and the presence of handaxes. The typotechnological characteristics of the bifacial tools have suggested that it may be attributed to the Late Acheulean culture (Marder et al. 1998, 2006). The faunal assemblage ($n = 338$) is dominated by *Palaeoloxodon antiquus* (Marder et al. 1998).

Ungulate Faunal Turnover in the Levantine Early Pleistocene

Faunal turnover is the result of local extinction, immigration, or evolution (anagenesis or cladogenesis). 'First appearance' taxa are identified either as immigrating species i.e., species that dispersed from other regions, or as in situ speciation occurring within the region (Barry et al. 1995). Following the methodology described by Barry et al. (1995), I present the faunal occurrences based on the presence or absence of species.

High fidelity biodiversity analyses require knowledge of the biocoenoses from which fossil assemblages were derived, and knowledge of the magnitude and type of taphonomic processes that might have affected the taphocoenoses between death and recovery (Behrensmeyer and Dechant Boaz 1980). Nonetheless, it is not necessary to estimate the original abundances or composition in the biocoenosis to test the hypothesis that an *observed shift* in composition (i.e., presence-absence) over time is biological or taphonomic in nature as suggested in this study. Thus, the use of mammal composition may provide insight into dispersal events and changes in the environment of the region, while making no assumptions about the absolute diversity in the original community. In this study, the analysis will be confined to the terrestrial ungulates, thereby constraining both the taphonomic and the ecological processes which may have affected the community (Hubbell 2001).

The use of confidence intervals has been suggested for the appearance and disappearance of taxa in the stratigraphic record to account for sampling biases (Bennington and Rutherford 1999). We cannot assess the First Appearance Datum (FAD) of the ‘Ubeidiya taxa because, with the exception of the poorly dated site of Bethlehem (Gardner and Bate 1937; Hooijer 1958), there are no fossiliforous sites in the region which predate it. Thus, we cannot calculate confidence intervals for the stratigraphic appearance of the taxa. However, we can securely place the Last Appearance Datum (LAD) for many of the taxa and the First Appearance Datum (FAD) for those which first appear at Gesher Benot Ya‘acov. In order to test for faunal turnover, I used the ‘range through’ method (Boltovsky 1988). This method assumes that taxa that do not appear in a given stratigraphic unit, but do appear in the units both above and below, may be considered to have occurred throughout the sequence. The observed absence may be attributed to sampling biases rather than a true local extinction.

Table 1 presents the taxonomic list of terrestrial ungulates from the Early and Early Middle Pleistocene sites in the Levant. Ungulate faunal lists were obtained from the following literature sources: ‘Ubeidiya (Martínez-Navarro 2004; Belmaker 2006), Latamne (Guérin et al. 1993), Dauqara (Besançon et al. 1984; Parenti et al. 1997; Copland 1998), Bitzat Ruhama (Ronen et al. 1998; Ronen 2006), Evron (Tchernov et al. 1994), Gesher Benot Ya‘acov (Martínez-Navarro 2004), Qesem (Stiner et al. 2004; Gopher et al. 2005), Holon (Chazan and Horwitz 2006; Chazan and Kolska Horwitz 2007), Revadim Quarry (Marder et al. 1998); and a composite list for the ungulate taxa in the Upper Paleolithic of the Levant was used to provide an upper stratigraphic estimate of taxa in the region (Tchernov 1984; Rabinovich 2003).

Figure 2 presents the range distribution of the terrestrial ungulate taxa in the ten assemblages, ordered by their estimated dates and by minimizing the number of range through taxa for sites with questionable ages (e.g., Dauqara, Bitzat Ruhama). A major turnover event is visible at the MBB dated at 0.78 Ma. This would suggest the identification of two major ungulate faunal units: the Early Pleistocene faunal unit including the sites of ‘Ubeidiya, Latamne, Dauqara, Evron, and Bitzat Ruhama, and the Early Middle Pleistocene faunal unit including the sites of Gesher Benot Ya‘acov, Qesem, Holon, and Revadim Quarry. However, two other smaller possible faunal turnovers are present in the region. The first is dated to c. 1.0 Ma and the second to c. 0.43 Ma. The faunal turnover dated at c. 1.0 Ma is observed between the sites of ‘Ubeidiya, Latamne, and Dauqara, identified here as ungulate faunal unit *‘Ubeidiya,* and Evron, which is identified as ungulate faunal unit *Evron*. Ungulate faunal unit *‘Ubeidiya* includes species such as *Praemegaceros verticornis* and *Mammuthus meridionalis,* which are absent from the latter group. Moreover, the local evolution of a more derived population of suids (*Kolpochoerus everonensis*) from the population of ‘Ubeidiya (*Kolpochoerus oldovaiensis*) (Haas 1970; Tchernov et al. 1994) warrants the distinction of a new biochronological stage. Bitzat Ruhama has only a small faunal assemblage and provides ambiguous results. It can be assigned to either faunal unit. However, given the dating results based on thermoluminescence and paleomagnetism (Laukhin et al. 2001), it would appear to be younger than ‘Ubeidiya and should be assigned to the *Evron* ungulate faunal unit.

A second small faunal turnover is apparent between Gesher Benot Ya‘acov and the sites of Qesem, Revadim Quarry, and Holon. Gesher Benot Ya‘acov is assigned to ungulate faunal unit *GBY,* while the sites of Qesem, Revadim Quarry, and Holon can be assigned to ungulate faunal unit *Qesem*. No new species are present in the latter sites, but there is an extinction of several archaic taxa such as *Megaloceros, Ovibovini,* and *Pelorovis* (but see Martínez-Navarro et al. 2007).

Table 1 Taxonomic list for terrestrial ungulates from Levantine Lower and early Middle Pleistocene: a combined faunal list for Upper Pleistocene ungulates is provided as an upper stratigraphic unit

'Ubeidiya	Latamne	Dauqara	Bitzat Ruhama	Evron	Gesher Benot Ya'aqov	Qesem	Holon	Revadim Quarry	Upper Pleistocene
Praemegaceros verticornis	*Praemegaceros verticornis*				*Megaloceros* sp.				
Pseudodama sp.									
Capreolus sp.				*Capreolus* cf. *capreolus*				*Capreolus* cf. *capreolus*	*Capreolus capreolus*
					Dama cf. *mesopotamica*	*Dama* sp.	*Dama dama mesopotamica*	*Dama* sp.	*Dama mesopotamica*
				Cervus elaphus	*Cervus* cf. *elaphus*	*Cervus* cf. *elaphus*	*Cervus elaphus*	*Cervus* cf. *elaphus*	*Cervus elaphus*
				Gazella sp.	*Gazella* sp.		*Gazella* cf. *gazella*		*Gazella gazella*
					Caprini indet.				
									Capra ibex
									Capra aegagrus
	Bos primigenius	*Bos primigenius*	*Bos* sp.	*Bos primigenius*		*Bos primigenius*	*Bos primigenius*	*Bos* cf. *primigenius*	*Bos primigenius*
Bovini indet. (cf. *Bison* sp.)	*Bison priscus*				*Bovini indet.* (cf. *Bison* sp.)				
Pelorovis oldowayensis					*Pelorovis* cf. *bubaloides*				
					Ovibovini indet.				
				Alcelaphus buselaphus					*Alcelaphus buselaphus*
Oryx cf. *gazella*									
cf. *Pontoceros* sp.	cf. *Pontoceros* sp.								
					Sus cf. *scrofa*	*Sus* cf. *scrofa*	*Sus* cf. *scrofa*	*Sus* sp.	*Sus scrofa*
Kolpochoerus olduvaiensis				*Kolpocheorus evronensis*					
Camelus sp.	*Camelus* sp.								*Camelus dromedarius*
Giraffa cf. *camelopardais*	*Giraffa camelopardalis*								
Equus cf. *altidens*	*Equus* cf. *altidens*	*Equus* cf. *altidens*	*Equus* cf. *altidens*						
Equus sp. (robust)									
					Equus cf. *caballus*	*Equus* cf. *caballus*		*Equus* sp.	*Equus caballus*
									Equus hemiones
Stephanorhinus etruscus	*Stephanorhinus hemitoechus*				*Stephanorhinus merckii*				
					Palaeoloxondon antiquus		*Palaeoloxondon antiquus*	*Palaeoloxondon antiquus*	
	Stegodon cf. *trigonocephalus*			*Stegodon* sp.	*Stegodon mediterraneus*				
Mammuthus merdionalis	*Mammuthus trogontherii*	*Mammuthus merdionalis*		*Elephas* sp.					

Ungulate faunal lists were obtained from the following sources: 'Ubeidiya (Belmaker 2002; Martínez-Navarro 2004), Latamne (Guérin et al. 1993), Daquara (Besançon et al. 1984; Parenti et al. 1997; Copland 1998) Bitzat Ruhama (Ronen et al. 1998; Ronen 2006), Evron (Tchernov et al. 1994), GBY (Martínez-Navarro 2000, 2004), Qesem (Stiner et al. 2004; Gopher et al. 2005), Holon (Chazan and Horwitz 2006), Revadim Quarry (Marder et al. 1998) and the combined faunal list from the Upper Pleistocene (Tchernov 1984).

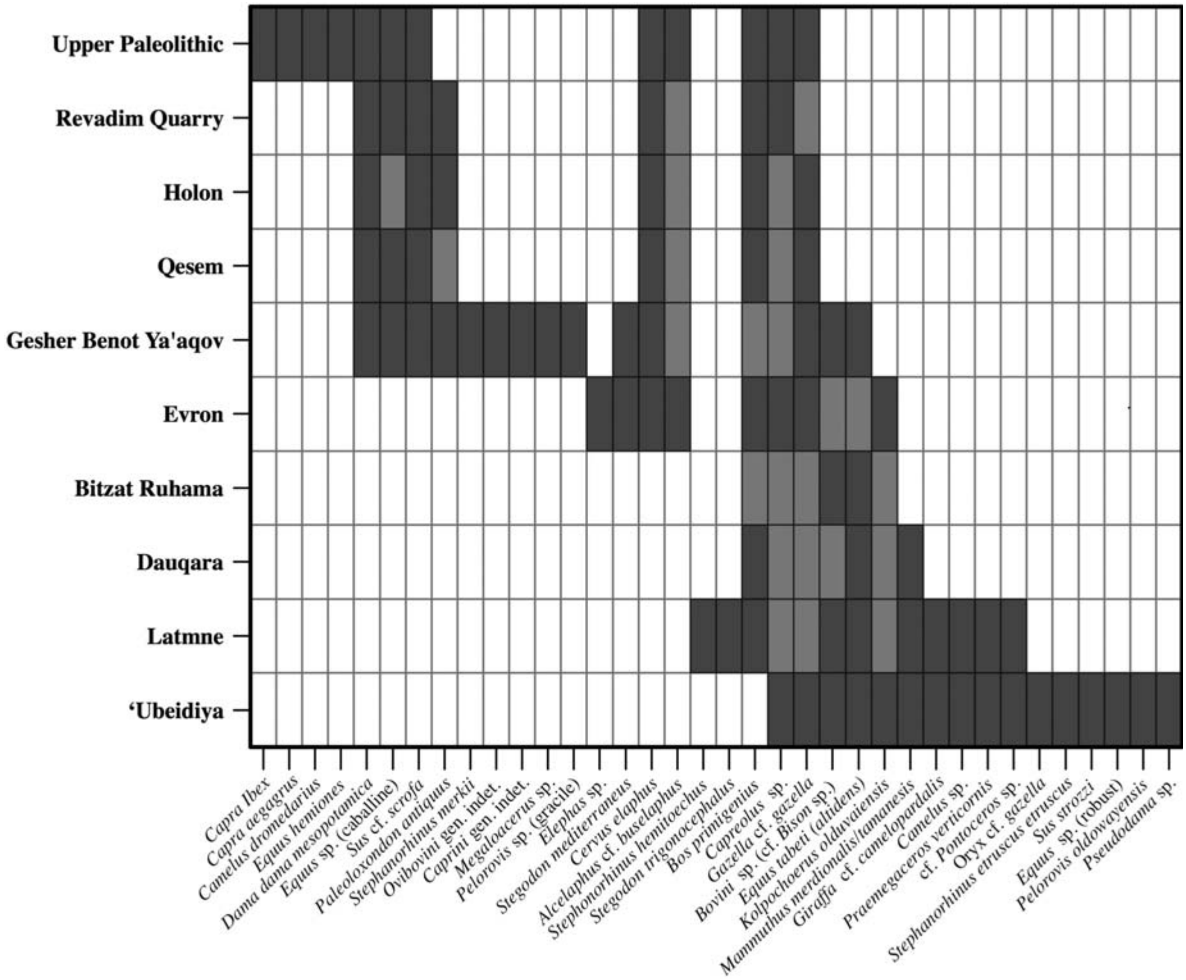

Fig. 2 Temporal distribution of fauna from the Early and Middle Pleistocene: dark squares denote presence, light squares denote assumed presence based on the range through method

There are only a few new additional species in the Late Pleistocene and no extinctions to clearly identify the nature of the turnover after the Early Middle Pleistocene. It has been suggested (Stiner et al. 2004) that the high relative abundance of cervids, specifically *Dama mesopotamica* in Qesem, differs from that of Later Middle and Upper Paleolithic sites in which the predominant taxon is *Gazella gazella*. This change has been attributed to a climatic shift (Stiner et al. 2004). Shifts in abundance reflect the local adaptation of the ungulate community to both temporal and spatial heterogeneous landscapes, but do not warrant the identification of new faunal units.

Correlation with Other Proxies for Paleoenvironments

The faunal turnovers in the Levant have been interpreted as a shift from tropical elements in the Early Pleistocene to those of Palaearctic origin in the Middle Pleistocene (Tchernov 1984). This interplay between the two groups of fauna has been viewed as reflecting a shift in habitat and climate from one dominated by savanna-like conditions to a more Mediterranean one. In order to test hypotheses regarding the linkage between faunal turnover and climate change, it would have been interesting to correlate the faunal data obtained from archaeological sites to the global isotope data from deep-sea cores as well as other evidence for large-scale global climate changes. However, precise correlations depend on a good chronological framework for the archaeological sites. Early Pleistocene climatic reconstructions in the Levant are rare (Ronen 2006), primarily due to the lack of radiometric dating of the archaeological and fossil-bearing sites that would allow for such an analysis.

A Late Cenozoic palynostratigraphy (Horowitz 2001) provides a general sequence throughout the Quaternary. This period is divided into ten palyzones, Q1 through QX, with a subdivision of the earliest period. The time period discussed in this paper (c. 1.8–0.43 Ma) corresponds to palyzones QIII–QVI. The sequence presents alternations between wet and dry Mediterranean flora. Unfortunately, actual pollen spectra within sediments of the archaeological sites themselves are even more rare. Few botanical remains have been retrieved from ‘Ubeidiya, all from the Limnic Inferior cycle. Macrofloral remains of fossilized leaves have been found in stratum III 19. These have been identified as *Pistacia lentiscus, Rhus tripartita,* and *Myriophyllum* sp. (Lorch 1966). Pollen spectra were extracted from stratum III 12 and analyzed by A. Horowitz (Bar-Yosef and Tchernov 1972). The analysis indicated 82% arboreal species, of which the overwhelming majorities are *Quercus* sp., followed by *Juniperus* sp. and *Olea* sp. Nonarboreal families include *Gramineae, Cruciferae,* and *Compositae* and are indicative of a Mediterranean habitat.

A small pollen spectrum from the site of Bitzat Ruhama is too small ($n = 114$) to be analyzed statistically (Zaidner 2003b). However, it is interesting to note that it indicates a relatively high percentage of arboreal pollen, including *Quercus, Pinus, Olea,* and *Cedrus*. Nonarboreal pollen includes *Chenopodiaceae, Palmae, Poaceae,* and *Liliaceae*. The presence of cedar may be suggestive of a colder environment in the region than is present there today (Zaidner 2003b).

The botanical remains of Gesher Benot Ya‘acov suggest that the climate pattern in the Hula valley at the time of deposition resembled the seasonal Mediterranean pattern seen today. Remains include oak (*Quercus* sp.), wild pistachio (*Pistacia atlantica*), wild olive (*Olea europaea*), plum (*Prunus* sp.), and jujube (*Ziziphus spina-christi*) (Goren-Inbar et al. 2004). Immersed or floating freshwater plants are common at the site and include species such as *Euryale ferox, Najas foveolata, Nymphoides* cf. *peltata, Potamogeton coloratus/polygonifolius,* the extinct *Stratiotes intermedius, Trapa natans,* and probably *Sagittaria sagittifolia*. Bank forest taxa include wild grape (*Vitis sylvestris*) and ash (*Fraxinus syriaca*). There is no paleobotanial evidence from other sites presented in this study.

Figure 3 presents the distribution of the ungulate faunal units in relation to the palyzones identified by Horowitz (2001). The palyzones alternate between periods of wet Mediterranean (a high proportion of arboreal pollen, specifically winter deciduous oak) and dry Mediterranean (a drop in arboreal pollen and an increase in desert vegetation pollen). The faunal turnovers do not appear to follow the same regime, either in tempo or in mode.

While the Early Pleistocene sites of ‘Ubeidiya and Latamne do have open steppe taxa such as *Camelus* sp. suggestive of a more arid environment within the Mediterranean *milieu,* the shift between the ungulate faunal unit *‘Ubeidiya* to ungulate faunal unit *Evron* does not clearly suggest the extinction of open habitat taxa and the appearance of more woodland or closed habitat elements. For example, *Evron* includes the appearance of taxa such as *Elephas, Bos,* and *Alcelaphus* and the extinction of *Praemegaceros verticornis* and *Pseudodama* sp. The shift would appear to be between the appearance of modern forms and the extinction of archaic ones. A similar pattern can be observed between the site of Gesher Benot Ya‘acov and sites from the Early Middle Pleistocene. The shift between the two faunal units *GBY* and *Qesem* is indicated by the extinction of archaic forms (e.g., *Megaceros, Pelorovis*), rather than the appearance or disappearance of specific habitat dependant taxa.

The distinction between palyzones does not correspond to that of the ungulate faunal units. Specifically, the faunal turnovers appear later in the geological record than those of the floral record, suggesting that there is a lag between the times when the climatic changes would affect the distribution of vegetation belts and when the ungulate community responds. This pattern was also found in the analysis of cenograms at ‘Ubeidiya. Montuire and Girard (1998) analyzed several mammal communities from ‘Ubeidiya and concluded that the shift

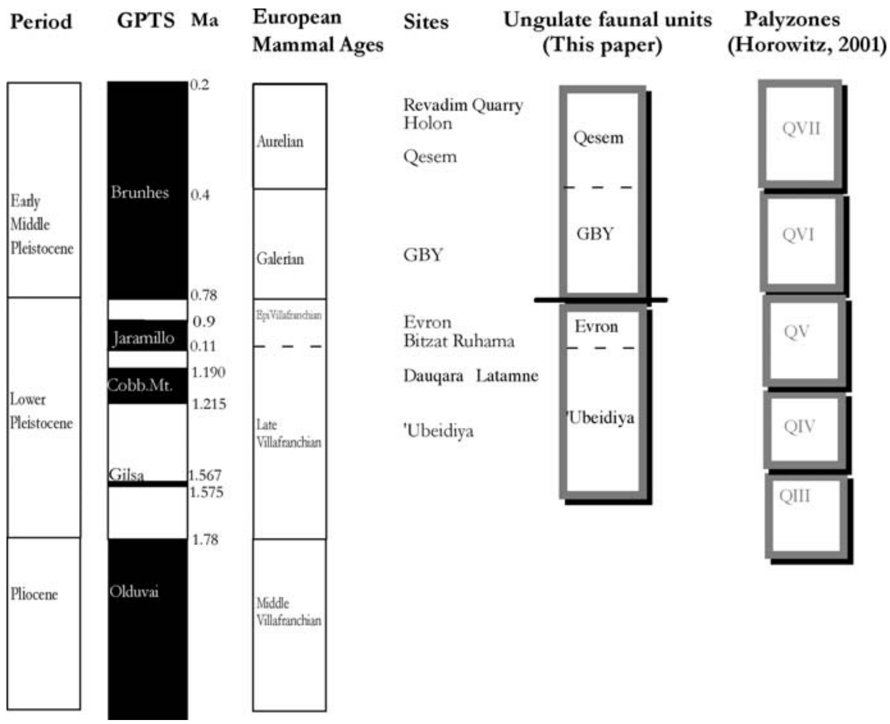

Fig. 3 Distribution of Lower Paleolithic sites with ungulate faunal units and palyzones in the Levantine Early Pleistocene and Early Middle Pleistocene

observed in the faunal record lagged behind the observed climatic shift, as interpreted by the sedimentological record. Thus it would appear that vegetation patterns respond quickly to shifts in climate, while the fauna respond in a later period to the shift in vegetation, creating the lag between the various paleoecological proxies.

Hominin Responses to Environmental Changes

The pattern observed for the fauna is similar to that of human cultural entities in the Early Pleistocene of the Levant. Throughout the Early Pleistocene Levantine *milieu,* differences in the lithic assemblages can be observed between and within sites. These include differences in the abundance of typological groups such as handaxes or spheroids, and the overall size distribution of the artifacts (Bar-Yosef 1994; Ronen 2006). However, detailed analyses do not warrant assigning any of the assemblages to distinct cultural entities, and they all exhibit affinities with the Levantine Acheulean (Bar-Yosef 1994). Moreover, despite local environmental changes, the typotechnological assemblages have been shown not to correlate with any specific environments (Bar-Yosef and Goren-Inbar 1993; Bar-Yosef and Vandermeersch 1993).

It has been suggested that the multiple dispersal events from Africa into the Levant in the Early Pleistocene were comprised of intergroup differences rather than environmental adaptations (Ronen 2006). Thus, different groups had a differential preference for their tool kit properties regardless of the distribution of raw materials at the site. For example, the artifacts at Bitzat Ruhama are exceptionally small, with a mean length of 25 mm. Large nodules of medium quality flint from the Mishash Formation are found in the vicinity of the site, but were not used in the production of the artifacts (Zaidner 2003a, 2003b).

When the transition between the Early and Middle Pleistocene is analyzed, a clear faunal turnover is observed. This break mirrors the clear distinction between the lithic assemblages of the sites dated to the Lower Pleistocene and that of Gesher Benot

Ya'acov. The lithic assemblage at Gesher Benot Ya'acov includes a unique cleaver component within its cultural *milieu* (Goren-Inbar et al. 1991, 1992a; Goren-Inbar and Saragusti 1996), and it has been suggested that that is the result of a second migration from Africa rather than an indigenous evolution of the regional culture (Bar-Yosef 1987; Goren-Inbar and Saragusti 1996). Unfortunately, there are no other sites in the region dated to this time period which would permit an assessment of the spatial and temporal distribution of this unique cultural entity. Goren-Inbar and Saragusti (1996) suggested that this absence is taphonomic rather than a true reflection of the rarity of the phenomenon.

Two cultural traditions have been identified in later populations, which postdate the Mid-Brunhes climatic shift (Bar-Yosef 1998a): The northern Acheulo-Yabrodian and the Late Acheulean south of the Yarkon River, which are roughly contemporaneous (Bar-Yosef 1998a, 1998b). The current state of research does not unequivocally support any conclusion regarding local biocultural continuity or a lack thereof between the Early Pleistocene and Middle Pleistocene populations (Shea 2001). Moreover, since there are currently few hominin skeletal remains associated with the lithic and faunal assemblage, it is not possible to determine which hominin species was/were responsible for the different assemblages (Barkai et al. 2003). If future analysis were to confirm a biological difference between these populations, it might indicate an increase in interspecies competition between the populations from the older dispersal and the 'newcomers.'

Ronen (2006) has suggested that the Late Middle Pleistocene population represents a continuation of the local cultural entities in the region surviving from the Early Pleistocene. If future analyses were to support a typotechnological continuity between Lower and Middle Paleolithic assemblages, this would suggest that hominins were one of the unique taxa that were able to persist beyond this faunal turnover in the region and would provide evidence for the unique adaptability and ecological success of early hominins, both as an inter- and intraspecies competitor. However, an interpretation that favors a discontinuity between the two populations is more consistent with the pattern emerging from the analysis of the ungulate fauna. This would suggest that the local populations in the Early Pleistocene of the Levant might not have survived beyond the MBB faunal break, perhaps due to increased competition with new dispersing populations. Thus, the presence of Early Pleistocene hominin populations in the Levant should be viewed as a 'cul de sac' rather than a corridor for dispersals from Africa into Eurasia. The appearance of the later Middle Paleolithic populations would confirm additional migration routes.

Discussion

The ungulate fauna in the Early and Middle Pleistocene of the Levant can be assigned to two main faunal units: the Early Pleistocene and the Middle Pleistocene. The two faunal units can be distinguished by a clear faunal break between them. Within each of these faunal units, there are two faunal turnovers of a lesser magnitude, the first associated with the Jaramillo normal event at 1.1 Ma and the second with the Mid-Brunhes climate break at 0.43 Ma. The distribution of cultural entities in the Levant during the Early Pleistocene mirrors the patterns that emerge from the analysis of the ungulate community. Thus, during the Early Pleistocene, several coexisting populations are identified as Levantine Acheulean, while the faunal break dated at 0.78 ma coincides with the appearance of a new cultural entity in the region at the site of Gesher Benot Ya'acov.

These faunal turnovers apparent in the Levant are consistent with the timing of the transitions between mammal age biochrones described for Europe as shown in Fig. 3 (Azzaroli et al. 1988; Guérin 1990; Caloi and Palombo 1997; Lindsay 1997; Milli and Palombo 2005; Masini and Sala 2007; Palombo and Sardella 2007). While the division into Early Villafranchian, Galerian, and Aurelian has been well established (Azzaroli et al. 1988), the absolute dates which divide the periods have been more controversial (Masini and Sala 2007; Palombo and Sardella 2007).

The onset of the Early Villafranchian is commonly attributed to the Olduvai subchron c. 1.8 Ma (Masini and Sala 2007) and the beginning of the Early Pleistocene (Napoleone et al. 2003). Azzaroli et al. (1988) suggested placing the Early Villafranchian to Galerian transition at the MBB at

0.78 Ma, although it has since been suggested that the onset of the Jaramillo should be placed at 1.1 Ma (Palombo and Sardella 2007 and reference therein). This is consistent with the identification of a short stage, the Epivillafranchian, which was described at the site of Untermassfeld, Germany (1.1 Ma) and which has been interpreted as an intermediate phase/zone between that of the classical Early Villafranchian and that of the Galerian (Kahlke 2000). The transition between the Galerian and the Aurelian is placed at the Mid-Brunhes climate event c. 0.43 Ma (Masini and Sala 2007; Palombo and Sardella 2007). The transition between the Galerian and the Aurelian is placed at the Mid-Brunhes climate event c. 0.43 Ma and (Masini and Sala 2007; Palombo and Sardella 2007).

The nature of faunal turnovers is region specific and depends on ecological and historical factors (Kostopoulos et al. 2007). While the nature of taxonomic composition, first appearance, and last appearance are different in the Levant and in other European local faunal assemblages (e.g., Greece, Italy, Spain, France, Balkans) because of a different species composition, it is interesting to note that the large faunal turnover occurs in all regions at the MBB (0.78 Ma), with the transition between the Early Villafranchian to the Galerian (Azzaroli et al. 1988; Kostopoulos et al. 2007). This transition is also recorded in the Early Pleistocene and Middle Pleistocene faunas in the Levant. Smaller turnovers at the Jaramillo (1.1 Ma) between the Early Villafranchian and the Epivillafranchian (or Proto-Galerian) in European mammal ages are observed in the transition between *'Ubeidiya* and *Evron* faunal units in the Levant. The transition between the Galerian and Aurelian at the Mid-Brunhes event (0.43 Ma) mirrors the shift between the *GBY* and *Qesem* faunal units.

The similarities between the Levantine faunal turnovers and those from Western Europe are of particular interest. The number and dating of faunal turnovers in the Early and Late Pleistocene differ to a greater extent between the Levant and Eastern Europe (Markova 2007), as well as between the Levant and Africa (McKee 2001), than between the Levant and Western Europe, as presented here. Since the early 1960s, emphasis has been placed on the paleoecological reconstruction of out-of-Africa sites based on large mammalian faunas. Specifically, the site of 'Ubeidiya (Haas 1966, 1968; Tchernov 1986) exhibited several taxa of African origin such as *Pelorovis oldowayensis* (Martínez-Navarro 2004). Subsequent excavation in circum-Mediterranean sites (albeit without human remains) such as Venta Micena, Spain, have also revealed African taxa (Martínez-Navarro and Palmqvist 1995) and further promoted the notion of the expansion of grassland into the Levant during the Early Pleistocene (Palmqvist et al. 2003). These analyses were based the paleoecological method of presence-absence of indicative species using taxa of African origin. However, a multivariate analysis using whole communities has suggested identifying the Early Pleistocene of the Levant as Mediterranean woodland (Belmaker [in press]) rather than savanna grassland. The association of a faunal turnover event between the Levant and Western Europe, and specifically Southern Europe, which was situated within the Mediterranean *milieu* during the Plio-Pleistocene (Suc 1984), further supports this paleoecological identification of the Levant.

Another interesting similarity between both regions is that the MBB faunal turnover is associated with both the appearance and extinction of taxa, while the Mid-Brunhes event is associated with the extinction of the large archaic ungulates with no new appearances. This would suggest that the MBB turnover is related to a climate change leading to the opening of new dispersal routes and allowed for new taxa to disperse into Eurasia, while the Mid-Brunhes climatic shift is related to a local deterioration in climatic conditions and lack of adaptation by species (Wang et al. 2003).

The ability of hominin populations to disperse from Africa into Eurasia is dependant on the opening of routes and passages from East Africa into the Levant. For example, during time periods when the sea level decreased, allowing for passage at the Bab el Mandab Strait, dispersal is possible; while at other times, when the sea level is higher, dispersal via the same route is precluded (Tchernov and Belmaker 2004). This is visible in the distribution of lithic traditions of the Levantine Paleolithic. During the Early Pleistocene all lithic traditions are within a similar cultural *milieu* (Levantine Acheulean). However, following the faunal turnover of 0.78 Ma, there is an appearance of a novel cultural tradition, which has been associated with a new dispersal event out of Africa and the local disappearance of earlier Levantine cultures. The appearance of a new cultural entity such as that which is found in Gesher Benot Ya'acov supports the model that the MBB climate shift was specifically related to the opening up of dispersal routes. On the other hand, the smaller turnovers at the Jaramillo and at the Mid-Brunhes were not clearly associated with the appearances of novel cultural entities, supporting the hypothesis that local hominin populations were able to maintain regional continuity despite local faunal turnover and changing climatic conditions.

This suggests that while local populations of hominins were able to withstand small level climate shift (i.e., the Jaramillo or the Mid-Burnhes), populations may not have adapted to the environmental changes that coincided with the MBB faunal turnover. Similarly, the turnover between the Early and the Late Middle Pleistocene is not associated with a shift in dispersal routes but only with climate change. Middle Paleolithic human populations adapted to the harsher climates of northern latitudes and were capable of surviving this climate change. Such adaptation may have included the use of fire (Clark and Harris 1985; Goren-Inbar et al. 2004) and large game hunting (Stiner 2002).

Conclusions

Four ungulate faunal units have been identified in the Levant: *'Ubeidiya, Evron, GBY,* and *Qesem*. The major faunal turnover in the Levantine ungulate fauna occurs across the MBB (0.78 Ma) between faunal units *Evron* and *GBY*. It is associated with the extinction of taxa as well the appearance of new forms, and is related to the opening of new dispersal routes coupled with the appearance of new cultural traditions. Two smaller turnover events, one in the Jaramillo (1.1 Ma) between faunal unit '*Ubeidiya* and *Evron,* and one at the Mid-Brunhes (0.43 Ma) between faunal unit *GBY* and *Qesem,* are also present. However, as opposed to the large turnover at the MBB, hominins exhibit cultural variability and continuity before and after these smaller faunal turnovers.

The timing of the transitions between the faunal units is similar to those observed for Western Europe between the Late Villafranchian to Epivillafranchian (1.1 Ma), Epivillafranchian to Galerian (0.78 Ma), and Galerian to Aurelian (0. 43 Ma), and suggests that the Levant was part of the Western European climatic and ecological *milieu* during this time period.

This study exemplifies how early hominins may have tolerated low and medium environmental changes, but not larger ones. The continued presence of hominins in the Levant during the Early Pleistocene was a process of several dispersal events rather than a long continuous occupation. The dispersal events of early hominins, and the subsequent distribution of cultural entities within the Levantine geographic space, are byproducts of interplay between hominin adaptability, behavior, and ecological and environmental changes, both global and local.

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DISCUSSION 2: Transitions: Behavioral Change in the Early Pleistocene

Robin Dennell

Abstract Like all periods, the Palaeolithic is subdivided into smaller units, and these tend to form the main units of study as blocks of relatively static behavior. This volume takes a different approach by focusing attention on the transitions between periods, when hominin behavior, or some component of the environment, changed over a relatively short period of time. This chapter reviews four of the volume contributions on transitions: the first looks at the earliest evidence for stone tools ca. 2.6-2.9 Ma; the second examines the transition from the Developed Oldowan of East Africa to the Early Acheulean; the third reviews the apparent co-existence of two traditions of making stone tools throughout much of the Early Palaeolithic; and the fourth examines the relationship between faunal and archeological change in the Levant. Each poses very different conceptual and methodological problems, and usefully illuminates the problems and benefits of studying transitions as phenomena in their own right.

Keywords Transitions • Acheulean • Oldowan • Kadar Gona • Levant • Small tool tradition

The Palaeolithic provides us with a record of hominin behavior that now extends back 2.6 Ma. Most of this is a record of flaked stones and broken bones—of lithic technology and the consumption of meat by hominins, or often their competitors. This evidence constitutes a fascinating mixture of time spans of what can easily seem to us as unimaginable monotony—especially during the Lower Palaeolithic—and substantial changes. These can sometimes appear relatively rapid, but are often so gradual that they are hard to discern over time spans that might encompass thousands of hominin generations. Overall, the changes that we observe in the Palaeolithic were ones that hominins themselves would almost certainly have never noticed. The Middle to Upper Palaeolithic transition in western Europe—arguably the most discussed and well-documented transition in the Palaeolithic—between 40 and 30 ka would have spanned 400–500 generations (allowing an average generation span of 20–25 years). Further back in time, the "transition" from the Lower to the Middle Palaeolithic in Europe and western Asia is seen, depending upon definition, as lasting from ca. 350 to 250 ka, or 5,000 generations. On such time scales, hominins would have been wholly unconscious of the changes that are now evident to us, with the benefit of hindsight.

Investigations of changes in hominin behavior that hominins themselves could not have noticed raise several interesting issues. One is the relative importance of agency versus process—how much change was directional and intended, and how much was random and unintended? Did changes persist because they had positive benefits, or because they were neutral? How were such changes transmitted to subsequent generations? Were there "eureka" moments in the early Palaeolithic, when a hominin realised the potential of, for example, invasive flaking, or a throwing spear? Another set of issues is whether transitions in behavior are simply a product of our own assumptions and databases. For example, in areas that are

R. Dennell (✉)
Department of Archaeology, University of Sheffield, Sheffield, UK

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supposedly “centers of origin” (such as East Africa), all change is seen as indigenous, and thus all changes in behavior are seen as evidence of transitions from a local background; in regions regarded as peripheral (notably western Europe), major changes are usually seen as intrusive. The rate of change can also be an behavior of our own making: for example, change invariably appears to have been very slow when our sampling intervals are several tens of millennia apart, and rates of change often accelerate as the sampling interval decreases. Just as with palaeontology, it is not always clear in Palaeolithic research whether punctuated equilibria is a more appropriate mechanism for explaining change than gradual evolution.

This volume is one of the few that has focussed on transitions in the Palaeolithic, and examines several “transitions” in behavior during the Palaeolithic. Four papers examine “transitions” in the early Palaeolithic. The first by Rogers and Semaw is the simplest in scope and looks at the earliest evidence for stone tools. Here, the transition is “from nothing to something”, from hominins that did not make stone tools to those that did after 2.6 Ma. This is not of course to deal with the transition as such, but with the consequences of that transition. Their paper provides one of the best summaries I’ve read of the earliest “Oldowan” assemblages in East Africa, of which Semaw in particular has immense experience from his own work in Ethiopia and especially on the oldest flaked stone assemblages so far found at Kadar Gona, Ethiopia. Several points of this paper struck me as particularly interesting. One I hadn’t previously realised is that because of a stratigraphic gap at Gona between 2.7 and 2.9 Ma, toolmaking may have begun > 2.6 Ma, although probably < 2.9 Ma. The second is that “there is no reason to exclude any 2.5 – Ma hominin from the capability of making stone tools”. This ability clearly precedes the emergence of our own genus (especially if the earliest stone tools turn out to be as old as 2.9 Ma), and clearly precedes any trend towards greater encephalisation, reduction in sexual dimorphism or larger body size. The third point is the association of these late Pliocene stone tool assemblages with grasslands: “In general, archaeological sites >2.0 Ma are found in mixed environments with a strong component of open grassland”, and “The overall evidence for late Pliocene hominins using stone tools in environments with substantial open grassland is strong”. Sites near river channels (for example, Gona, Hadar, Omo, West Turkana) indicate the presence of riparian woodland as well as grassland, but lake margin sites (notably those on the Middle Awash and at Kanjera) “are dominated by open grasslands and seem to have very minor woodland components”. Hominins at Kanjera were even prepared to transport stone up to 13 km in order to use those environments. Fourthly, the primary purpose of flaking stone was to produce sharp flakes with which (judging from the cut-marked bone at Bouri) to extract meat from large carcasses. Taking these points together – the association of these early assemblages with grasslands, the indications that toolmaking facilitated (or enabled) the scavenging of large mammals, the likelihood that several types of hominins were probably flaking stone tools – with the evidence that australopithecines were widespread across the grasslands of Africa by 3.0–3.5 Ma (Brunet et al. 1995), and that grasslands at that time extended from North China to West Africa (Dowsett et al. 1994), I wonder yet again when hominins first left Africa. Perhaps the question I raised ten years ago “did australopithecines leave Africa 3 Ma?” (Dennell 1998) seems less unreasonable now than it appeared at the time. A final perceptive point by Rogers and Semaw is the difficulty of demonstrating any causal link between climatic change and the onset of tool-making: instead, we need first to focus on micro-environments, and establish the range of environmental tolerances and preferences before inferring a positive, neutral or negative role of climatic change.

Semaw, Rogers and Stout examined the Oldowan-Acheulean transition and asked “is there a “Developed Oldowan” artifact tradition”? I confess this is a question that I’ve never had the inclination to investigate, but I welcome both their efforts and conclusions. For those not familiar with the minutiae of early lithic typology in East Africa, the Developed Oldowan was first recognized by Mary Leakey (1971), in her pioneering work at Olduvai. Developed Oldowan A (DOA) was first recognized in the lower and middle parts of Bed II, and is probably 1.7–1.5 Ma. It differed from the Oldowan in Bed I in that spheroids and light-duty tools were more abundant, as were “protobifaces” (i.e., attempts to flake an Acheulean biface) and heavy-duty tools. Developed Oldowan B (DOB) appeared in the middle part of Bed II, ca. 1.5–1.4 Ma, and around the same time as the earliest Acheulean assemblages. DOB assemblages contained crude bifaces (mainly on river cobbles), as well as some bifaces on large flakes, and light-duty tools that were classified as awls and burins. Developed Oldowan C (DOC) was essentially the same as DOB but stratigraphically more recent.

Mary Leakey's classification of the Oldowan and Developed Oldowan was similar to Louis Leakey's (1934) classification of the East African Acheulean, which in turn closely followed Breuil's classification of the French Acheulean. These were "progressivist" schemes that envisaged a gradual but inexorable trend towards greater perfection in early human behavior (see Dennell 1990), from, in this instance, initially simple attempts at flaking "crude" tools to ones that, over time, showed increasing refined and more "evolved" types of artifacts. Yet, as Isaac pointed out many years ago, it was not clear whether one was sampling "stages" of development, or merely different aspects of lithic variability at any given moment in time—with only a few sampling points over long periods, it was impossible to assess the role that raw material availability, site function, site formation processes, and so on may have had on sample composition. Additionally, there was a tendency to overtypologize, and to overestimate the range of tools in these very early assemblages.

Semaw and his coauthors reassess the Developed Oldowan very differently from that initially suggested by Mary Leakey. In their view, the "Developed Oldowan A" should be subsumed within the Oldowan, and "Developed Oldowan B and C" should be classified as part of the Early Acheulean. They suggest that the spheroids and subspheroids in DOA assemblages were probably derived from an increased use of quartz for both cores and hammer stones. The awls and burins were probably accidentally made, and the "protobifaces" were probably heavily worked cores or choppers rather than hesitant and inept attempts (over hundreds of generations) to make a true biface. Choppers, of course, are not exclusive to the Oldowan and are found even in Late Pleistocene contexts. The bifaces and large flakes seen in the DOB and DOC are typical of the Early Acheulean, and should be regarded as such.

The exciting part of their paper is that the advent of the Acheulean ca. 1.7 Ma denotes a "quantum" leap in tool-making rather than an indigenous development from the Oldowan. Specifically, the production of hand axes, cleavers, and picks necessitated a focus on large-sized raw materials, irrespective of grain, for making large blanks, and the ability to detach large flakes; to flake invasively; and to shape purposefully, with predetermination or preconception of shape. As Isaac once pointed out, the Acheulean may denote new tasks, and not just new tools, and perhaps also involve a higher-level cerebral organization, with longer sequential-action planning, working memory, and a possible link to an expansion of Broca's area. I would suggest that whereas several types of hominins probably made Oldowan assemblages, only the genus *Homo* was capable of making Acheulean ones. That hypothesis requires further testing. A second suggestion is that the Acheulean may be an intrusive tradition into East Africa: not all change in a "center of origin" need have been local. To investigate that possibility further requires new information from adjacent regions, including Southwest Asia.

Burdukieicz's chapter examines the earliest "microlithic" assemblages of Eurasia. The basis of his argument is that both Oldowan (Mode 1) and Acheulean (Mode 2) assemblages were used in Eurasia in the early Pleistocene, and small-tool "microlithic" assemblages developed from this background as a separate tradition. He suggests that it indicates a widespread use of hafting (as most of these tools are too small to be used in the hand), and indicate an adaptation to wooded environments or ones where bamboo was common.

As a devil's advocate, I wonder how much of this "microlithic tradition" simply reflects local raw material availability. At Bizat Ruhama (Israel), for example, the small size of tools in this assemblage stems from the raw materials that were available within 5 km of the site. Limestone would have been the easiest to obtain, but was never used. Flint was available in the form of small stream pebbles. By far the most common type was a brecciated flint, found in pebbles averaging 80 mm in length; however, this was poor in quality, difficult to flake, and used for only 20% of tools. The preferred choice was a brown or beige flint that was easier to knap; however, the pebbles of these were only half the size of the brecciate variety. Consequently, tools made from these types of flint were not only much smaller than those made from brecciated flint because the raw material was smaller, but they were also retouched more because the quality was better, which in turn made them even smaller (Ronen et al. 1998; Zaidner 2003; Zaidner et al. 2003). I would also place the age of the site at 560,000–920,000 years old on the basis of a RTL date of 740±180 ka for the occupation layer, rather than 1 Ma.

At Evron Quarry, a small-tool assemblage was found in a series of shoreline and coastal deposits, with most of the evidence from Layer 4—a water-lain yellow-grey sand. There is some evidence of fluvial winnowing, where smaller items (both lithic and faunal) sank to the bottom of Layer 4. Most artifacts were made from small flint nodules that were available from the river. The faunal remains were very fragmented—mainly isolated teeth (Tchernov et al. 1994); again, some water-sorting is implied. Contra to Burdukieicz, hand axes were not found in the excavation but elsewhere in the quarry area; these had a yellow sand matrix that may be linked to Layer 4, but it cannot be demonstrated that they were an integral part of the assemblage found in the excavated part of that layer (Ronen and Amiel (1974) and Ronen (1991). Although the artifacts from sites in the Nihewan Basin, North China—such as Donggutuo, Xiaochangliang, Xiantai, and Majuangou I-IV—are usually very small, so too were the nodules that were flaked. The Nihewan Basin is deficient in large nodules of high-quality stone. At Donggutuo, most tools are very small, with a median size of 2–3 cm. At Xiaochangliang, the artifacts were in very fine-grained laminated silt and fine sands; again, small tools were made from small nodules (Chen Shen and Chun Sen 2003; Zhu et al. 2001). However, at Majuangou, the stone used was poor-quality chert, sandstone, quartz, and andesite, but the artifacts were larger than other clasts in the deposits, indicating that these hominins were transporting stone from elsewhere (see Zhu et al. 2004). At Locality 1 in Zhoukoudian, 70% of the tools in the earlier phases (Layers 8–11) were large; those in younger deposits were much smaller, but the deposits were often finer (Zhang 1985). In Tajikistan, Central Asia, the only raw material was small pebbles of quartzite, limestone, schists, cornelian, porphyry, and poor-quality flint and chert in stream deposits, and the hominins at Kuldara (880–955 ka) (see Ranov 1995; Ranov and Dodonov 2003) and at later sites could not have flaked large tools if they had wanted to.

I would suggest that early hominins were often desperate for flakable stone and used whatever was available, however small (as at Bizat Ruhama, Evron Quarry, or in Tajikistan) or low quality (as in the Nihewan Basin). Although there are instances were hominins produced large flake tools but not hand axes—as at Yarimburgaz, western Turkey, or at several British sites with Clactonian flake assemblages—examples of when they could have produced large flake tools but decided consistently to flake only very small ones seem to be very rare. In these assessments of sites with small-tool assemblages, we need also to know the size of the stones or nodules that were being flaked, the size and condition of any faunal items, and the taphonomic history of the site. Also, bifaces—the hallmark of Mode 2 Acheulean assemblages—were often very rare components, and this also means that sample size has to be taken into account when classifying assemblages as Mode 1 or Mode 2. In short, it seems to be unclear whether we are dealing with a continental-wide, million-year “tradition” of making small tools, or a series of local responses to the nonavailability of large stone that could be flaked.

Additionally, a note of caution is needed about the use of bamboo—it was certainly not used in Central Asia, and was probably not used in North China. There is no evidence of bamboo in the three pollen analyses from Locality 1 (Zhoukoudian), and the only evidence was indirect, based on the supposed presence of panda (*Ailuripoda melaneuca*). This evidence comprised a distal humerus from Layer 5, which Aigner (1981:115) considered doubtful. Similarly, there is no evidence for hafting in the form either of resin adhering to tools (as at Campitello, Italy (Mazza et al. 2006)) or abrasion on the hafted part.

Belmaker’s paper differs in its approach from other papers by looking at transitions in the environment in which early hominins lived—in this case, those in the Levant during the Early to Middle Pleistocene. Here, there is continuity in lithic tradition (the Acheulean) but a considerable degree of faunal change. Her conclusions are that hominins could survive episodes of minor environmental disruption, but not major ones; and that the Levantine record indicates a series of dispersals, rather than continuous occupation. Her paper contains a useful review of the Levantine Early and Middle Pleistocene faunal record. Four faunal units are recognized: Unit One, containing the sites of ‘Ubeidiya, Latamne and Dauqara; Unit Two, Evron Quarry and perhaps Bizat Ruhama; Unit Three, Gesher Benot Ya’aqov (GBY), and Unit Four, Holon, Qesem, and Revadim. Changes are minor between the early Pleistocene units of ‘Ubeidiya and Evron: *Praemegaceros verticornis* and

Mammuthus meridionalis/tamanensis are absent from Evron, which has a suid population *Kalpochoerus evronensis* that seems derived from *K. oldovaiensis*, recorded at 'Ubeidiya. Evron also has the last record of *Stegodon* in the Levant (Tchernov et al. 1994). The GBY faunal unit has many new features, and differs only slightly with the Qesem fauna, which has no new species but lacks archaic taxa such as *Megaloceros*, Ovibovini, and *Pelorovis*. Overall, changes between units One and Two were minor, as were the changes between units Three and Four, and it makes sense to recognize two major sets of evidence—one from the Early Pleistocene with the 'Ubeidiya and Evron fauna, and one from the Middle Pleistocene that contains the GBY and Qesem faunas.

The archaeological evidence from the Levant is consistent with this pattern: the Acheulean assemblages from GBY, particularly the abundance of cleavers and the use of the Kombewa technique of flaking, may indicate the arrival of a new influx of hominins from East Africa. A point not made in her paper, but one that I consider important, is that GBY provides the last indication of any faunal connection with East Africa. As noted by O'Regan et al. (2005: 241), "The idea that the Levant was a route of faunal exchange into and out of East Africa … is not supported" by their analyses of the Levantine and African Middle Pleistocene faunal records. This continued throughout the Middle Pleistocene. The 'Levantine Corridor' was a *cul de sac* rather than a passageway, as the Saharan belt was too firmly closed to allow free dispersal into sub-Saharan domains" (Tchernov 1992:118). The only indication of any faunal movement between the Levant and East Africa during the entire Middle Pleistocene (0.78–0.125 ka) is a recent record of *Nycereute*s (racoon dog) at Hayonim (Stiner et al. 2001).

I agree entirely with Belmaker that the Levant provides evidence of several dispersals from Africa—an initial set into Southwest Asia that is evidenced by Dmanisi (1.8 Ma); a second that brought Acheulean assemblages to the Levant ca. 1.4 Ma, as at 'Ubeidiya; and a third resulting in a different type of Acheulean at GBY at c. 0.8 Ma. In the Middle Pleistocene after GBY, faunal exchange with East Africa ceased. What happened in the Middle Pleistocene is still unclear; as she notes, the evidence for or against continuity in lithic assemblages between the late Acheulean and the Jabrudian, or between these and the Early Middle Pleistocene, is still ambiguous, although a case can be made for discontinuity. However, the Levant should have been one of those "core" areas of Southwest Asia (along with, probably, western Turkey), where hominin residence was almost always possible because of the region's higher rainfall. Inland, away from the Mediterranean, occupation was probably feasible only during warm and moist interglacial periods. However, it is possible that during the type of short episodes of extremely low temperatures and aridity that are seen in marine cores, even the Levant was abandoned during parts of the Middle Pleistocene. It is an intriguing possibility, and emphasizes the need again for detailed climatic information for the archaeological records of regions such as the Levant.

As is evident from these papers, each transition has to be studied on its own terms, and at present, we are far from undertaking comparative analyses of transitions in lithic design or subsistence behavior in different regions, at different periods, or on different time scales. This will doubtless happen, but only after the type of detailed regional analyses seen in this volume have taken place.

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Part III
Lower to Middle Paleolithic Transitions

Assessing the Lower to Middle Paleolithic Transition

Michael Chazan

Abstract This paper considers three different approaches to the use of the concept of time series as applied to archaeological chronology, with particular reference to the Lower to Middle Paleolithic transition. Perspectives on this transition based on the theoretical positions of Leroi-Gourhan and Childe are considered along with the possibility of adopting the concept of time series as a measure of values at fixed intervals.

Keywords Paleolithic • Chronology • Leroi-Gourhan • Childe • Fire • Basecamp

Chronological periods can be considered to be a time series method of classification. The *Oxford English Dictionary* offers several ways of interpreting this statement. Chronologies could be either a sequence of events that constitute time or events measured by time. A third option is actually the negation of chronological periods, as it emphasizes a series of values of some quantity obtained at successive times (often with equal intervals between them). In this paper I will explore each of these meanings for time series as applied to the transition between the Lower and Middle Paleolithic.[1]

Modes, *Fait*, and *Tendance*: Time Embodied

André Leroi-Gourhan is today widely recognized for providing the theoretical framework for the study of prehistoric technology (see articles in Auduze and Schlanger (2004)). Yet, although the *chaîne opératoire* has been widely adopted by archaeologists, other aspects of Leroi-Gourhan's writing have not found traction in contemporary archaeology. The idea of tendency (*tendance*) is among the least explored of Leroi-Gourhan's concepts, in large part because it is suspiciously reminiscent of the neo-Lamarckian teleology that pervades much of Leroi-Gourhan's writing about biology (Leroi-Gourhan 1964). However, technology is not biology and the idea of *tendance* might have some value in understanding the large-scale regularities in technological change that underlie much of Paleolithic chronology.

If we go back to the founding events of American anthropology, we can find a tension between the concepts that Leroi-Gourhan came to encapsulate under the distinction between *tendance* and *fait* (fact). In the North American context, this tension took the form of the debate over the exhibit of prehistoric artifacts at the Smithsonian Museum of Natural History (Chazan 2000a). Otis Mason, the curator of the museum, chose to develop an elaborate exhibit that followed the development of particular forms of tools (i.e., containers, knives) across time and space. The goal of the exhibit was to give a sense of the grand sweep of human cultural development. Newly arrived in the United States, Franz Boas attacked this as a meaningless presentation. For Boas, artifacts only took on significance within their cultural context. He therefore argued

M. Chazan (✉)
Department of Anthropology, University of Toronto, Toronto, Ontario, Canada

[1] I include discussion of the African archaeological record which is usually subsumed under the terms Early (or Earlier) and Middle Stone Age.

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that the exhibit should be organized to show the entire cultural repertoire of particular groups.

Leroi-Gourhan was able to conceive of these approaches as two faces of a single reality. On the one hand, there is a certain global regularity to the development of human technology, a regularity he recognized under the rubric of *tendance*. At the same time, he used the term *fait* to recognize that the local manifestation of the *tendance* will vary. One must approach these ideas with tremendous caution. The *tendance* is in a sense a disembodied reality that exists outside its physical manifestation in the form of a particular *fait*. Leroi-Gourhan was clearly heavily influenced by the teleological views of Teilhard de Chardin and Henri Bergson, in which evolution is guided by a metaphysical force (Stiegler 1998).

Nonetheless, the recognition of *tendance* and *fait* as two aspects of a single reality has potential value for improving our understanding of prehistory and, more particularly, the transition between the Lower and Middle Paleolithic. Grahame Clark's system describing modes of stone tool production is particularly relevant in this context (see discussion in Foley and Lahr (2003); Carbonell et al. (2007)). Following Clark, Mode 1 refers to simple chopper-flake industries, Mode 2 refers to biface industries, and Mode 3 refers to prepared core industries. There is a general association between the Lower to Middle Paleolithic transition and the eclipse of Mode 2. The modes described by Clark are at the level of *tendance*. When viewed from this perspective, we can adopt the Modes without obscuring the variation in their physical manifestations. The particular expression of a mode within an assemblage would exist at the level of the *fait*.

For Leroi-Gourhan the *tendance* exists outside the physical time sequence; in a very real sense the *tendance* constitutes time. This is a very obscure statement. How can something other than time itself constitute time? One example is the way that we think of our own lives as constituting a temporal framework. We do calibrate our age to the calendar, but we also measure events against the timescale of our lives, noting events that occurred 'when we were young' or in terms of where we lived at the time. But how can we use such a conception of time in an archaeological context without appeal to metaphysical forces? Part of the answer to this question lies in refuting Leroi-Gourhan's equation of biological and technological evolution. This aspect of Leroi-Gourhan's thought is inconsistent with his emphasis on the particularity of human technique. Leroi-Gourhan was hobbled by his adherence to an overall directionality to evolution, where technique springs from biology. Leaving this idea behind, we can begin to ask why it is that *tendance* appears to have value for technology while it has little value for biology. One answer can be found in Leroi-Gourhan's insistence that technology is the result of the interaction between the interior world of the human mind and the exterior world of materials, as expressed in the title of his major work, *L'Homme et la Matiere* (Leroi-Gourhan 1943). Stone tool manufacture is limited by the qualities and characteristics of the fracture of brittle materials. At the same time, the functions of these tools are limited to a set of actions, many of which are catalogued in *L'Homme et la Matiere*. Perhaps it is therefore inevitable that the development of tool technology followed general tendencies dictated by the constraints of the material and the ways in which the tools are employed. There might be an inevitability in the shift from Mode 2 to Mode 3 that we recognize as the Lower to Middle Paleolithic transition. If we choose to accept the concept of modes and the validity of *tendance* we are forced to accept that the interaction between humans and material results in directional change that takes place at a rate that has nothing to do with the lives of individual people. We are forced to begin to consider the novelty of human technique.[2]

The Social Context of the Transition: Events in Time

Most contemporary scientific practice views archaeological chronologies as events in time, rather than events that embody time. There is an absolute entity 'time' that is exterior to human experience and archaeological periods are tethered to time through the use of chronometric dating methods. Thus, an archaeological period exists 'in time' and its temporal dimension can be measured.

[2] Following this perspective it may not be coincidental that Foley and Lahr are able to adopt Clark's modes to a cladogram, as cladograms have a highly ambiguous relationship to time (see Sober 1988). By contrast, Carbonell et al. (2007) place the modes within a time frame.

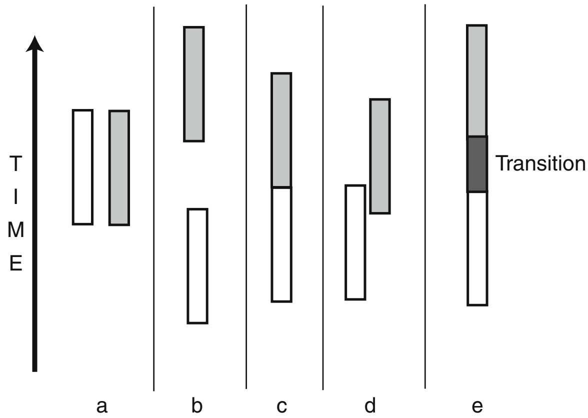

Fig. 1 Temporal relationships between archaeological periods. **a**. Periods overlap in time. **b**. Clear temporal separation between periods. **c**. Temporal continuity between periods. **d**. Partial temporal overlap between periods. **e**. Transitional period at the temporal interface between two periods

Adopting this definition of archaeological periods does not require that these events are temporally exclusionary, as they may overlap in time (Fig. 1a). In such a case, to talk of a transition would be inaccurate. An archaeological example would be the Amudian and Acheulo-Yabrudian of the Middle East, which are widely believed to be contemporaneous.[3] In such a case, there would not be a transition between chronological periods. A second scenario in which the idea of a transition would be misplaced is a case where there is clear temporal separation between events (Fig. 1b). Discussion of the Lower Paleolithic to Mesolithic transition would fit in this category, as there are intervening periods. For there to be a transition, archaeological periods must be temporally continuous (Fig. 1c). There can also be a transition in the case where there is a partial temporal overlap between periods (Fig. 1d).

There is a certain irony in defining archaeological periods as events in a book about transitions. The common conceptualization of prehistory is that the transitions are the events, punctuating periods of 'non-event.' From the perspective presented here, either transitions are a passage from one event to another, or transitional periods can exist at the interface between two time periods (Fig. 1e). Far more difficult are the related questions of the nature of the events we describe as archaeological periods and, of direct relevance to the question of transitions, the nature of the process that causes change from one period to the next.

Leroi-Gourhan brings our attention to the importance of technical processes, but in a sense his view of technology floats outside the realm of society. Reading Leroi-Gourhan, one gains a powerful sense of the interaction between people and the material world, but a sense of underlying social forces is absent. From this perspective one can read Leroi-Gourhan as a response to Marx, pointing out the internal dynamics of systems of technology and communication that come to have a life of their own independent of society. The shortcoming of such an emphasis can be seen by comparing Leroi-Gourhan to V. Gordon Childe. For Childe, technological change involved changes not only in the means of production but also in the organization of production (see essays in Harris 1992). As a Marxist, Childe was able to focus on the social transformations that were associated with the material changes visible in the archaeological record. The origins of agriculture and the urban revolution are concepts that are far greater in their breadth than the description of modes. Identifying the transformation of society seems more compelling than tracing *tendances* in technological development. In the context of the Lower to Middle Paleolithic transition, this issue takes on particular urgency. If this transition is simply the shift from Mode 2 to Mode 3, then the use of the dichotomy between Lower and Middle Paleolithic is redundant. Childe forces us to ask whether it is possible that what is involved is not only a stage in the development of technology, but also a shift in the way human societies are organized. Before attempting to address this question, it is important to stress contemporary critiques of Childe. Although Childe viewed the major transitions of prehistory as uniform on a global scale, few today would accept such a simplified view. Both agriculture and urbanism are highly variable phenomena. Secondly, while Childe viewed transitions as rapid events, archaeologists today stress the long 'intermediate landscapes' that characterize these transitions (Smith 2001).

Both Lower and Middle Paleolithic societies combined hunting, gathering, and scavenging for subsistence. Glynn Isaac pointed to the importance of sharing of meat among members of hunter-gatherer

[3] I do not discuss chronological units within the Lower Paleolithic in this paper. See Chazan (2001) for a brief discussion of this issue.

societies within the context of home base sites (Isaac 1978). Yet Rollins (2004) has recently pointed out that few clear candidates for Lower Paleolithic home base sites have been identified, and those that have been found date to OIS 11 or later (Gowlett 2006). Thus, the appearance of home base camps in the archaeological record might be evidence of the kind of shift in the social relations underlying subsistence that Childe identified as critical to understanding change in prehistory.

Several lines of evidence support the argument that the Lower to Middle Paleolithic transition involved a fundamental change in society. Lower Paleolithic cave sites are rare and most are very late in the sequence (see Rolland 2004 for a partial list of exceptions). This is significant as cave sites are by definition base camps, places to which meat was transported from the kill site and where a context for sharing would exist.[4] There is also a clear shift in the also intensity of the controlled use of fire. Although the controlled use of fire has now been documented on a number of Lower Paleolithic sites, it is of extremely low intensity compared to the highly intense use of fire found on Middle Paleolithic sites (see discussions of the evidence for Lower Paleolithic use of fire in Alperson-Afil et al. (2007); Goren-Inbar et al. (2004); Gowlett (2006); de Lumley (2006); Thieme (2005)). The evidence for fire at Beeches Pit, West Suffolk (MIS 11) is currently the most compelling evidence for the repeated use of fire with the intensity to affect both large lithic elements and faunal remains (Preece et al. 2006). Intensive burning is characteristic of many Middle Paleolithic, and Middle Stone Age sites and hearths are often clearly identifiable (Mellars 1996; Schiegl et al. 1996). Recent evidence from analysis of sediments from Tabun Cave underscores the massive scale of burning that took place on these sites (Ablert et al. 1999).

In recent years a consensus has emerged that some form of hunting was practiced by Lower Paleolithic hominins, and that it is likely that even very large animals such as elephants were hunted (see references in Chazan and Horwitz (2006); see Rabinovich et al. (2008d) for evidence of butchery of medium-sized animals). Faunal assemblages from Middle Paleolithic sites are dominated by large- to middle-sized animals, and evidence for the exploitation of very large animals is rare (Gaudzinski and Roebroeks 2000; Stiner 1994). The systematic hunting of medium- to large-sized animals in the Middle Paleolithic is compatible with the transport of meat from the kill site to a base camp where meat was redistributed. The absence of very large fauna from Middle Paleolithic assemblages is puzzling. In some areas, particularly the Near East, this pattern may be the result of the extinction of Pleistocene species of elephant. However, it is tempting to link the pattern of faunal exploitation in the Middle Paleolithic to the emergence of an economy based on the transport and redistribution of meat.

The combination of the lines of evidence indicates a significant shift in hominin behavior related to the use of fire, settlement patterns, and prey selection across the Lower to Middle Paleolithic transition. If these lines of evidence can be connected with the emergence of home bases as defined by Isaac, then the Lower to Middle Paleolithic transition can be related to the kinds of social change that Childe saw as driving transitions in later prehistory.

Values at Intervals

There is a degree of awkwardness to the treatment of archaeological periods as events, as things that happened. After all, these are abstractions, whereas it is the actions of living individuals and the interaction between individuals and their environment/society in the past that are the actual events. While Leroi-Gourhan's concept of *tendance* might be dismissed as unnecessary metaphysics, an approach based on Childe might equally be criticized for imposing form on a highly complex reality. We might also argue that these concepts, and more broadly, the idea of transitions in the Paleolithic, are at best useful heuristics. They help us organize the way that we think about change through time.

[4] This statement needs qualification following my publication of early dates for cave occupation at Wonderwerk Cave, South Africa (Chazan et al. 2008). As discussed in this publication the very low density of artifacts at Wonderwerk suggests that the cave was not a base camp occupation during the Earlier Stone Age.

The situation becomes all the more complex when one adds speciation events within the hominin lineage as potential causal factors in the shift from the Lower to the Middle Paleolithic or from Mode 2 to Mode 3 technology (see Hopkinson 2007). Biological classification draws on highly complex ideas about time that are distinct from the archaeological issues raised here (Gould 1977; Ridley 1986; Sober 1988). The simplest approach would be to view species as 'events' with temporal boundaries. One could then explore the degree of correlation between the temporal boundaries of species and archaeological periods and where correlation is found to infer a causal relationship. However, there are many problems with such an approach, including the treatment of species as clearly temporally-bounded entities, and the lack of a basis for inferring causality.

The third definition of time sequence offers an alternative, a Paleolithic world without archaeological periodization. According to this definition, a time sequence involves the measure of values at fixed time intervals. For archaeology, 'values' would refer to evidence related to hominin adaptation, technology, and society (one could also add hominin species). Examples of such an approach have begun to emerge; for instance, global studies of the last interglacial or other moments in time (Soffer and Gamble 1990).

The question is whether we are today in a position to discard the use of archaeological periods in the Paleolithic in favor of looking at other kinds of events in time. There are reasons for caution in this regard. One obvious limitation is that many Paleolithic localities, particularly surface sites, are not datable with currently available technology. Even in dated sites, there is a lack of precision inherent in the methods used in this time range. However, recent developments in terms of both fieldwork and dating methods have begun to make a serious dent in these shortfalls (for an overview of ESR see Rink [1997]; for a discussion of the use of optically stimulated luminescence see Wintle [1993]; for recent developments in cosmogenic isotope dating see Muzikar and Granger [2006]). The limited precision of these methods leaves a significant theoretical issue for the use of an approach that measures 'values' at fixed time intervals. Beyond the question of what is meant by 'values' there is a very real question of what is meant by time intervals and, more significantly, the nature of the 'moments in time' at which values are measured. The emerging practice is to use Oxygen Isotope Stages as both time intervals and the points at which values are measured. Thus, for example, we might ask questions about the differences in lithic technology between OIS 7 and 9. One advantage of this approach is that the OIS time scale is used by most scientists working on the Pleistocene from geology, paleontology, and paleoclimatology. When archaeologists adopt this time scale it facilitates synthesis across data sets. A second advantage is that OIS stages are a realistic target for dating methods. The major disadvantage of adopting oxygen isotope stages as time units is that this implies a uniformity to these stages that is clearly unwarranted. For, example, OIS 7, which falls towards the end of the time range associated with the Lower Paleolithic, shows a very high degree of variability (Rohling et al. 1998).

Conclusion

This paper considers three different approaches to the use of the concept of time series as applied to archaeological chronology, with particular reference to the Lower to Middle Paleolithic transition (Fig. 2). In the first case, Leroi-Gourhan's concept

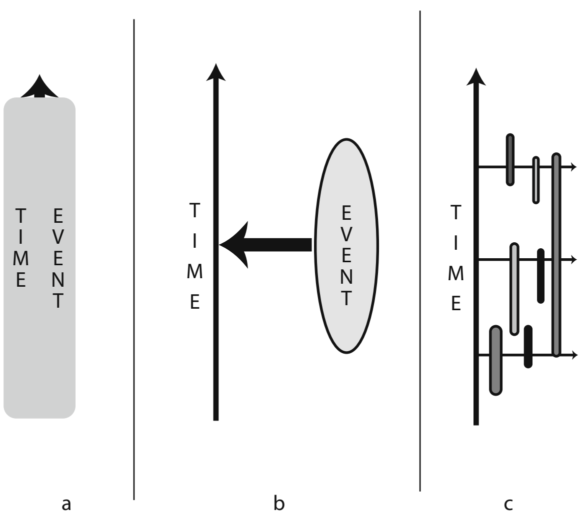

Fig. 2 The concept of time series as applied to archaeological chronology. **a**. The archaeological sequence embodies time. **b**. Archaeological periods as events in time.**c**. Time sequence as a measure of values at fixed intervals

of *tendance* was used to illustrate how an archaeological sequence can embody time. The applicability of Gordon Childe's conception of transitions as reflecting changes in social relations was then explored as an example of chronological periods as events in time. Finally, the definition of time sequence as a measure of values at fixed intervals was considered as a possible basis for a Paleolithic archaeology without archaeological periodization (although this is only possible by adopting periodization based on the paleoclimatic record). These three approaches are distinct but not necessarily incompatible. There is no inherent reason for archaeologists not to adopt all three approaches, depending on the questions they are exploring. The only requirement would be to not conflate these very different conceptions of the relationship between the archaeological record and time.

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The East Asian Middle Paleolithic Reexamined

Christopher J. Norton, Xing Gao, and Xingwu Feng

Abstract The criteria to define the Middle Paleolithic in East Asia have traditionally been presence/absence of archaic *Homo sapiens* fossils, biostratigraphy, lithostratigraphy, the Middle-Late Pleistocene transition, and lithic technology. In this paper, we examine the use of the Middle-Late Pleistocene shift as a valid criterion for characterizing the Middle Paleolithic in East Asia. Our review indicates that the most representative "Middle Paleolithic" sites in China (Zhoukoudian Locality 15, Dingcun, Xujiayao, Dali) all have chronometric ages that bracket the Middle-Late Pleistocene transition. However, the age range for these sites is extremely wide, extending from the middle Middle Pleistocene (c. 500 ka) to the middle Late Pleistocene (75 ka). This very large chronometric span suggests that the Middle-Late Pleistocene transition (140–100 ka) is of little use for defining a distinct Middle Paleolithic in East Asia. Other evidence to support a distinct East Asian Middle Paleolithic is also not strong, particularly distinct changes in lithic technology. Accordingly, we argue that an "Early" Paleolithic, representing the originally designated Lower and Middle Paleolithic sites, is more applicable to the uniqueness of the East Asian archaeological record.

Keywords East Asia • Early Paleolithic • Lower-Middle Paleolithic transition • Middle-Late Pleistocene transition

C.J. Norton (✉)
Department of Anthropology, University of Hawai'i, Honolulu, HI, USA

Introduction

Identifying behavioral transitions are a necessary, though sometimes frustrating part of organizing human prehistory, particularly because it is often difficult to develop a model applicable across all spatio-temporal facies. This is especially relevant early in archaeology when prehistorians first began synthesizing our behavioral trajectory from the beginning of time to the present day (Daniel 1981; Trigger 2006). The three-stage model of culture history (e.g., Christian J. Thomsen's division of archaeological materials into three stages: Stone Age, Bronze Age, Iron Age) forms the foundation from which to divide human behavioral variation. As time progressed, archaeologists devised more detailed distinctions (Trigger 2006). A good example is the Old World Paleolithic period, which was divided into three stages, Lower, Middle, and Upper (for Africa, Early, Middle, Late Stone Ages) (Klein 1999; Trigger 2006). The Lower Paleolithic is defined by simple core and flake tool technology beginning c. 2.6 Ma, with more refined handaxes and cleavers appearing after c. 1.6 Ma (Toth and Schick 2005). In some regions of the Old World such as East Asia, the presence/absence of typical Acheulian handaxes and cleavers is still debated (see Corvinus 2004; Norton et al. 2006; Lycett 2007; Norton and Bae 2008; Petraglia and Shipton 2008). The Middle Paleolithic (c. 250–40 ka) is generally defined by the Levallois, or prepared core technique, which is a more advanced stone knapping methodology. The Upper Paleolithic (c. 40–10 ka) is characterized by the presence of blade and microblade technology (Toth and Schick

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1986; Schick and Toth 1993, 2001; Klein 1999; Toth and Schick 2005).

When Western paleoanthropologists began working in East Asia in the early part of the 20th century, they applied the three-stage system to the Paleolithic archaeological record, where it came into standard usage (Gao and Norton 2002). However, Western scientists, and most Chinese scholars who studied directly under them, never took into account the characteristics that were distinctive of the eastern Old World Paleolithic record (Gao 2000; Gao and Norton 2002). Traditionally, the transitions between the Lower, Middle, and Upper Paleolithic in East Asia have been based on biostratigraphic and/or geologic ages and the presence/absence of distinct hominin taxa. For instance, the Middle Paleolithic in China is associated with archaic *Homo sapiens,* particularly in northern China (Gao 1999; Gao and Norton 2002). The Middle Paleolithic in South China is more difficult to define because of the paucity of transitional fauna, poor chronometric dating sequences, and the presence of only a few hominin fossil localities dating to that time period. Nevertheless, more than 40 sites in China and a few in Korea have been assigned to this cultural category (Bae 1997; Norton 2000; Gao and Norton 2002).

One important criterion in East Asia used to define the Lower-Middle Paleolithic transition has been the association of sites that date to the Middle-Late Pleistocene shift (c. 140–100 ka) with the latter cultural stage (Qiu 1985, 1989; Zhang 1985, 1987). In order to address the evidence for defining this behavioral transition in China and broader East Asia, the most representative Middle Paleolithic sites are discussed here.

Background of Sites

Zhoukoudian Locality 15 (ZKD Loc. 15), Xujiayao, Dingcun, and Dali are cave and open-air sites in northern China that are associated with archaic *H. sapiens* fossils and/or have been initially dated to the Middle-Late Pleistocene transition (Fig.1).

ZKD Loc. 15 is part of the limestone cave complex on Longgushan (Dragon Bone Hill), located 50 km southwest of Beijing (Gao 2000; Gao and Norton 2002). ZKD Loc. 15 was discovered in 1932 during fieldwork at Locality 1. The site was subsequently excavated from 1935 to 1937. In addition to a diversity of Middle and Late Pleistocene

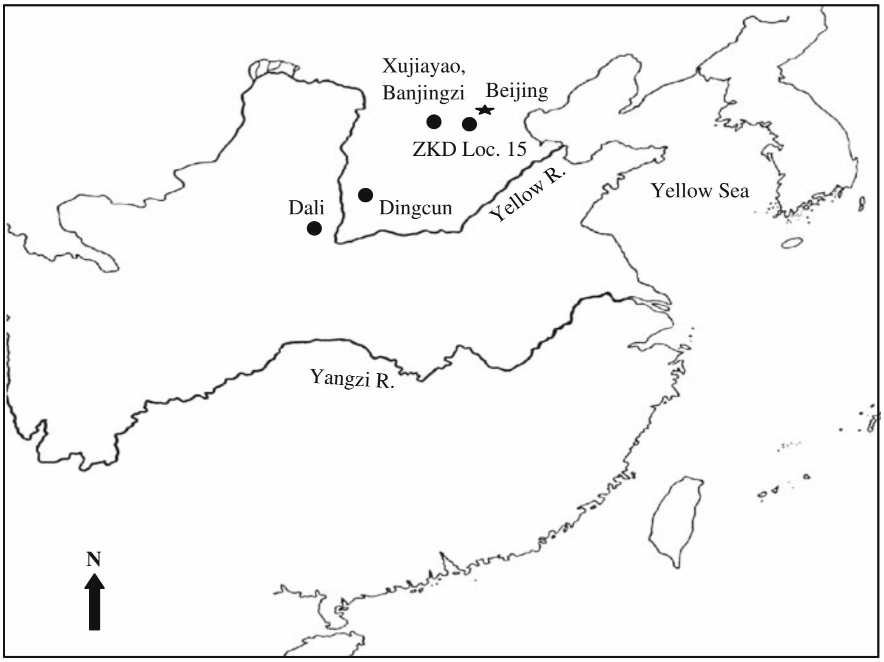


Fig. 1 "Middle Paleolithic" sites discussed in this paper

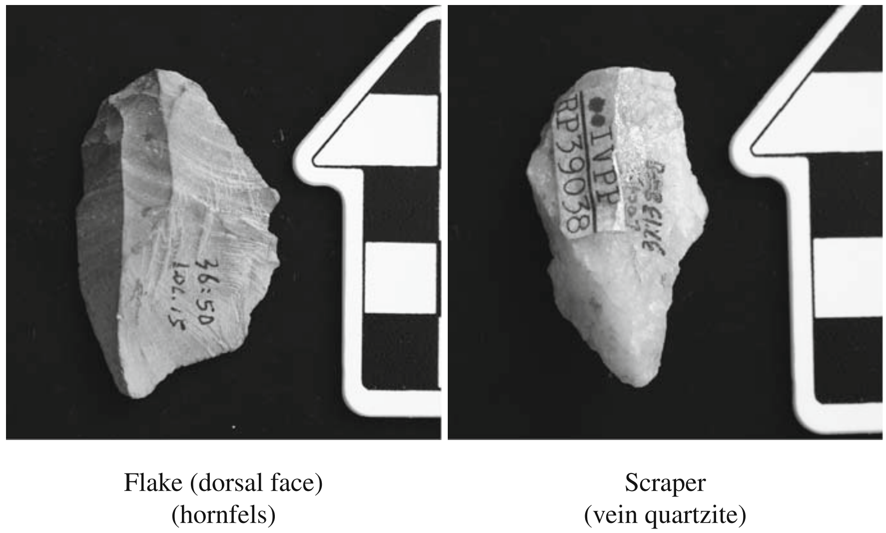


Fig. 2 Typical small flake tools from Zhoukoudian Loc. 15

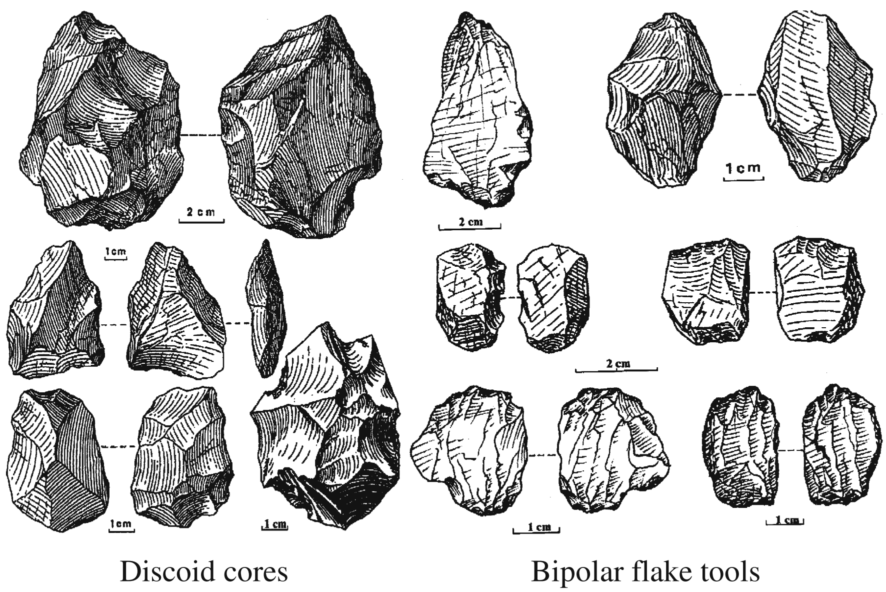


Fig. 3 Typical small core and flake tools from Zhoukoudian Loc. 15

faunal remains, an array of small flake artifacts was collected (Figs.2 and 3). The initial uranium series (U-series) chronometric dates indicated an age range between 140 and 110 ka for Level 2, the primary cultural level (Table 1).

Xujiayao, a fluvial-lacustrine open-air site, is located in the western region of the Nihewan Basin (Jia and Wei 1976; Jia et al. 1979; Norton and Gao 2008a). It was excavated three times in the late 1970s, with an array of vertebrate paleontological and Paleolithic materials recovered during the excavations. Due to the high density of archaic *H. sapiens* fossils, equid and rhinoceros bones, and artifacts, particularly stone spheroids ("bola balls") and bone tools, found in the same stratigraphic levels, Xujiayao was interpreted to have been an archaic *H. sapiens* Middle Paleolithic horse kill site (Fig. 4; Norton and Gao 2008a). The initial U-series dates on equid teeth samples suggested an age range between 114 and 88 ka (Table 1).

Dingcun is located in Shanxi Province, North China, and was originally discovered in 1953. The Dingcun "site" is actually comprised of 14 separate localities, situated along the Fen River (Norton et al.

Table 1 Chronometric dates for Xujiayao, Zhoukoudian Locality 15, Dali, and Dingcun

Site	Specimen #	Age	Material	Method	Reference
Zhoukoudian locality 15	Level 2	140,000-110,000 BP	Cervid teeth	Uranium series	Gao (2000)
Zhoukoudian locality 15	ZSW-1	230,400 ±2,200 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-2	86,600 ±1,300 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-3	351,000 ±28,000 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-4	93,100 ±1,000 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-5(I)	347,000 ±15,000 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-5(II)	326,000 ±16,000 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-5(III)	281,000 ±6,000 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-6	263,800 ±4,400 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-8	173,500 ±1,800 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-10	225,800 ±3,300 BP	Speleothem	Uranium series	Shen et al. (2004a)
Zhoukoudian locality 15	ZSW-11	154,500 ±2,100 BP	Speleothem	Uranium series	Shen et al. (2004a)
Xujiayao	BKY 80001	99,000 ±6,000 BP	Equid dentine	Uranium series	Chen et al. (1982); Wu and Wang (1985)
Xujiayao	BKY 80002	88,000 ±5,000 BP	Equid dentine	Uranium series	Chen et al. (1982); Wu and Wang (1985)
Xujiayao	BKY 80003	102,000 ±6,000 BP	Equid dentine	Uranium series	Chen et al. (1982); Wu and Wang (1985)
Xujiayao	BKY 80012	114,000 ±17,000 BP	Equid dentine	Uranium series	Chen et al. (1982); Wu and Wang (1985)
Xujiayao	BKY 81012	94,000 ±7,000 BP	Equid dentine	Uranium series	Chen et al. (1982); Wu and Wang (1985)
Xujiayao	BKY 81014	91,000 ±9,000 BP	Rhinoceros enamel	Uranium series	Chen et al. (1982); Wu and Wang (1985)
Xujiayao	ZK-670-0(1)	16,920 ±2,000 BP	Rhinoceros bone	^{14}C	Wu and Wang (1985)
Xujiayao	ZK-670-0(2)	16,450 ±2,000 BP	Rhinoceros bone	^{14}C	Wu and Wang (1985)
Xujiayao	Not applicable	Early Brunhes	Not applicable	Magneto-stratigraphy	Lovlie et al. (2001)
Dingcun	BKY 80056	>100,000 BP	Bovid dentine	Uranium series	Chen et al. (1984)
Dingcun	BKY 80057	200,000 ±18,000 BP	Bovid dentine	Uranium series	Chen et al. (1984)
Dingcun	BKY 81077	260,000-127,000 BP	Rhinoceros dentine	Uranium series	Chen et al. (1984)
Dingcun	BKY 81078	210,000-161,000 BP	Cervid dentine	Uranium series	Chen et al. (1984)
Dingcun	BKY 81076	>200,000 BP	Cervid dentine	Uranium series	Chen et al. (1984)
Dingcun	BKY 81079	255,000-107,000 BP	Equid dentine	Uranium series	Chen et al. (1984)
Dali	BKY 80045	146,000-114,000 BP	Dentine	Uranium series	Chen et al. (1984)
Dali	BKY 80028	226,000-182,000 BP	Cervid horn	Uranium series	Chen et al. (1984)
Dali	BKY 80025	209,000 ±23,000 BP	Bovid dentine	Uranium series	Chen et al. (1984)
Dali	BKY 80039	216,000-106,000 BP	Cervid dentine	Uranium series	Chen et al. (1984)
Dali	BKY 80038	380,000-172,000 BP	Equid dentine	Uranium series	Chen et al. (1984)
Dali	Dali-1	279,500 ±110,700 BP	Deposit and shell	Electron spin resonance	Yin et al. (2001)
Dali	Dali-2	282,500 ±116,600 BP	Shell	Electron spin resonance	Yin et al. (2001)
Dali	Dali-2a	267,100 ±72,200 BP	Shell	Electron spin resonance	Yin et al. (2001)
Dali	Dali-3	246,600 ±65,600 BP	Shell	Electron spin resonance	Yin et al. (2001)

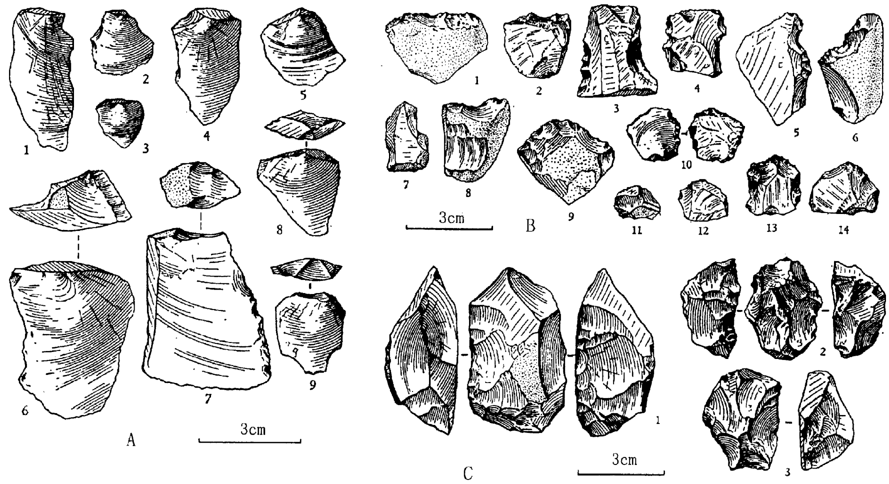


Fig. 4 Typical small flake tools from Xujiayao. A1-3: flakes with percussion-platform; A4-5: flakes with ridged-platform; A6-9: flakes with repair-platform; B1-2: scraper with straight edge; B3-4: scraper with lateral edges; B5-8: scraper with concave edge; B9: scraper with bulge edge; B10-14: end scraper; C1-3: tortoise shell-like scraper

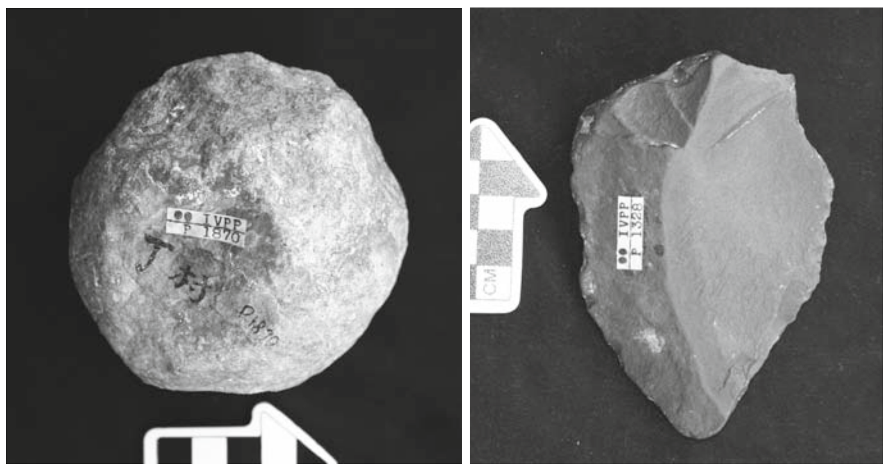


Fig. 5 Typical lithic artifacts from Dingcun

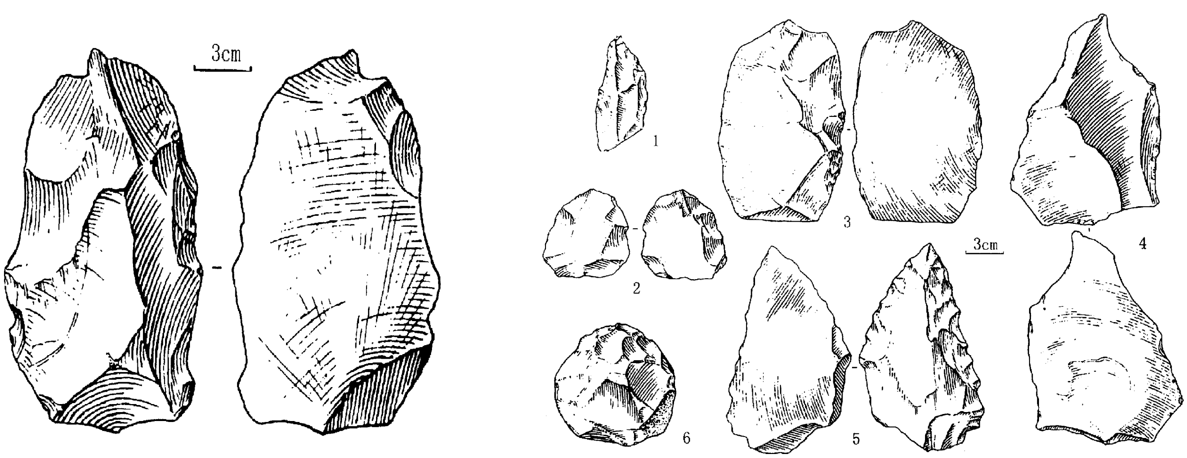
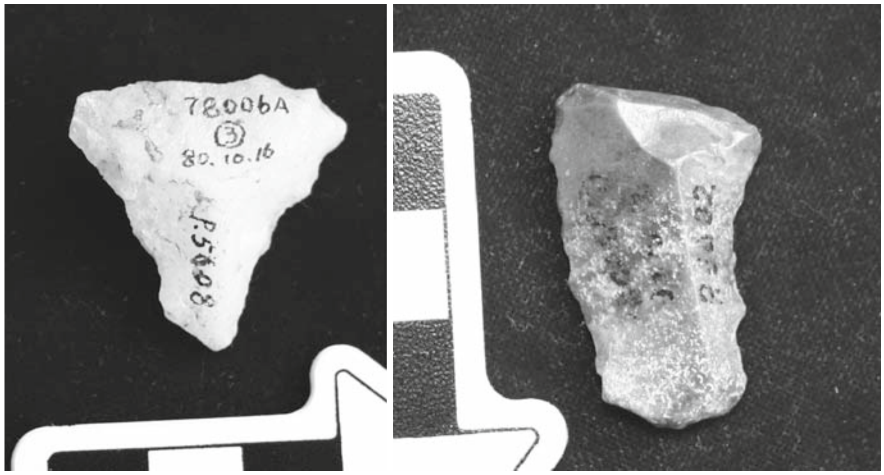


Fig. 6 Typical small flake tools from Dingcun. A: tool with multiple edges; B1 (P0037): triangular-prism point; B2 (P0661): chopper with multiple edges; B3 (P1983): tool with multiple edges; B4 (P0010) flakes with chopping traces; B5 (P0227): rostra-like point; B6 (P0532): stone ball

Fig. 7 Typical small flake tools from Dali



Scraper (vein quartz) — Flake (with use wear) (chert)

2006). During the fieldwork, a diversity of vertebrate paleontological remains and archaic *H. sapiens* teeth and parietal remains were collected. An array of lithic artifacts, in particular spheroids and picks produced on high quality dark hornfels were also found in association with the paleontological materials (Figs. 5 and 6). A series of U-series dates, along with lithostratigraphic and biostratigraphic reconstructions, indicated an age range between 260 and 107 ka (Table 1).

Dali is an open-air site discovered in 1978 in Shaanxi Province, North China, best known for the presence of an archaic *H. sapiens* skull (Wu and Poirier 1995). An array of Palearctic fauna was found in association with the hominin fossil. Only a few lithics, primarily scrapers and points produced on poor quality quartz (Fig. 7), were found in association with the hominin skull (Zhang and Zhou 1984). The initial U-series dates on associated teeth and horn produced an age range between 380 and 106 ka (Table 1).

Can the Middle-Late Pleistocene Shift Be a Criterion for Defining the Lower-Middle Paleolithic Transition in East Asia?

The Middle-Late Pleistocene transition is a criterion used to define the Middle Paleolithic in China and broader East Asia (e.g., Zhang 1985; Qiu 1989). Using the age criterion from sites like ZKD Loc. 15, Xujiayao, Dingcun, and Dali is problematical, however. We discuss this in more detail below.

The initial U-series and ESR dates from ZKD Loc. 15 indicated an age range between 140 and 100 ka for the primary cultural level (Table 1; Gao 2000). However, a recent U-series analysis on associated speleothem samples from the site indicates that the lower part of Level 2 (primary cultural level) dates between 284 and 155 ka (Shen et al. 2004a). This suggests that the hominin occupation of the cave may date to the middle Middle Pleistocene rather than the Middle-Late Pleistocene transition. The new age range would also indicate that the hominin occupation of ZKD Loc. 15 is penecontemporaneous with ZKD Loc. 4 ("New Cave") and the upper occupation levels of Loc. 1, which at one time may have been separate chambers within the same cave system (Shen et al. 2001, 2004a, 2004b).

Uranium-series analysis of equid teeth from the Xujiayao site suggested an age bracket of 114–88 ka (Table 1; Chen et al. 1984). However ^{14}C dates on associated rhinoceros bone suggested a significantly younger 16 ka date (Wu and Wang 1985). A more recent chronomagnetostratigraphic reconstruction of the Xujiayao deposits indicated that the uppermost c. 15 m of deposits represent a normal-polarity magnetization (Brunhes), with a reversed-polarity magnetization (Matuyama) below that (Lovlie et al. 2001). Based on their reconstruction, it was argued that the Xujiayao paleoanthropological materials date to c. 0.5 Ma. Lovlie et al. (2001) explain the younger U-series dates by proposing that the lithics were in situ, but that the bones were redeposited via fluvial processes. Although this scenario may be possible, very little taphonomic evidence to support this hypothesis is present in the archaeofaunal assemblage (Norton and Gao 2008a). We are currently investigating the issue of the age of the Xujiayao deposits using optically stimulated luminescence (OSL) in order to ascertain whether a smaller, but more reliable, age bracket can be determined.

The age range for Dingcun is between 260 and 107 ka based on biostratigraphy and U-series studies (Table 1). Presence of *Bubalus* in the faunal assemblage indicates a Middle Pleistocene age, though it may represent the Middle-Late Pleistocene transition. Nevertheless, as mentioned above, Dingcun is actually comprised of 14 localities, so determining a narrower age range for all of these archaeological deposits is difficult. Researchers from Peking University are currently conducting an OSL analysis of the deposits from locality 54–100, which is where most of the archaic *H. sapiens* fossils were collected (J.F. Zhang [personal communication 2007]). Application of OSL in conjunction with the previous studies will hopefully better clarify the age of the Dingcun deposits, particularly the locality and level where the hominin parietal derived.

Initial U-series dates from Dali indicated an age range of 380–106 ka (Table 1; Chen et al. 1984). A more recent ESR analysis suggests a smaller age range between 283 and 246 ka (Yin et al. 2001). According to this more recent study, it appears that Dali is much older than the Middle-Late Pleistocene transition in China. The chronometric dates correlate well with the biostratigraphic dataset. That is, *Bubalus,* a taxa normally restricted to the Oriental biogeographic zone, was identified in the Dali assemblage. *Bubalus* appears as far north as Zhoukoudian and the Korean Peninsula only during the Middle Pleistocene (Dong et al. 2000; Norton et al. 2009).

Discussion

The answer to our initial question is no, the Middle-Late Pleistocene transition alone cannot be used as a criterion to represent the Lower-Middle Paleolithic shift in East Asia. Analysis of the most representative Middle Paleolithic sites in China (ZKD Loc. 15, Xujiayao, Dingcun, Dali) indicates that these localities likely have occupation ranges that bracket the Middle-Late Pleistocene transition. However as discussed here, these sites have questions about their ages and in most cases, very wide age ranges. This is a problem that not only affects the sites discussed here, but most of the sites in East Asia that have been designated Middle Paleolithic.

Nevertheless, as we have argued elsewhere (e.g., Gao 2000; Gao and Norton 2002), defining a distinct Middle Paleolithic period primarily depends on the archaeological evidence, with biostratigraphy, chronology, lithostratigraphy, and presence/absence of archaic *H. sapiens* only indirectly related. Results of previous lithic analyses found little evidence for a distinct Middle Paleolithic in East Asia (Gao and Norton 2002). For instance, most lithic specialists originally considered the ZKD Loc. 1 stone toolkit to be typologically representative of the Chinese Lower Paleolithic, and the ZKD Loc. 15 lithics to be Middle Paleolithic (e.g., Zhang 1987). However, comparative analysis of the lithics from these two sites indicated that even though there were general trends in the composition of the assemblages, they were not distinct enough to be considered technochronologically separate (Gao 2000; Gao and Norton 2002).

Many other sites exist in China that have been tentatively dated to the Middle-Late Pleistocene and are referred to as Middle Paleolithic. For instance, the Banjingzi site (U-series: 108–74 ka), located in the Nihewan Basin, is considered typical Middle Paleolithic (Li et al. 1991). However, the irregularity of flaking technology and similarities to artifacts from the nearby Lower Paleolithic site of Xihoudu (c. 1.27 Ma; Zhu et al. 2003), suggests a continuous simple core and flake tool technology.

Elsewhere (Gao and Norton 2002), we have combined the Lower and Middle Paleolithic into one Early Paleolithic category. Nevertheless, we were not, and are not now suggesting that the East Asian Early Paleolithic was a stagnant, continuous cultural path between c. 1.7 Ma – c. 40 ka. Variation in the archaeological record exists. For instance, Acheulian-like handaxes have been found in the Bose (Baise) Basin in Guangxi Province, South

China (Hou et al. 2000; Wang et al. 2006), and Luonan Basin, North China (Wang 2005), in addition to being present as far north and east as the Korean Peninsula (Norton et al. 2006; Norton and Bae 2008). Furthermore, Acheulian-like cleavers have been found at sites in central China and Korea (Norton 2000; Norton et al. 2006; Wang 2006). However, the handaxes and cleavers may not have been produced in the same way as the typical Acheulian bifaces and large cutting tools known from Africa or the Indian Subcontinent (Corvinus 2004; Lycett 2007; Norton and Bae 2008). In terms of stone knapping technology, there is a decrease in the block-on-block method for flake production, while evidence for direct hard-hammer percussion increased through time (Gao and Norton 2002; Zhang 2004).

Although very little evidence for a distinct Middle Paleolithic is present in the Chinese sites discussed in this paper, each locality still offers a tremendous amount of information for paleoanthropological research. For instance, evidence of effective hominin hunting of equids appears to be present at Xujiayao; which, depending on the age of the site, will determine its behavioral implications (Norton and Gao 2008a). If Xujiayao is really coeval with Zhoukoudian Locality 1, then it would be the earliest known evidence of primary access to large game in East Asia during the Middle Pleistocene. If Xujiayao is late Late Pleistocene, then this would be further evidence for effective hominin hunting in this region of the Old World during this time period (e.g., see the Zhoukoudian Upper Cave taphonomic analysis [Norton and Gao 2008b]). Our fieldwork at Xujiayao to determine the age of the deposits will certainly serve to modify our behavioral interpretations.

Conclusions

The Middle-Late Pleistocene shift cannot be used as evidence for distinguishing between the Lower and Middle Paleolithic in East Asia. Furthermore, the three-stage transitional model for the Paleolithic is not applicable in this region of the Old World. The “Early” and “Late” Paleolithic are more apropos designations to provisionally describe the behavioral history of Pleistocene hominins in East Asia. However, future research in East Asia will determine whether even this division needs to be further refined.

There is a tremendous increase every year in the number of multidisciplinary research programs whose goal is to reconstruct the paleoanthropological and paleoenvironmental histories of sites and regions in East Asia using the most current (21st century) theoretical and methodological approaches. As such, it should be clear that terminology and cultural constructs that were applicable when paleoanthropological research began in East Asia (in the early part of the 20th century) are often not appropriate now given the current state of knowledge. The focus of this paper, using the Middle-Late Pleistocene transition as a criterion for the East Asian Middle Paleolithic, is a case in point. Hopefully, our conclusions will prompt scientists to think more critically about the criteria we currently utilize to define transitions in East Asian prehistory.

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The Lower to Middle Paleolithic Transition in South Asia and Its Implications for Hominin Cognition and Dispersals

H. James and M.D. Petraglia

Abstract The widespread appearance of prepared core–based industries during the Middle Pleistocene has been argued to represent a significant step in cognitive evolution. Yet recent research has indicated that prepared core technology develops in the Acheulean industries of Africa and Eurasia. Here, the evidence for a similar, in situ development of prepared core technology is described within a number of sites from the Indian subcontinent. The implications for our understanding of the role of hominin cognitive evolution and dispersals during the Acheulean to Middle Paleolithic transition are discussed.

Keywords South Asia • Acheulean • Middle Paleolithic • Cognition • Dispersals

Introduction

Out-of-Africa dispersals provide an important theoretical framework for understanding potential changes in the fossil and archaeological record. Certain technological changes that occur during the Pleistocene are sometimes interpreted as representing cognitive (and therefore biological) change. Such technological transitions therefore become inextricably linked to the dispersals of hominin populations because such widespread cognitive changes require either steady gene flow between populations or physical movement of hominins. Population movements are often the preferred mechanism for the spread of different lithic technologies, accounting for the spread of the Acheulean, for example, or more controversially, to infer changes in the Middle to Upper Paleolithic transition. Attempts have been made to consider the Acheulean to Middle Paleolithic transition within this framework, proposing a localised, African invention of prepared core technology that is then carried throughout the Old World via dispersals of *Homo helmei* from Africa (Lahr and Foley 1994, 1998). But the question remains, does such a single origin and spread model fit the archaeological record? And if it does not, what mechanisms can explain the cultural change that occurs during the transition from the Acheulean to the Middle Paleolithic?

Situated on the hypothesised route of a number of hominin dispersals in the Pleistocene, the Indian subcontinent represents a dynamic location to examine technological transitions and changes during various stages of the Paleolithic. Surrounded by the Bay of Bengal and the Arabian Sea, and bordered by the Himalayas to the North, the subcontinent is subdivided by mountain ranges (e.g., Western Ghats, Eastern Ghats) and river valleys (e.g., Narmada, Ganges). Evidence for a monsoonal climate within the region dates back to the Miocene, though its effects have varied in intensity (An et al. 2001; Rettalack 1995), and the resulting marked, but varied, seasonal changes in wet and dry periods have been argued to affect hominin settlement patterns (James and Petraglia 2005; Korisettar 2007; Korisettar and Rajaguru 1998; Korisettar and Ramesh 2002). The variable topographic and climatic conditions of the

H. James (✉)
Leverhulme Centre for Human Evolutionary Studies, University of Cambridge, Cambridge, UK

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South Asian landscape provided a wide range of environments for hominin exploitation. Research in the region has suggested that hominins preferentially occupied basins where water (e.g., lakes, springs, and streams), animal communities, and access to lithic resources converged (Korisettar 2007); and abundant archaeological research indicates evidence for both Acheulean and Middle Paleolithic industries throughout the subcontinent.

Abundant evidence has been accumulated about the Acheulean and Middle Paleolithic within South Asia (see, e.g., Kennedy 2000; Sankalia 1974; Settar and Korisettar 2002 for reviews). Though research has been dominated by surface surveys (e.g., Allchin et al. 1978; Marathe 1981), a number of excavated sites exist from both cultural periods (e.g., Joshi 1978; Misra 1995; Pappu 1999, 2001a, 2001b; Pappu et al. 2003; Sali 1989). Fossil evidence is, however, much less common. A single find, the Narmada cranium, dates to the Middle Pleistocene. This partial cranium, from the Narmada River Valley, India, has been dated to c. 250 ka (e.g., Athreya 2007; Cameron et al. 2004; Kennedy et al. 1991; Sonakia 1985).

Despite the lack of hominin fossils, the large number of Acheulean and Middle Paleolithic sites from the subcontinent provide good information regarding the nature of the transition from bifacial (Acheulean) to flake core (Middle Paleolithic) industries, and as such have the potential to add to our knowledge of the processes behind cognitive evolution in the hominin lineage. Here we describe the Acheulean to Middle Paleolithic transition in the Indian subcontinent. Using the best-described lithic assemblages from a number of stratified sites, we provide evidence for a gradual in situ development of prepared core technology that has its origins in the preceding Acheulean. Such findings have implications for the understanding of the interaction of cultural change, cognition, and dispersals within the Middle Pleistocene.

Prepared Core Technology, Dispersals, and Cognitive Evolution

Researchers indicate that the appearance of Acheulean technology c. 1.6 mya represents a significant, adaptive change in hominin behaviours when compared to the Oldowan technologies that characterised hominin cultural behaviour during the Pliocene (McBrearty and Brooks 2000). The production of bifacially worked large cutting tools (e.g., handaxes and cleavers) required a concept of desired variables (e.g., edge shape) and a specific set of production steps that were reproduced repeatedly to produce the characteristic biface forms that characterise the Acheulean (e.g., Gowlett 2006). The variability in shape in Acheulean bifaces is heavily influenced by both raw material and the relative amount of reshaping the tools underwent before discard (McPherron 2006), yet at the same time the conservatism in biface form provides interesting clues to the mental capabilities of its producers. The reproduction of the technological procedures of biface manufacture has been argued to represent evidence for learning, or at the very least, the systematic passing of tool manufacturing information from one generation to the next, either by observation or by the presence of early forms of communication (Petraglia 2006).

It has been argued that the change from the production aims and methods of the Acheulean to those of prepared core technologies represents a cognitive change of evolutionary significance (e.g., Foley and Lahr 1997; White and Ashton 2003). The change can be seen to represent the appearance of abstract mental processes (needed during the process of core preparation) (Foley and Lahr 1997). Though similar volumetric considerations are present in the production of both handaxes and prepared cores, there is a shift between the former being the desired end product and the latter being the means to a desired end product (White and Ashton 2003). If the appearance of such behaviours is considered to be the result of a biological change, then from an evolutionary perspective, it is more parsimonious to postulate a single origin and then the spread of such a neurological change, than to assume that it occurred several times in several different areas independently (though the later scenario is, of course, possible).

First proposed in the early 1990s (Foley and Lahr 1997; Lahr and Foley 1994, 1998), the Mode 3 hypothesis postulates the spread of prepared core technology in Africa and Eurasia via the dispersal of a hominin population that represents the last common ancestor of Neanderthals and Anatomically Modern Humans. This population, classified as

Homo helmei, evolved within Africa during a period of fluctuating environmental change within which the development of prepared core technology took place (Foley and Lahr 1997). The appearance of the majority of Mode 3 assemblages during the Middle Pleistocene is seen to be the result of the spread of a hominin population with different mental capacities to the populations within Africa and elsewhere that still produced Acheulean industries during this period, though this change in cognitive capacity is not necessarily considered to be the mark of the evolution of a new species.

The fragmentary nature and poor chronological resolution of fossil remains from the Middle Pleistocene makes it difficult to examine whether or not a significantly different hominin population evolved and dispersed during this period. In addition, while Africa provides considerable evidence for the in situ evolution of prepared core technology from local Acheulean industries (e.g., Clark 1989; Clark 1951; Gowlett 1980; Phillipson 1985; Sharon and Beaumont 2006), the local evolution of prepared core technology has been argued to be present in both Europe (e.g., White and Ashton 2003) and South Asia (Petraglia et al. 2003). The evidence for the in situ development of prepared core technology during the Acheulean to Middle Paleolithic transition within South Asia is outlined below, and the implications for hominin dispersals and cognitive change are considered.

The Lower to Middle Paleolithic Transition in South Asia

Over a hundred years of archaeological research has produced a wealth of evidence regarding the nature of the Acheulean and the Middle Paleolithic in South Asia (e.g., Kennedy 2000; Paddayya 1984) (Fig. 1). The production of large bifacially worked cutting tools (such as handaxes and cleavers), alongside minimally retouched and large scrapers on flakes struck from cores, characterises the South Asian Acheulean (e.g., Misra 1978; Paddayya 1984; Petraglia 2001). Like other regions of the Old World, a gradual finessing of handaxe production has been suggested as a difference between the Early and Late Acheulean. In contrast, the Middle Paleolithic is a flake-based industry, dominated by prepared cores and retouched flakes (of which scrapers and points are the most common forms). Diminutive bifaces have been recorded in a number of South Asian Middle Paleolithic collections, while the industries of the period generally contain a significant blade and flake-blade component (James 2003; James and Petraglia 2005; Jayaswal 1978; Paddayya 1984). Though there is a shift in the usage of different raw materials (quartzite dominates in the Acheulean, with a gradual shift to chert during the Middle Paleolithic), the principle technological changes during the Acheulean to Middle Paleolithic transition appear to be the development of prepared core technology, the reduction in size and numbers of bifaces, and an increase in blade and flake-blade production. Significantly, the dominance of prepared core technology within the Middle Paleolithic has its roots within the Late Acheulean, where the presence of prepared cores and flakes has been recorded within a number of localities throughout the subcontinent. The early appearance of prepared core technology in the subcontinent alongside the continuation of characteristic Acheulean bifaces within prepared core–based (Mode 3) industries supports the in situ development of Middle Paleolithic technologies from local Acheulean industries.

The following sections describe Late Acheulean and early Middle Paleolithic assemblages from sites that are often cited as key to understanding the Acheulean and Middle Paleolithic transition in the Indian subcontinent. The assemblages discussed have been selected either because they have a secure stratigraphic context or because they are from surface survey contexts that do not appear to represent transported assemblages. Below we present evidence for prepared cores in the Acheulean, then we describe the presence of transitional biface technology in the early Middle Paleolithic.

Prepared Core Technology in the South Asian Acheulean

Bhimbetka FIII-23 (Misra 1978, 1985)

The Bhimbetka industrial sequence represents one of the most significant sites within the Indian subcontinent, providing evidence of a stratified

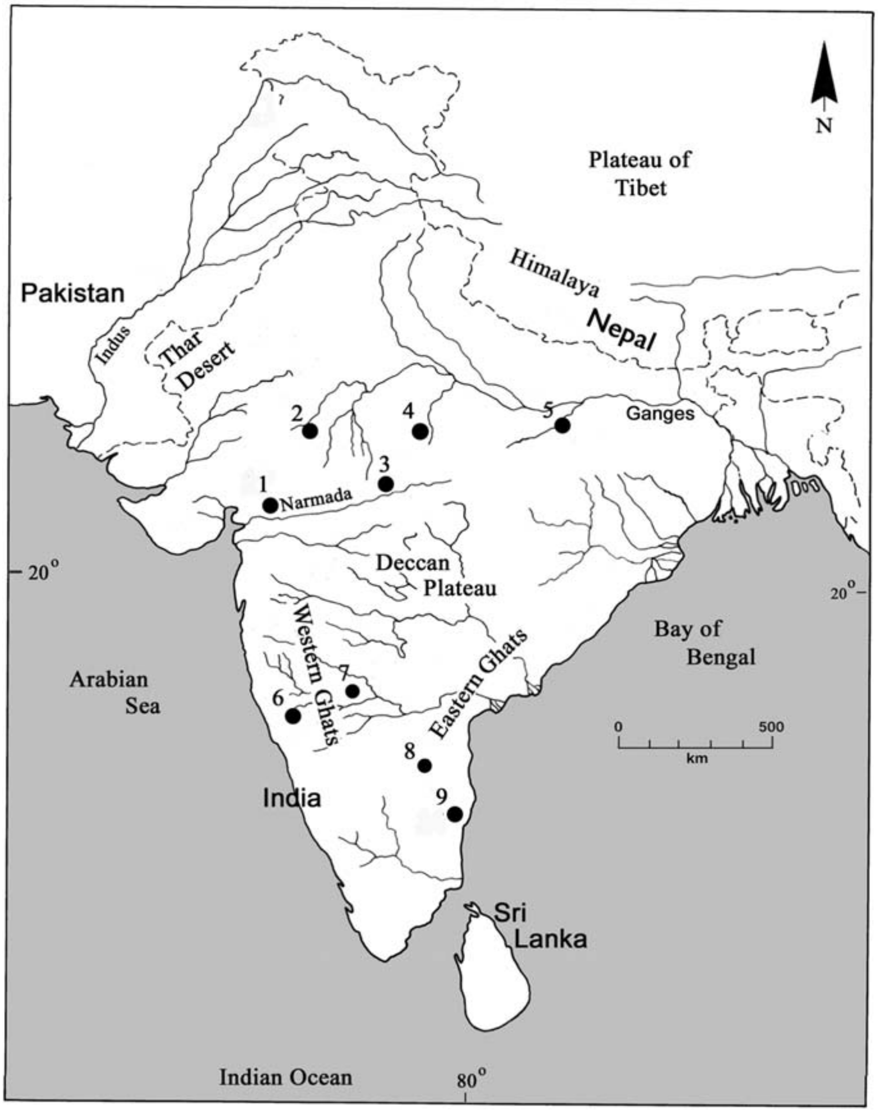

Fig. 1 Map showing Acheulean and Middle Paleolithic localities within South Asia. Locations represent sites or site clusters discussed in the text. 1, Orsang Valley Complex; 2, Beas-Berach Complex; 3, Bhimbetka; 4, Bariapur; 5, Middle Son Valley Complex; 6, Kaladgi Basin Complex; 7, Hunsgi-Baichbal Basin Complex; 8, Gunjana Valley Complex; 9, Kortallayar Basin Complex (Adapted from James and Petraglia 2005)

sequence from the Acheulean to the Mesolithic (Misra 1985). The Acheulean industry from cave FIII-23 is manufactured on orthoquartzite (partially metamorphosed sandstone), with the large cutting tools being made on a more intensely metamorphosed purple–dark grey quartzite, and flakes being made on a yellowish quartzite. Both flakes and large cutting tools were recovered from each of the Acheulean strata, often from the same working floors (Misra 1978). The lack of purple-grey debitage and of significant local deposits of the raw material, however, indicate that the bifacial element was probably produced elsewhere (Misra 1978). Such handaxes and cleavers are symmetrically shaped and exhibit a high standard of workmanship, but represent only a very small percentage of the artefacts recovered from the site, with cleavers more common than handaxes (Misra 1978). Non-bifacial artefacts, which do seem to have been produced on the site, dominate the sample, with scrapers representing the most common retouched tool type (Misra 1978, 1985). Non-prepared flakes struck from amorphous, bifacial, and discoidal cores dominate blank production, though blades are also reported. Significantly, 11 Levallois cores, and 164 Levallois flakes are also reported (Misra

1978), indicating the presence of prepared cores and prepared flakes in this Acheulean assemblage.

The Beas-Berach Complex (Misra 1967)

The results of a surface survey undertaken within the Beas-Berach region of Western India have suggested evidence for prepared core technology within the Acheulean industries of the Berach, Wagan, and Gambhiri Valleys. Prepared flakes are reported in small numbers from both of the valleys, while a single tortoise core was recovered from the Gambhiri (Misra 1967). At Nagari, Berach Basin, a single Levallois core is reported in an assemblage containing five prepared flakes and dominated by handaxes, cleavers, and scrapers. Discoids, choppers, and chopping tools are also reported. Within the Wagan Valley, the site of Hajiakheri is characterised by 3 prepared cores (2 discoidal and 2 blade), alongside scrapers, choppers, chopping tools, handaxes, and cleavers. At Bhutia and Beawar single examples of discoidal cores are reported, with both industries again containing handaxes. Discoids are present, but cleavers, scrapers, choppers, and chopping tools are restricted to Bhutia. Five prepared flakes are recorded within the Bhutia assemblage.

Bariapur (Soundara Rajan 1961)

At the Acheulean site of Bariapur (River Ken, near Panna, Central India), prepared platform cores and flakes with prepared platforms occur (3 of 10 cores, 5 of 17 flakes) within an assemblage of 112 lithic artefacts. This evidence for core and flake preparation occurs in an industry with handaxes (n = 32) and cleavers (n = 9) as well as choppers and chopping tools (pebble tools, n = 38, rostoid tools, n = 6).

Sihawal II (Kenoyer and Pal 1983)

The excavated Lower Paleolithic assemblage from Sihawal II (Middle Son Valley) provides evidence for prepared core reduction. Here two prepared cores (1 discoidal and 1 blade) and 5 prepared flakes are recorded among an assemblage of 109 artefacts (11 cores, 95 flakes). Of the 14 retouched artefacts, scrapers dominate (n = 8), with single examples of a handaxe, a cleaver, and a chopper also present (Kenoyer and Pal 1983).

Lakhmapur West (Petraglia et al, 2003)

At Lakhmapur West, in the Kaladgi Basin, the presence of both Acheulian and Middle Paleolithic assemblages was recorded, each associated with particular sedimentary environments. The 151 Acheulean artefacts occurred within a semicontinuous "stone line" surface 1.2–1.5m below the surface. Flakes dominate, the majority lacking diagnostic features that would assign them to a particular reduction technique. Some flakes, however, exhibited features indicative of the prepared core technique. Twenty cores were recovered, ranging from those with minimal flaking to those which displayed more deliberate preparation. Two prepared cores exhibited flaking along their perimeters and along one main surface, and both exhibited a negative flake scar, suggesting that a flake of controlled shape had been struck. Unlike Bhimbetka, large cutting tools dominate the retouched artefacts within the assemblage, with handaxes (n = 14) more common than cleavers (n = 1). The number of flake scars on the handaxes (mean = 19) was high, indicating fine flaking and trimming.

Isampur (Petraglia et al. 2005)

The site of Isampur in the Hungsi-Baichbal Valley provides considerable evidence for handaxe and cleaver manufacturing processes. A number of large-sized cores were recovered that show preparatory techniques. Some of the cores made on thick slabs show evidence of preparatory flake removal along their corners and along their perimeters. Such cores provided the means by which large flakes of predictable size and shape were produced. These large flakes often served as blanks for making cleavers. At Isampur, flakes struck from such prepared cores form a crucial part of the biface manufacturing method (Petraglia et al. 2005).

Bifaces in the Early Middle Paleolithic

The characteristic elements of the Acheulean of the Indian subcontinent, bifacially worked handaxes and cleavers are also found within the Middle Paleolithic, where instead of forming the focus of tool production they are combined with a range of retouched flake tools. Some of the clearest evidence for this combination is described below.

Lakhmapur East (Petraglia et al, 2003)

Lakhmapur East, Kaladgi Basin, produced evidence for a Middle Paleolithic industry consisting of 1,701 artefacts. Flakes comprised the majority of the assemblage, but diminutive handaxes and cleavers were also present, though in small numbers. Like the assemblage from Lakhmapur West, artefacts from Lakhmapur East were produced mainly on quartzite, though evidence for the use of chert was seen in the recovery of 6 artefacts made on this material. Scrapers, borers, and points occurred in low frequencies. Sixty-six cores were recovered during the excavation, including regular (unprepared) cores, prepared cores, and pyramidal cores (which represented the byproducts of a prepared core flaking technique). The limited levels of retouch and the presence of diminutive bifaces has led to the industry being classified as Early Middle Paleolithic (Fig. 2) (Petraglia et al. 2003). Lakhmapur East therefore provides evidence of a Middle Paleolithic industry with a large cutting tool component—albeit large cutting tools that are reduced in size in comparison to their Late Acheulean counterparts within Lakhmapur West.

The Orsang Valley (Ajithprasad 2005a,2005b)

Two distinct Middle Paleolithic industries have been reported from the Orsang Valley, one made of fine-grained quartzite and containing flake-

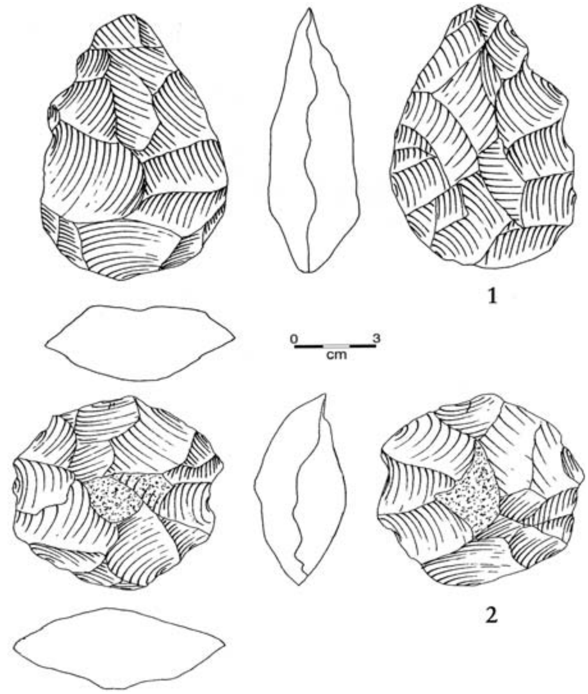

Fig. 2 Early Middle Paleolithic artefacts from the Kaladgi Basin, Karnataka, India. 1, diminutive biface; 2, prepared flake core (after Petraglia et al. 2003, Figs. 8 and 9)

blades and blade-based artefacts. The other industry, found at 19 sites, is produced on the same raw material as the earlier Acheulean industries. Unlike the industries of the Acheulean (which are characterised by handaxes, scrapers, and retouched flakes, with handaxes from stratigraphically later sites more intensely and finely worked than those from earlier sites [Ajithprasad 2005a]), these early Middle Paleolithic sites are dominated by Levallois and prepared flakes (and other Middle Paleolithic tool forms, including scrapers). Yet these industries retain a high handaxe component (Ajithprasad 2005b). The handaxes in these industries (average length 7 cm, range 5.5–9 cm), however, are reduced in size from those of the Late Acheulean and more finely flaked (Ajithprasad 2005b) (Fig. 3).

Narayana Nellore (Raju 1988)

"Miniature" handaxes made on fine-grained quartzite also characterise the assemblage from the Middle Paleolithic site of Narayana Nellore

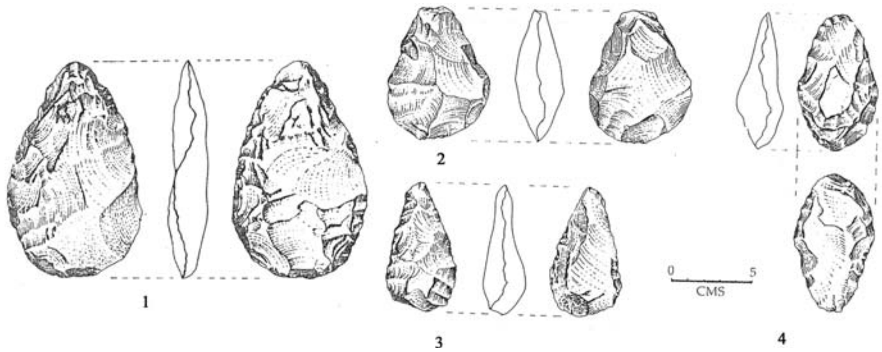

Fig. 3 Acheulean and Middle Paleolithic handaxes from the Orsang Valley. 1, Acheulean Ovate; 2, 3, 4, miniature handaxes from the Early Middle Paleolithic (Adapted from Ajithprasad 2005a, Figs. 14.3b, c)

in the Gunjana Valley, suggesting that the use of the same raw materials and reduction in handaxe size are also characteristic of the Acheulean to Middle Paleolithic transition (Raju 1988). At Narayana Nellore, diminutive bifaces are found alongside flake blades and scrapers within a lithic assemblage dominated by points. The handaxes recovered from Narayana Nellore range between 70 and 115 mm in size, a considerable drop from the 90 to 190 mm range found at the Acheulean sites of Netivaripalli, Venkatarajupalli, Siddareddipalli, Konetiraju Kandrika, Tummachetlapalli, and Malemarpuram from within the same valley (Raju 1988) (Fig. 4).

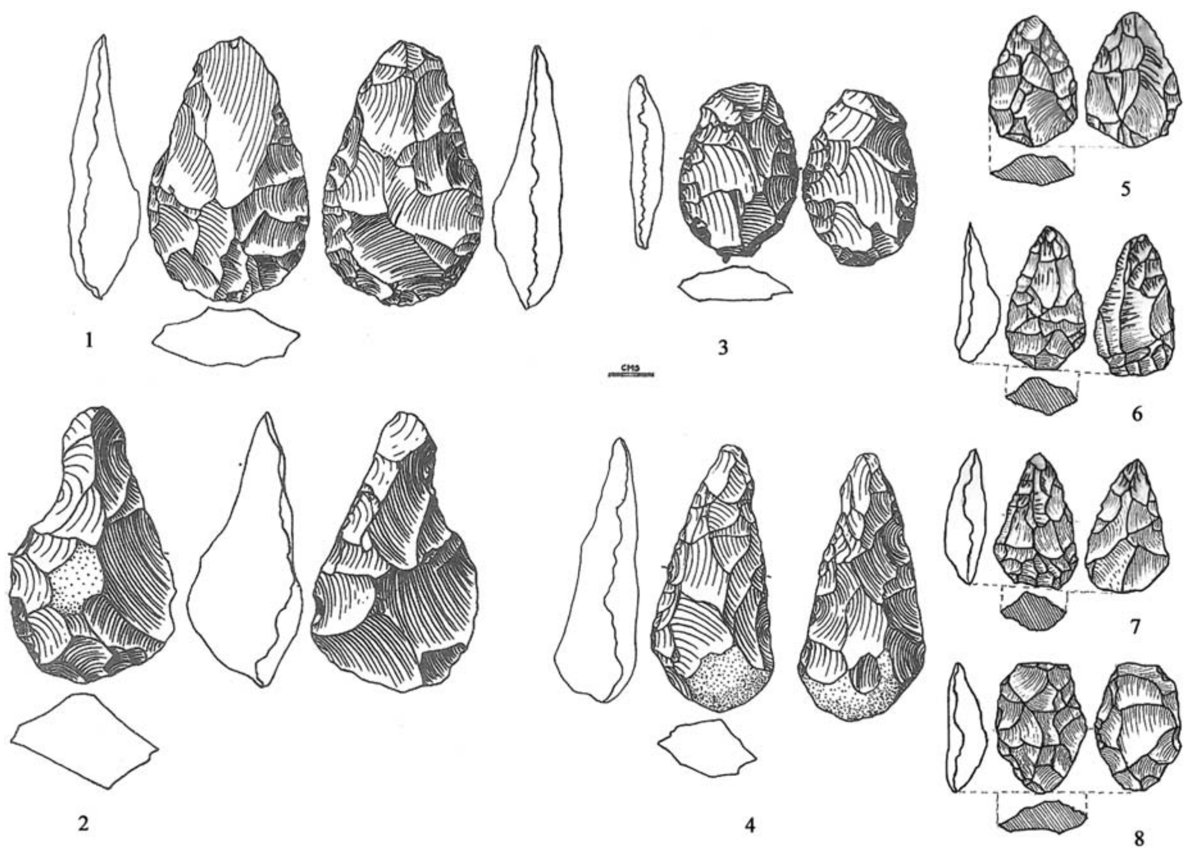

Fig. 4 Acheulean and Middle Paleolithic handaxes from the Gunjana Valley. 1, 2, 3, 4, Acheulean handaxes; 5, 6, 7, 8, Middle Paleolithic (Adapted from Raju 1988, Figs. 2.2, 2.3, 2.4, 3.1)

Kortallayer Basin (Pappu 2001a)

In general, the Kortallayer Basin is characterised by an increase in prepared cores alongside a decrease in the frequency and size of handaxes. Interestingly however, at the Acheulean sites of Mailapur and Pankulan, "miniature" handaxes are found alongside the more standard, larger-sized bifaces evident in the South Asian Acheulean. Larger-sized handaxes are also reported within the Middle Paleolithic sites of Attirampakkam, Aryathur, Nambakkam, Mailapur, and Gunipalayam, although "miniature" bifaces are also present (Pappu 2001a). It seems that small-sized handaxes are not an invention of the Middle Paleolithic, but instead a continuance of artefact types manufactured in the Acheulean. It is notable that some very small bifaces are occasionally present in the Hunsgi-Baichbal Valley (Noll and Petraglia 2003).

Taken together, the evidence from the Kaladgi Basin, Kortallayer Basin, and Gunjana and Orsang Valleys suggests the gradual development of a Middle Paleolithic technology from earlier industries. There is a gradual reduction in the size of bifaces and an increased adoption of a prepared core technology which is present in the Acheulean industries of the Indian subcontinent.

The Implications for Hominin Cognition and Dispersals

Early Middle Paleolithic industries within South Asia combine prepared core technology and diminutive but finely flaked handaxes. Such technological innovations emerged in the preceding Acheulean of the region. As such, the transition from the Acheulean to the Middle Paleolithic in the Indian subcontinent can be characterised as a gradual change rather than as a sudden technological change. Prepared core technology and scrapers become increasingly dominant, while handaxe size reduces. Such a gradual transition has implications for our understanding of hominin dispersals and cognitive change during the Pleistocene. The archaeological record from the Indian subcontinent shows no evidence for a dispersal of an intrusive hominin population carrying prepared core technology. Yet dispersals remain the most parsimonious explanation for the spread of wide-scale cognitive change. The lack of archaeological evidence for a dispersal of hominin populations into the Indian subcontinent during the Acheulean to Middle Paleolithic transition may therefore suggest that the appearance of the Middle Paleolithic is not a direct indicator of cognitive change. So while it remains possible that cognitive change occurred during this period, it is clear that the phenomenon of the appearance of the Middle Paleolithic needs a different explanatory framework.

The shift from the Acheulean to the prepared core–based technology of the Middle Paleolithic indicates a change in emphasis in lithic production, yet such a shift may be the result of a technological choice (or cultural change) rather than an indicator of biological change. In other words, while it can be argued that different, and perhaps more abstract, mental concepts are needed in order to produce prepared core technology than to produce handaxes, the appearance of prepared core technology does not necessarily provide a chronological marker for the biological evolution of such abilities. The evidence for the in situ gradual development of prepared core–based industries within the Indian subcontinent is not an isolated phenomenon, with considerable evidence for a similar transition being present within both Africa and Western Europe. Taken together, such evidence argues that the transition from Acheulean to Middle Paleolithic technology is a cultural or adaptive change, rather than a biological one.

Cultural change, like biological evolution, is a process mediated by natural selection and drift (i.e., random, nonselective variation). The relative dominance of each of these processes varies with population size. In small populations drift is more significant (Shennan 2000, 2001, 2002). Given the small, fractured populations likely to be present within the Old World in the Middle Pleistocene, the dominance of drift over natural selection could well have affected the distribution of cultural traits, including prepared core technology. Such a picture is further complicated by recent research which suggests that prepared core industries would have an adaptive significance in environments where raw materials were less abundant, as Levallois production strategies enable flakes to be produced more efficiently (Brantingham and

Kuhn 2001). Simply put, if the emergence of prepared core technology is seen as a cultural change rather than a biological one, then the appearance of technology at different times and in different places is precisely what should be expected.

Such arguments have wider implications for how we should view the Paleolithic archaeological record. Technological change and cognitive change are different phenomena governed by similar but different processes. And while biological changes in cognition undoubtedly affect the ability of a species to produce technologies, technological change is not necessarily evidence for biological (or cognitive) change. Though this has the effect of making dispersals of different hominin populations more difficult to track within the archaeological record, understanding the way in which cultural evolution occurs has the potential to add considerably to our knowledge of hominin lifestyles.

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DISCUSSION 3: The Lower to Middle Paleolithic Transition

Paola Villa

Abstract This paper presents a synthesis of the current state of knowledge about the Lower to Middle Paleolithic transition in Western Europe. The European Middle Paleolithic is defined by the appearance of Levallois technology by about 300,000 years ago and associated changes in the conception of tools. The Levallois technology is a major innovation of the Middle Pleistocene. The apparent continuity between the two major phases of the European Paleolithic based on the presence of bifaces in both periods is discussed and rejected. The Middle Paleolithic bifaces are quite different in conception from the classic Acheulian handaxes. The bifacial knives of the Keilmesser group in Central and Eastern Europe and the bifaces of the Mousterian of Acheulian Tradition in SW France have a standardized morphology and specific functions (for the MTA bifaces this is now confirmed by recent microwear analyses; Claud, 2008). Both kinds of tools were resharpened, modified and had a long use life. Other bifacial pieces had one or more working edges and can be typologically assimilated to flake tools. Current speculations about changes in hunting patterns and the reorganization of human societies around base camps in the Middle Pleistocene are discussed.

Keywords Western Europe • Levallois technology • Middle Paleolithic • Bifaces

P. Villa (✉)
University of Colorado Museum of Natural History, Boulder, Colorado, USA

Introduction

As noted by Chazan (this volume), the distinctions between the two earliest major phases of human prehistory were first proposed for the Western European record by Gabriel de Mortillet in the 19th century. Since no paper in this volume deals specifically with the subject of the Lower to Middle Paleolithic transition in Western Europe, it seems useful to present a synthesis of the current state of knowledge about this topic in the region, as a way of introduction to the papers that follow. The Middle and Upper Pleistocene European record is rich in information on chronology and on changes in settlements, paleoenvironments, and technology; thus it can provide a contrast or lend support to interpretations of the diversity of the evolutionary record from other regions.

The Western European Record

To date, the oldest Acheulian sites in Africa are Konso Gardula in Ethiopia (ca. 1.7 my) and KS4 (ca. 1.65 my) in the Kokiselei Complex of the Nachukui Formation in West Turkana, Kenya (Gibbon et al., 2009; Roche et al. 2003). In Western Europe, however, the oldest occurrences of the Acheulian are almost a million years later. In Spain, France, and Italy, Acheulian bifaces and cleavers are not found before the early part of the Middle Pleistocene; thus,

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the total duration of the Acheulian is much shorter than in Africa (Santonja and Villa, 2006).

The European Middle Paleolithic, now commonly defined by the appearance of the Levallois technology, began about 300,000 years ago; this is the evidence as it stands now. The Levallois technology is documented at a number of sites in western Europe dating to MIS 8—e.g., Argoeuves and Salouel in the Somme valley (northern France), Mesvin IV in Belgium, and Orgnac Level 5b in southern France (Soriano, 2000; Moncel et al., 2005). Purfleet in the Lower Thames Valley (England), with a core technology that has been defined as simple prepared core technology (= proto-Levallois of earlier authors) appears to be slightly older, at the transition between MIS 9 and 8 (White and Ashton, 2003). The Levallois technology in Western Europe might even be older than MIS 8, but at present, the evidence is not strong enough. Published descriptions of levels TD10 and TD 11 at Gran Dolina indicate the occurrence of Levallois technology. Those levels have been dated to MIS 11 to 9; however, these dates remain unconfirmed (Berger et al., 2008). Levallois technology occurs in the upper levels of Ambrona (AS 6); morphostratigraphic correlations with the terraces of Jalón and Henares rivers in the region suggest an age greater than 350 ka (Santonja and Villa, 2006). However, the combined ESR/U-series dates (Falguères et al., 2006) show a stratigraphic inversion with lower levels having a date younger than the upper levels; thus, the age of AS6 cannot be estimated with a good degree of confidence.

Throughout the Middle Pleistocene, there is a long coexistence between industries based on Levallois technology and biface industries. In Western Europe, industries with bifaces and non-Levallois debitage (e.g., Cagny l'Epinette level H, Gouzeaucourt, Gentelle) occur throughout MIS 8 to 6, together with industries without bifaces and without Levallois debitage (e.g., Ariendorf, Schöningen, Tönchesberg), industries with Levallois debitage and some bifaces (e.g., Mesvin IV, Le Pucheuil, Vimy, La Cotte de Saint-Brelade Layer 5) and industries with Levallois debitage and without bifaces (e.g., Biache St. Vaast) (Soriano, 2000). A comparable record is documented in Spain and in Italy (Santonja and Villa, 2006). Blade production appears in northwestern France during MIS 6 (e.g., at La Cotte de St. Brelade Layer 5 and at Le Pucheuil), and is well-represented during MIS 5 (Soriano, 2000; Delagnes and Meignen, 2006). In the Upper Pleistocene, during MIS 4 and early MIS 3, industries of Levallois debitage without bifaces are common. Nevertheless, the Micoquian of Central Europe and the Mousterian of Acheulian Tradition in France are both characterized by bifacial pieces: the Micoquian has backed bifacial knives (*Keilmesser*; Jöris, 2006) and plano-convex bifaces, the Mousterian of Acheulian Tradition has mostly cordiform bifaces. Flat triangular bifaces are found at about this time in northern France (Soressi, 2002).

Thus, if we were to take the disappearance or the decline of bifaces as the marker of the Middle Paleolithic, we should say that there is really no transition nor a clear boundary between the Lower and Middle Paleolithic. Tools made on flakes, once considered a feature of the Middle Paleolithic, are common in Acheulian industries, as well as in Middle Paleolithic industries; during the Middle Paleolithic, industries with bifaces are as common as industries without bifaces. However, the appearance of Levallois technology marks important structural changes in stone artifact assemblages.

A first observation is that there is a significant degree of variability in early Middle Paleolithic assemblages (i.e., MIS 8 to 6). Several kinds of production sequences occur at the same site. Thus, La Cotte Layer 5 is characterized by a predominant unidirectional recurrent Levallois method, together with blade production and bifacial shaping. Le Pucheuil series B shows four different production methods: (1) a recurrent unidirectional Levallois system for the production of convergent flakes and classic Levallois points; (2) a recurrent centripetal Levallois system; (3) a system for the production of a particular kind of flake: small, wide, with a thick platform and a curved thin distal edge, apparently used unretouched; and (4) production of blades and elongated flakes. In addition, there are also a few bifacial pieces and flakes from bifacial shaping (Delagnes and Ropars, 1996). This diversity of production sequences within the same site is a common phenomenon in Middle Paleolithic assemblages between MIS 5 to 3 (Delagnes and Meignen, 2006).

The second kind of observation concerns the variability in the conception of tools. With the exception of specialized forms such as cleavers and ficrons, Acheulian bifaces were not made for any exclusive function. The classic Acheulian bifaces appear to be polyfunctional tools with high mobility and resharpening potential; small tools were made on flakes often obtained by the "clactonian" method, and only limited retouch (Keeley, 1980, 1993). In the Middle Paleolithic, bifacial pieces are imported, exported, and resharpened—sometimes recycled to the point that they lose their symmetrical morphology and become a different kind of tool. Flake tools are conceived for a shorter use-life, and are made following two different conceptions: some have a predetermined morphology and are directly used in their raw form or with limited retouch (e.g., Levallois points or Levallois flakes); others are made on blanks of variable, not predetermined, morphology and are intensely retouched. Each tool appears to consist of several functional elements (a back or prehension area; one or more working edges or active areas; hafting areas present on Mousterian points and convergent scrapers), and retouch can be used in two ways—to resharpen an acute edge or to create a stronger, less-acute working angle, sometimes on the same tool. Middle Paleolithic tools are very flexible and their versatility and adaptation to different environmental constraints explains the long duration of the Middle Paleolithic and also the fact that typologically identical pieces had different uses (Soriano, 2000).

It is also important to note that the Middle Paleolithic bifacial pieces differ in conception from the classic Acheulian hand axes. Some have an asymmetrical shape that is in direct relation to their function (e.g., the Keilmesser or backed bifacial knives of Central and Eastern Europe, dated to 80 and 40 ka; Jöris, 2006). Others have a variable shape, are often resharpened or reworked, and have one or more specific working edges that can be a denticulate, or a cutting edge, a scraping edge, or a pointed edge; these bifacial pieces can be typologically assimilated to flake tools (Boëda et al., 1996). This tendency is already in evidence in the early Middle Paleolithic at sites such as La Cotte Layer 5 or Le Pucheuil.

In summary, the Levallois technology appears to be a major innovation of the Middle Pleistocene; associated phenomena are the development of more elaborate and diversified flake-tool equipment, changes in the nature and function of bifaces, and the invention of hafting. Direct evidence that hafting technology was already practiced in the Middle Pleistocene by Neanderthals has been provided by finds of birch-bark tar on the proximal part of two flakes associated with a *Palaeoloxodon antiquus* at the site of Bucine in central Italy, dated to MIS 6 by rodent biostratigraphy (Mazza et al., 2006).

Origins of the Levallois Technology

It has been argued that the Levallois method is conceptually derived from the shaping method characteristic of hand axes. The final purpose of the Levallois method is the production of select flakes; in bifacial shaping, the block or blank is reduced through flaking to a desired form. The two systems appear opposite each other; yet, in the Levallois there is an elaborate shaping phase controlling the core volume and morphology prior to the detachment of the desired flakes (White and Ashton, 2003). Thus it should not be a surprise that the Levallois technology never developed in areas mostly lacking hand axes (as in China), and that in the Middle Paleolithic bifaces underwent a transformation that made them somewhat equivalent to flake tools. It is significant that bifaces or bifacial pieces are not an important element in early Middle Paleolithic industries characterized by Levallois debitage. There is, in fact, a marked decrease in proportions of bifaces in industries of MIS 8 and 7 compared to the previous periods. In the MTA, the Levallois method and cordiform bifaces can be quite common; but those bifaces had become the support of other tools and had different functional areas on different edges of the same piece (Soriano, 2000; Soressi, 2002; White and Ashton, 2003).

Some authors believe that the Levallois method had its origins in Africa and was spread to Europe and the Near East through the immigration of African hominids (Foley and Lahr, 1997); for others, the evolution of the Levallois technology in Europe is an in situ phenomenon, emerging through a gradual evolution. The fact is that the earliest manifestations of Levallois technology in Europe are dominated by the recurrent parallel (unidirectional or bidirectional) method (e.g., Purfleet, Mesvin IV) and by the lineal method (Mesvin IV). The centripetal method is known only later, in MIS 6 (Soriano, 2000). It is difficult to reconcile the process of gradual emergence and diversification of the Levallois method in Europe (especially evident at Orgnac 3; White and Ashton, 2003) with the idea of the introduction of a fully developed method through immigration of African hominids. Unfortunately, the origins and evolution of Levallois technology in Africa is not very well-known. In South Africa, the Victoria West is a prepared core technology for the production of large flakes, preferentially struck from the side of the core and used as cleaver blanks, and less commonly, as hand-axe blanks. The Victoria West method is associated with the Acheulian at Canteen Koppie and other Vaal River sites; it has an early date, in the early part of the Middle Pleistocene, if not earlier, and is considered a development from an earlier (undescribed) Levallois technology. The Fauresmith industrial complex—defined by the presence of Levallois points and hand axes—is younger and separated from the Victoria West phase by an unknown span of time (Sharon and Beaumont, 2006). In East Africa, in the Kapthurin Formation, the Levallois technology with the centripetal method is documented at Koimilot in assemblages without hand axes and an estimated age of about 250 ka; the earliest evidence of Levallois technology for the production of large flakes with the centripetal method is found at Acheulian sites with a minimum age of 285 ka (Tryon and McBrearty, 2006; Tryon, 2006). Based on available descriptions, there seems to be little commonality between the origins and evolutionary trajectory of the Levallois in Africa as compared to Europe. This is why the suggestion of an independent evolution is plausible.

The Record from Asia

The paper by Petraglia and James in this section outlines the evidence for the gradual development of the prepared core technology from regional Acheulian technology in India. As in the case of Western Europe, their argument is based on the continuation of characteristic Acheulian bifaces within assemblages dominated by the prepared core technology, the associated reduction in the size and numbers of bifaces, an increase in the number of retouched small tools (especially scrapers and points), and the occurrence of a significant blade component. A few long stratified sequences support their argument; there is, however, a paucity of chronological data for the period, so the ages and the temporal boundaries of the lithic industries are not well-known.

According to Norton, Gao, and Feng, the basic division of the archaeological record into Lower and Middle Paleolithic has little utility in East Asia. The criteria used and the age estimates used to separate the Lower from the so-called Middle Paleolithic sites are not valid, and those terms should be rejected in favor of a simpler term—Early Paleolithic—representing the originally designated Lower and Middle Paleolithic sites. The wide range of ages assigned to many sites make it difficult to identify time trends in technology; nevertheless, the authors argue that it would not be appropriate to describe the East Asian record as homogeneous and static and that there is much unrecognized variation in stone technology and in behavioral patterns.

A Different Perspective

The paper by Chazan addresses the topic of general trends and large scale regularities in evolutionary trajectories of change from the Lower to the Middle Paleolithic periods. He states that the change from Lower to Middle Paleolithic can be defined as the change from Mode 2 to Mode 3 industries. He then tries to define the social and behavioral factors that supported these technological changes. Following Rolland (2004), who first linked the appearance of home bases and fireplaces at about 400 ka, and discussions by Gowlett (2006) about the use of fire at Beeches Pit and the possible evidence for mastering the art of fire kindling at the site, Chazan suggests that the major change in the Lower to Middle Paleolithic transition is the reorganization of hominin societies around base camps. He sees a shift from the Lower Paleolithic exploitation of very large mammals to the hunting of large and medium-sized prey in the Middle Paleolithic. Very large mammals were butchered at their death site, while smaller prey provided transportable food and allowed sharing in a home-base context. The use of fire—which is important in creating human habitation—and the shift to hunting large- and medium-sized game, mark a change in the way hominins lived and is the defining criterion of the Lower to Middle Paleolithic transition.

I find the author's suggestions interesting, but I must express reservations about how he advanced the arguments and reached conclusions. The problem is that the author does not support his arguments in a satisfactory manner; most of his statements remain too general to be convincing, and appear entrenched in a very synthetic and eclectic reading of the data. What are the criteria by which we identify home bases in the archaeological record? If the use of fire is a diagnostic criterion, what should we make of the evidence of a series of fireplaces in several stratigraphic units at the Acheulian site of Gesher Benot Ya'akov (Israel) at about 790 ka? The associated burnt small artifacts indicate that hearths were the center of specific activities, such as flint knapping (Goren-Inbar et al. 2004; Alperson-Afil et al., 2007; Alperson-Afil, 2008). Moreover, the low level of preserved traces of fire at many sites, and the lack of attention in the past to taphonomic problems mean that home bases (so defined) have very low visibility in the archaeological record.

Other kinds of changes that, according to Chazan, accompany the change from the Lower to the Middle Paleolithic would be the shift from open-air sites to caves and, as mentioned above, the shift in ways of acquiring meat resources. The archaeological record does not seem so clear-cut to me. Many Lower Paleolithic sites associated with very large mammals, such as elephants or hippopotami, are a complex mixture of natural and anthropic components; some of the faunal remains at these sites are natural occurrences without a clear evidence of human intervention e.g., FLK North Level 6, where the hypothetical cutmarks have been shown to be abrasion striations, Nadung'a 4 in Kenya, Ambrona in Spain, and La Polledrara in Italy (Domínguez-Rodrigo, 2007; Delagnes et al., 2006; Villa et al., 1999, 2005;). On the other hand, several Middle Paleolithic sites are associated with elephants (*Palaeoloxodon antiquus* and *Mammuthus primigenius*)—e.g., Lynford in England, La Cotte de St. Brelade on the island of Jersey (English Channel), and Lehringen and Gröbern in Germany (Schreve, 2006; Scott, 1986; Gamble, 1999; Weber, 2000; Thieme and Veil, 1985). Lower Paleolithic sites in caves are certainly rare in Western Europe (but see Gran Dolina, Sima del Elefante, and Sima de los Huesos at Atapuerca in Spain, Arago, Lunel Viel, Grotte de l'Observatoire, and the earlier part of the sequence at Lazaret in France; Visogliano in Italy), but what is the role of natural erosion in destroying the record? Finally, many Lower Paleolithic sites are associated with medium to large mammals—e.g., Gran Dolina TD 6, Venosa Notarchirico level alpha, Miesenheim I, Boxgrove GTP 17 Unit 4b, and Isernia where *Bison* is the dominant species (Villa and Lenoir, 2009).

Since the adaptive trends discussed by Chazan are clearly time-transgressive, and differently expressed in different areas of the Old World, one might draw the conclusion that, as long as we try to find evolutionary trends on a global scale, there is no chronological boundary between the Lower and Middle Paleolithic. But, as Chazan notes at the beginning of his paper, the Lower to Middle Paleolithic transition is a durable archaeological construct. Chazan is right to note that this boundary heralds the emergence of profound behavioral changes. But a closer analysis of lithic technology and its functional and social context are needed to explain why "Mode 3" industries were so successful for such a long time and how they articulate with the underlying reorganization of hominin societies around base camps and fireplaces.

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Part IV
Middle to Upper Palaeolithic Transitions

The Middle-Upper Paleolithic Transition Revisited

Robert G. Bednarik

Abstract The transition from tool industries traditionally seen as Middle Paleolithic to those perceived as Upper Paleolithic has for decades been assumed to coincide chronologically with the 'replacement' in Europe of the resident 'Neanderthals' by 'invading' 'anatomically modern people' from Africa. The basis of this belief is critically examined in view of recent developments in the dating of hominin remains in Europe, and in the exposure of fake datings of several key specimens. It is shown that there is no comprehensive evidence that any of the Early Upper Paleolithic traditions were introduced by fully modern hominins, but that there was instead a gradual process of gracilization rather than outright replacement evident in the fossil record. The same is shown to occur with tool industries and paleoart production, which develop progressively and gradually. The gradual change from robust to gracile skeletal architecture is not limited to Europe; it is a feature of all four continents occupied by humans 50,000 years ago. If the Aurignacian rock art and portable art in Europe is by robusts, such as Neanderthaloids, which appears to be the case, the various versions of the African Eve hypothesis must be considered to be refuted decisively.

Keywords Middle Paleolithic • Upper Paleolithic • Robusts • Graciles • Paleoart • Replacement hypothesis • Domestication hypothesis

R.G. Bednarik (✉)
International Federation of Rock Art Organisations (IFRAO), Caulfield South, Australia

More than a decade ago I pointed out that we have no evidence whatsoever that the Early Aurignacian is the work of 'Moderns' (Bednarik 1995), to which I can now add that we have no proof of a 'physically modern' morphology of the makers of *any tool tradition of the entire first half of the so-called Upper Paleolithic*—including the entire Aurignacian. The search for physical modernity is itself misguided (Tobias 1995); modernity is indicated by cognition and culture, and more specifically by the external storage of cultural information (Donald 1993). The present archaeological and paleoanthropological evidence suggests that we have Neanderthaloid remains from the time interval in question, and we have no securely provenanced 'Moderns.' European Pleistocene archaeologists are obliged to consider the possibility that the Aurignacian is the work either of 'Neanderthals' or of their descendants who experienced genetic drift rather than 'replacement.' Science works by falsification, and the proposition to be tested now is that Aurignacian 'art,' like Châtelperronian 'art,' *was created not by 'Moderns.'*

The replacement model has depended greatly on a series of 'anatomically modern' hominin specimens from across Europe, especially central Europe, all of which have been severely misdated. A case in point is the Vogelherd skull (Stetten I): anyone who has actually examined it will have been struck by its modern appearance, both anatomically and in terms of its preservation (Fig. 1). That is precisely why careful commentators warned that 'judging by its appearance it would fit much better into a late phase of the Neolithic' (Czarnetzki 1983, 231). Gieseler (1974) had expressed similar concerns

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Fig. 1 Stetten I, claimed by replacement advocates to be 32,000 years old. It is in fact Neolithic

about Stetten II, a cranial fragment, and others also favoured an attribution to the site's Neolithic occupation. The putative age of the Stetten specimens, 32 ka, now stands refuted by their direct dating to the late Neolithic period (Conard et al. 2004), confirming the obvious: that they are intrusive burials. Direct carbon isotope determinations of samples taken from the mandible of Stetten 1, the cranium of Stetten 2, a humerus of Stetten 3, and a vertebra of Stetten 4 all agree, falling between 3980 ± 35 BP and 4995 ± 35 BP. Contrary to Churchill and Smith (2000a), the Stetten specimens tell us therefore nothing about the skeletal anatomy of the 'Aurignacians.'

The Hahnöfersand calvarium, described as so robust that it was judged to show typical Neanderthal features (Bräuer 1980), was initially dated to the earliest 'Upper Paleolithic' (Fra-24: 36,300 ± 600 BP; UCLA-2363: 35,000 ± 2000 BP, or 33,200 ± 2990 BP; Bräuer 1980). These results conflict sharply with those now secured by Terberger and Street (2003): P-11493: 7470 ± 100 BP; OxA-10306: 7500 ± 55 BP. The redating of the skull fragment from Paderborn-Sande yielded even more dramatic differences. Originally dated at 27,400 ± 600 BP (Fra-15; Henke and Protsch 1978), Terberger and Street (2003) report an age of only 238 ± 39 BP (OxA-9879). Then there is the cranial fragment of Binshof near Speyer, dated by R. Protsch in the 1970s as Fra-40 to 21,300 ± 320 BP. According to Terberger and Street it is only 3090 ± 45 carbon years old (OxA-9880). These authors also analyzed two individuals from the Urdhöhle near Döbritz, which had been attributed to the Upper Paleolithic, and found them both to be about 8400 years old. The skull from Kelsterbach had been dated to 31,200 ± 1600 BP (Fra-5) (Protsch and Semmel 1978; Henke and Rothe 1994), but has mysteriously disappeared. It is now also believed to be of the Holocene, perhaps the Metal Ages (Terberger and Street 2003). Indeed, because of the fake datings by Protsch (Schulz 2004), of all the German 'Upper Paleolithic' specimens, only one remains safely dated to earlier than 13,000 BP, from Mittlere Klause in Bavaria. A carbon isotope date of 18,200 ± 200 BP (UCLA-1869) from a tibia fragment (Protsch and Glowatzki 1974) has been confirmed by Terberger and Street's date from a vertebra, of 18,590 ± 260 BP (OxA-9856). It has therefore become clear that there are currently no 'modern' remains from the first two-thirds of the west central European Upper Paleolithic.

Similarly, the sample from Crô-Magnon in France, traditionally regarded as typical representatives of invading Moderns in Europe, has been falsely attributed. Sonneville-Bordes (1959) placed the four adults and three or four juveniles in the late Aurignacian; Movius (1969) suggested an age of about 30 ka BP and preferred an attribution to the Aurignacian 2 (Fig. 2). Excavation was *careless,* with iron tool marks found on the adult remains. The recent redating to about 27,760 carbon years BP (Henry-Gambier 2002) renders previous opinions invalid, and the remains are probably of the Gravettian, i.e., the 'culture' that succeeded the Aurignacian. Moreover, the very pronounced supraorbital torus, projecting occipital bone, and other features of cranium 3 are Neanderthaloid rather than gracile. This and other aspects of the generally somewhat robust Crô-Magnon series question the full 'modernity' of the group—but irrespective of this, it tells us also nothing about the anatomy of the 'Aurignacians.'

Similarly tenuous are the identical claims for the Mladeč specimens from the Czech Republic. It is uncertain that the cave was even accessible to Upper Paleolithic humans; their remains may have entered the cave via a vertical shaft from above. The site was entirely bereft of archaeological strata by the time systematic excavations were

Fig. 2 One of the Crô-Magnon specimens, attributed to the Aurignacian, is in fact of the Gravettian

developed, and little is known about its archaeology (Jelínek 1987; Bednarik 2006). Recent attempts to provide direct dates from some of the human remains (Wild et al. 2005) yielded five results ranging from about 26,330 to 31,500 BP. The fossils are therefore at best from the latest part of the Aurignacian period (45 ka to 30 ka BP), but also point to a possible Gravettian age. Moreover, there is considerable evidence that the Mladeč humans were far from fully 'modern' (Frayer 1986; Smith 1982, 1985; Trinkaus and Le May 1982). Sexual dimorphism is pronounced, with male crania being very robust. The female specimens show similarities with, as well as differences from, accepted Neanderthal females (Fig. 3). The Mladeč population thus seems to occupy an intermediate position between late Neanderthaloid *Homo sapiens,* and *H. sapiens sapiens,* a position it shares with numerous human remains from other Czech sites. The material from Pavlov Hill is among the most robust available from the European Upper Paleolithic, sharing its age of between 26 and 27 ka with yet another Moravian site of the Gravettian, Předmostí. The more gracile finds from Dolní Vestonice are around 25 ka old and still feature some archaic characteristics (particularly the Neanderthaloid specimen DV16). Morphologically similar specimens also come from Cioclovina (Romania), Bacho Kiro levels 6/7 (Bulgaria), and Miesslingtal (Austria), so this is unlikely to be a local phenomenon.

Other specimens that have been considered as very early European Moderns include the calotte from Podbaba, near Prague, variously described as sapienoid and Neanderthaloid, but undated; it probably belongs to the Mladeč-Předmostí-Pavlov-Dolní Vestonice spectrum. Then there are the robust but 'modern' hominid remains of the EUP (early 'Upper Paleolithic') at Velika Pećina, Croatia, close to the Neanderthal site Vindija. This specimen has also been a principal support for the

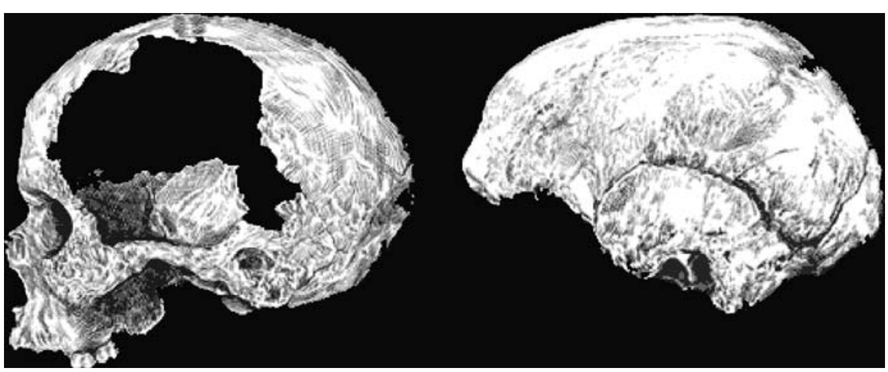

Fig. 3 Mladeč 1, a gracile female (*left*) and Mladeč 5, a robust male (*right*), c. 30,000 BP

replacement advocates, but it too has joined the long list of European humans whose age was grossly overestimated. It is now considered to be only 5045 ± 40 carbon years old (OxA-8294; Smith et al. 1999).

The loss of the only relevant Spanish remains, from El Castillo and apparently of the very early Aurignacian, renders it impossible to determine their anatomy. French contenders for EUP age present a mosaic of unreliable provenience or uncertain age, and direct dating is mostly not available. Like the Vogelherd and other specimens, those from Roche-Courbon (Geay 1957), La Rochette, Bouil Bleu, and Combe-Capelle (originally attributed to the Châtelperronian levels; Klaatsch and Hauser 1910) are thought to be of Holocene burials (Asmus 1964; Foucher et al. 1995; Perpère 1971), and the first-mentioned is now apparently lost. Similar considerations apply to the partial skeleton from Les Cottés, whose stratigraphical position could not be ascertained (Perpère 1973). Finds from La Quina, La Chaise de Vouthon, and Les Roches are too fragmentary to provide diagnostic details. The *os frontale* and fragmentary right maxilla with four teeth from La Crouzade, the mandible fragment from Isturitz, and the two juvenile mandibles from Les Rois range from robust to very robust. The Fontéchevade parietal bone does lack prominent tori but the site's juvenile mandibular fragment is robust. The currently earliest 'intermediate' finds in Europe, the Peştera cu Oase mandible and separate face (Fig. 4) from southwestern Romania (Trinkaus et al. 2003), are perhaps about 35,000 carbon years old, but they are without an archaeological context and certainly not anatomically modern. 'Derived Neanderthal features' identify these remains as post-Neanderthal rather than a gracile 'Modern.' This is particularly apparent from the substantially complete frontal bones found in the same cave in 2003, which is clearly not 'modern,' nor is it 'Neanderthal.' More recently, Soficaru et al. (2006) have reported six human bones from another Romanian cave, Peştera Muierii, which are clearly intermediate between robust and gracile Europeans. Although found in 1952, they have now been dated to about 30,000 carbon years, which might correspond to around 35,000 sidereal years, and combine a partly modern, partly archaic brain case with a suite of other intermediate features (Fig. 5).

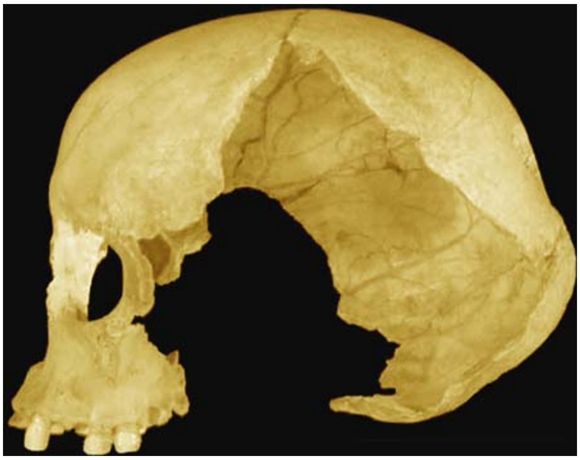

Fig. 5 Peştera Muierii skull combining robust and gracile features, c. 30,000 BP

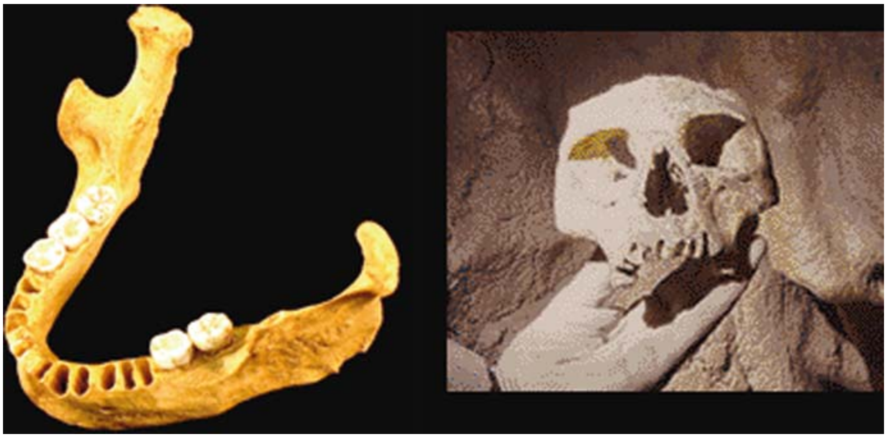

Fig. 4 Peştera cu Oase mandible and separate face, intermediate between robust and gracile

This pattern of features intermediate between what paleoanthropologists regard as Neanderthals and Moderns is found in literally hundreds of specimens apparently on the order of 45–25 ka old. Gracilization is a universal process in all world regions then occupied by humans, from Portugal to Australia. Intermediate forms between archaic *Homo sapiens* and *Homo sapiens sapiens* include examples, some of them much older, from right across the breadth of Eurasia, such as those from Lagar Velho, Crete, Starosel'e, Rozhok, Akhshtyr', Romankovo, Samara, Sungir', Podkumok, Khvalynsk, Skhodnya, Narmada, as well as Chinese remains such as those from Jinniushan. In Australia, the robust Kow Swamp population is only 10,000 years old, while gracile specimens from the same general region are tens of thousands of years older. This presents an overall picture that is very different from that which the replacement protagonists prefer. Their model cannot tolerate intermediate forms, nor can it allow hybrids, yet in Europe there is a clear continuation of some Neanderthaloid features right up to and into the Holocene. This is demonstrated not only by the Hahnöfersand specimen, but also by many others, such as the equally robust Mesolithic skull fragment from Drigge, about 6250 years old (Terberger 1998), and many more late specimens previously thought to be of the EUP. They range in age from the Magdalenian through the Neolithic, and younger. The process of gracilization has in fact continued to the present time, with notable changes continuing in the Final Pleistocene and the Holocene.

There are now almost no supposedly modern specimens left as possible contenders for attribution to EUP or Aurignacoid industries. The maxilla from Kent's Cavern, United Kingdom (~31 ^{14}C ka BP, possibly older), and Pestera Cioclovina (~29 ^{14}C ka BP) lack secure and diagnostic archaeological associations as well as morphological criteria. There are, however, numerous Neanderthal remains to fill this void. Of particular interest are the most recent, those from Saint Césaire (~36 ka), Arcy-sur-Cure (~34 ka), Trou de l'Abîme (Aurignacian), Vindija Cave (Olschewian, ~28 and ~29 ka), and Máriaremete Upper Cave (Jankovichian, ~38 ka). At the first site, the Neanderthal remains of a burial occur together with clear Châtelperronian artefacts, which until 1979 had been generally assumed to be the work of anatomically modern humans. Arcy-sur-Cure yielded numerous ornaments and portable art objects, again with a Châtelperronian. This prompted various convoluted explanations of how these pendants could have possibly found their way into a 'Neanderthal' assemblage (e.g., Hublin et al. 1996; White 1993; a similar argument was used by Karavanic and Smith [1998] in explaining the UP bone points of Neanderthals in Vindija layer G1). The Jankovichian or Trans-Danubian Szeletian (Allsworth-Jones 2004) has provided three mandibular 'Neanderthal' teeth (Gábori-Csánk 1993). Trou de l'Abîme near Couvin in southern Belgium yielded Neanderthal remains together with a typical Aurignacian industry, and the Vindija late Neanderthals used EUP tools and technology. These most recent 'Neanderthals' found so far are more gracile than Neanderthals of earlier periods, and they are considered to be transitional (Frayer et al. 1993; Smith and Ranyard 1980; Wolpoff 1999; Wolpoff et al. 1981). Vindija Vi-207 is a mandible of 29,080 ± 400 carbon years BP (OxA-8296); Vindija Vi-208 is a parietal of 28,020 ± 360 carbon years BP (OxA-8295) (Smith et al. 1999). These 'late Neanderthals' (or very robust 'Moderns') exhibit significant reduction in 'Neanderthaloid' features, such as mid-facial prognathism and supraorbital tori. The related stone tools and bone points are of EUP typology, and Ahern et al. (2004) also report the occurrence of apparent bone fabricators.

There are only three realistic alternatives to account for the EUP tool, rock art, and portable art traditions of Europe: they are either the work of 'Neanderthals,' or of the descendants of Neanderthals, or of invading 'Moderns.' There is currently no evidence for the third possibility. Of particular interest are the very numerous human footprints in Chauvet Cave (in Salle des Bauges, Salle du Crâne, and Galerie des Croisillions). While ichnological evidence may not be conclusive in this respect, its consideration is worthwhile. The superbly preserved human tracks I have examined in the cave are, in my view, more likely to be of Neanderthaloids than of 'Moderns,' for a number of reasons. In most if not all 'Neanderthal' skeletal remains it appears that the big toe is shorter than the second toe, whereas the converse applies to the known 'Crô-Magnon' remains as well as footprints. This may of course be coincidence; both versions can be found among

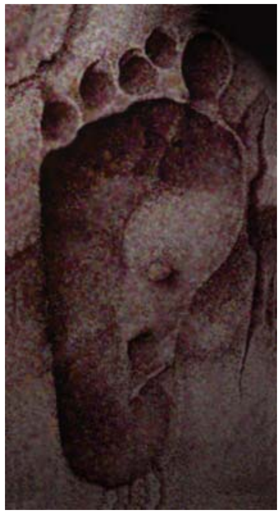

Fig. 6 Footprint of a child in Chauvet Cave, apparently of a Neanderthaloid individual

Fig. 7 Therianthropic ivory figure from Hohlenstein-Stadel, Germany, Aurignacian

modern Europeans. However, in the case of the supposedly 8–10-year-old child that strode though Chauvet Cave, the second toe is not only longer, it is offset above its two neighbours (Fig. 6). In a child not used to wearing tight footwear, this might be a diagnostic feature. Moreover, the Chauvet tracks also show other characteristics that differ from most modern human tracks. The ratio of the widths across the heel and the front of the foot is markedly greater, and more pressure has been applied to the outside margin, which is perfectly straight (Clottes 2001, Fig. 28). This suggests a somewhat bow-legged gait, which may be consistent with Neanderthals.

The conceptually most complex portable and parietal art of the Upper Paleolithic is of the Aurignacian, including the two therianthropes from Swabia (Hohlenstein-Stadel, Schmid [1989], and Hohle Fels, Conard et al. [2003]) (Fig. 7); numerous further portable items from other caves in the Swabian Alb; the anthropomorph from Galgenberg (Bednarik 1989) (Fig. 8); the small corpus of rock art of l'Aldène, reflecting the principal faunal elements in the Chauvet art (and created before the decorated passage became closed 30,260 ± 220 BP (Ambert et al. 2005, 276–7; Ambert and Guendon 2005); the early phase of the rock art in Baume Latrone (Bednarik 1986; Bégouën 1941; Drouot 1953); and most particularly the early phase in Chauvet Cave (Chauvet et al. 1995; Clottes 2001; Clottes et al. 1995; Valladas et al. 2004), a site that

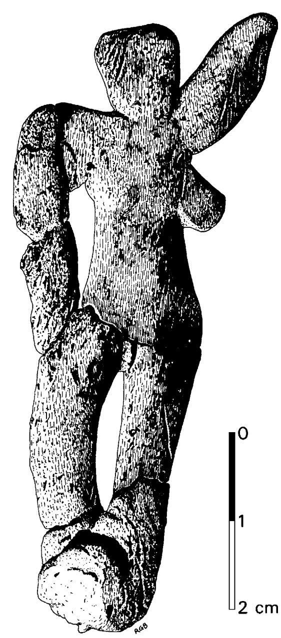

Fig. 8 Serpentine figurine from Galgenberg, Austria, Aurignacian

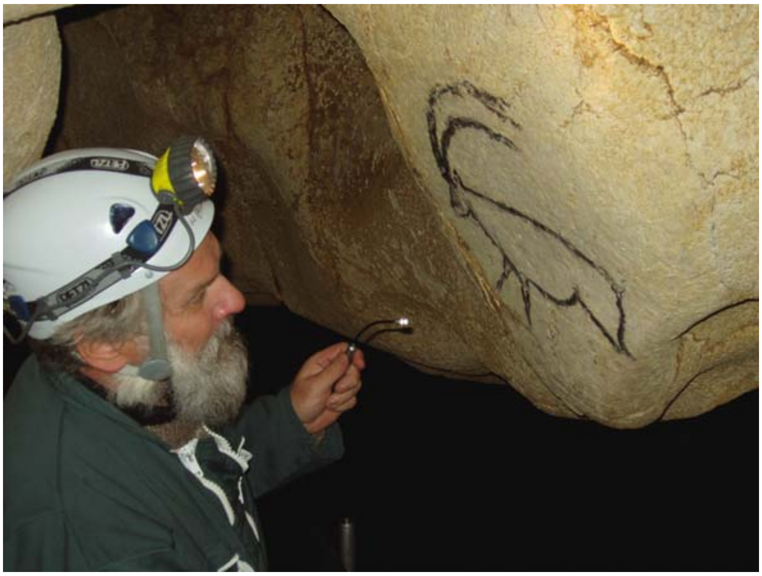

Fig. 9 The author in Chauvet Cave (photograph by J. Clottes)

probably became sealed about 24 ka ago (Bednarik 2004) (Fig. 9). 'Aurignacians' seem to have been especially interested in 'dangerous animals,' and one of the most interesting cultural markers of 'Aurignacoid' traditions is the evidence of intentionally deposited remains of cave bears, especially their skulls. I will consider this aspect (found in Chauvet), one of many connecting the Middle Paleolithic with the EUP, in a separate paper.

In summary, we have no evidence that the Aurignacian, Châtelperronian, Uluzzian, Proto-Aurignacian, Olschewian, Bachokirian, Bohunician, Spitsyn culture, Szeletian, Jankovichian, Streletsian, Altmühlian, Lincombian, or Jerzmanovician (all of which seem to have developed in situ) are the work of physically modern people. We have evidence that at least five or six of them are the work of 'Neanderthals' or 'post-Neanderthals,' and quite probably this applies to all pre-Gravettian traditions in Europe. By the time of the Gravettian, the rate of gracilization of humans suggests culturally moderated breeding: robust characteristics were selected against by culturally determined preferences. Gracilization is a global phenomenon of the Final Pleistocene and Holocene, and it has been completely neglected until now that its great evolutionary cost (reduced muscle bulk and brain size, more delicate bone architecture) suggests that natural selection was replaced by 'self-domestication' (through culturally mediated mating choices, as implied by the distinctive sexual dimorphism of intermediate populations, such as those from the Czech sites).

This questions the entire model of the transition from 'Middle Paleolithic' to 'Upper Paleolithic' 'cultures' as it has been perceived by the discipline for many decades. The simplistic notion that the introduction of a genetically new population in Europe coincided chronologically with the appearance of a radically different technology and paleoart has been gradually eroded since the Châtelperronian had to be yielded to the 'Neanderthals.' There is now no evidence of the replacement of either culture or human population, but there is ample evidence of continuity. It has been known since the mid 19th century that paleoart has existed for hundreds of millennia in Europe, but this escaped the supporters of the replacement theory. 'Upper Paleolithic' aspects of technology in much earlier periods have been evident for a long time, and the entire nomenclature of the human history of the Pleistocene is in dire need of revision. Moreover, the impotence of paleoanthropology has been well illustrated for the past 150 years, from its response to the finds of the Kleine Feldhofer Cave and the first Javanese hominins, to Piltdown, to the pandemonium that followed the report of a small Final Pleistocene hominin from Flores just a few years ago. These and many other examples should teach us to be sceptical of anything claimed in this field. The present Flores controversy, where warring protagonists offer interpretations ranging from ape to australopithecine to *Homo ergaster* to *Homo erectus* to *Homo sapiens,* has merely confirmed how history tends to repeat itself.

Perhaps some of the above-cited evidence can be challenged, but that is yet to be demonstrated. The present evidence implies that the paleoart of the Aurignacian, like that of the Châtelperronian and Bachokirian, is not the work of 'fully modern' *H. sapiens sapiens*. Archaeologists wishing to falsify this proposition will need to present unambiguously fully modern human remains (i.e., free of significant robust features) from a secure EUP context. Until they do this, the 'domestication' hypothesis is much better supported than the replacement hypothesis, and the makers of Aurignacian tools, rock art, and portable art were apparently not physically 'modern.' They were either 'Neanderthals' or 'post-Neanderthals.'

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Historical Perspectives on the European Transition from Middle to Upper Paleolithic

Francis B. Harrold

Abstract This paper examines the historical development of understandings of the transitions in Europe from the Middle to the Upper Paleolithic and from Neanderthals to anatomically modern humans, and of the linkages (if any) between the two processes. Although the particular claims, and the databases supporting them, have changed greatly over time, the main line of contention regarding both transitions has been between advocated of rapid, even revolutionary change with a strong allochthonous component, versus those embracing gradual, primarily autochthonous transitions. Proponents of both approaches have proved to be adept at accommodating their views to changes in available data and theoretical approaches. Yet, as an emerging quasi-consensus on the fate of the Neanderthals indicates, these opposing approaches are not indefinitely able to avoid modification in the face of accumulating evidentiary patterns.

Keywords Middle Paleolithic • Upper Paleolithic • Transitional industries • Neanderthals • Cro-Magnon • Anatomically modern humans • Paleolithic industries • OIS-3

The symposium on "Transitions in the Paleolithic" from which this volume emerged, was held 150 years after the epochal discovery of the first reported Neanderthal in the Feldhofer Cave, and nearly 20 years after the 1987 Cambridge conference on the "Origins and Dispersal of Modern Humans" (Mellars and Stringer, eds. 1989; Mellars, ed. 1990), which helped to make the origins of modern humans and modern behavior central concerns in paleoanthropology. We may note as well that it occurred nearly a century after the discoveries of Neanderthal remains at Le Moustier and at La Chapelle-aux-Saints in 1908, finds which initiated a series of French Neanderthal discoveries (including La Quina in 1910 and La Ferrassie in 1909–1916) in the course of excavations that provided extremely important Middle and Upper archaeological assemblages. In view of these anniversaries and near-anniversaries, it may be a fitting exercise to look at current understandings of the Middle-Upper Paleolithic transition in historical perspective. We will see that some currents of contemporary thought reflect questions posed, and answers suggested, in the early days of the study of human biological and cultural evolution, though they have been modified and recast in the light of new data, methods, and theories.

The scientific literature that has accumulated on the origins of modern humans and modern behavior is vast, and a thorough intellectual history of the subject—or, indeed, even a thorough survey of the current theoretical landscape—would be a formidable undertaking, beyond the scope of this paper. Here I will only emphasize some aspects of this history that seem important in understanding why research and argument in this contentious realm today take the form they do. I will do this from the perspective of one who has worked mainly in

F.B. Harrold (✉)
St. Cloud State University, St. Cloud, MN, USA

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Western Europe, where the study of modern human origins began, and where its intellectual frameworks were mainly constructed (before being exported, often inappropriately, to other regions of the world). The main concern here is with thinking on the transitions in Europe from the Middle to Upper Paleolithic, and from Neanderthals to anatomically modern humans (or AMH) that occurred during Oxygen Isotope Stage (OIS) 3, between about 60,000 and 25,000 years ago (in uncalibrated radiocarbon years—probably equaling around 60,000 + to 29,000 calendar years ago [Mellars 2006a; Van Andel 2003]).

It should be noted as well that, while the biological evolution of human populations and the behaviorally-based change in archaeological industries are analytically separable subjects that are studied using different sorts of data, the mutual influence of human behavior and biology is a cornerstone tenet of paleoanthropology. While nearly all workers accept that biological evolution or replacement need not be accompanied by industrial change in the archaeological record (and vice versa), it has long been accepted that patterns of cultural behavior are part of human adaptation, and can over time influence the course of biological evolution; at the same time, human cultural capabilities are themselves the product of biological evolution. The period under study was one of both biological change and cultural change in Europe. As we will see, a prominent model explicitly links the cultural change to biological change (population replacement). Any model of cultural change in mid-Last Glacial Europe would need to indicate some understanding of its relationship with biological change, and the reverse is true as well.

Early Thought on the Emergence of Moderns

By the late 1860s, some raw materials for discussion of modern human origins in Western Europe had been excavated: Neanderthal remains, as well of those of Upper Pleistocene anatomically modern humans (or AMH) at Cro-Magnon, and Paleolithic artifacts (and faunas) from a number of sites, most prominently in the Dordogne region of southwestern France. It took time, however, for pioneering prehistorians to discern patterned change in Paleolithic industries over (relative) time, and to relate Neanderthals and Cro-Magnons to these industries and (again, in relative time) to each other.

The pioneering prehistorian Edouard Lartet (Lartet and Christy 1865–1875) recognized the distinctiveness of the Middle Paleolithic artifacts from Le Moustier relative to the Upper Paleolithic industries stratified above them. However, the first attempts at periodizing the Paleolithic and temporally ordering the deposits of various sites were based on faunal remains from these sites rather than artifacts, as might be logically expected given the antecedent development of paleontology (Sackett 1981, 1991).

As the available database of excavated materials (collected, unfortunately, with generally crude methods) grew, Gabriel de Mortillet developed a systematic classification of the Paleolithic that was based primarily on artifacts rather than fauna. He recognized the distinctive flake-based industry from Le Moustier, and used the term Mousterian for it and similar collections (de Mortillet 1867, 1897; Coye 2005; Sackett 1991). He also recognized an Aurignacian industry, though he proved eventually to be wrong about the sequence of Upper Paleolithic industries, placing the Aurignacian after the Solutrean. More broadly, he did correctly place the usually blade-dominated industries of the Upper Paleolithic (Solutrean, Aurignacian, Magdalenian) following the Mousterian. In a scheme consistent with the unilineal evolutionism then predominant in cultural anthropology, he saw each of the culture-stratigraphic units he defined as a stage or *époque* in a presumably universal process of cultural evolution through which primitive humanity had gradually progressed. While it was assumed that this cultural evolution paralleled in some way the biological evolution of early humans, links to particular human fossil forms were not specified. This is unsurprising, given the small number of Pleistocene human fossils then known, and their frequent lack of clear association with identified industries.

A different, and ultimately more influential, approach to Paleolithic systematics was that of Henri Breuil (e.g., Breuil 1913). By 1913 he was working with an improved database, which included repeated associations between Neanderthal fossils and Middle Paleolithic assemblages. For Breuil, the sequence of Paleolithic industries represented a succession, not of epochs, but of *industries* (Coye 2005)—of culturally-based groupings of assemblages, which could be variably influenced by cultural change in situ, diffusion of practices and ideas, and migration of human groups. In his view, the most striking transition in the Paleolithic record was the one from Mousterian to Upper Paleolithic—whose earliest industry, he showed, was the Aurignacian. He saw this transition as representing, not merely another stage in a gradual evolutionary process, but the replacement of Neanderthals in Europe by immigrating Cro-Magnon AMH—in his terms, a major social, racial, and industrial transition.

Breuil's interpretation set the dominant tone for decades to come for understandings of the Middle-Upper Paleolithic transition. It was reinforced by the interpretations of Neanderthal fossils from La Chapelle-aux-Saints and other sites by Marcellin Boule (e.g., Boule 1921), according to whom Neanderthals were strikingly different from, and more primitive than, AMH. In this view, the common AMH-Neanderthal ancestor was very ancient indeed; Neanderthals had no role in the direct ancestry of AMH, whose Cro-Magnon representatives had entered Europe from far to the east. The Mousterian industry of the Neanderthals lacked the art and other creative accomplishments of the Cro-Magnons' Upper Paleolithic.

Paleolithic industries were understood as representing culturally distinct, and sometimes biologically distinct, human populations. Most subsequent western European workers followed this basic model, with variations. For instance, Peyrony (1933) revised Breuil's classification of the earlier Upper Paleolithic, splitting Breuil's three-phase "Aurignacian" into two parallel cultural phyla, the Aurignacian and the Perigordian. The Upper Paleolithic in this scheme still marked the eclipse of the Neanderthals by AMH, though the Aurignacian and Perigordian were associated by Peyrony with two different races of modern people, the Cro-Magnon and Combe-Capelle races, respectively (Harrold 2000).

That there had somewhere been an evolutionary transition from more archaic humans to AMH had long been widely accepted. But this transition, in Breuil's view (and that of most workers), was placed outside Europe, perhaps in North Africa, or—especially after Garrod's discoveries at Skhul in Palestine (McCown and Keith 1939)—in the Near East. Howell (1957) cast this idea in terms of evolutionary processes such as gene flow and isolation; he suggested that while Last Glacial climates isolated European Neanderthals from evolutionary currents elsewhere, early Neanderthals in the Near East gave rise to transitional populations (represented at Skhul), and eventually, AMH. Such suggestions propose continuity between archaic *Homo* and AMH, but they locate the evolutionary transformation outside Europe, and identify the European Neanderthals as being on an evolutionary dead end.

However, there has long been a tradition of interpretations contrary to the Breuilian model, stressing the fossil or the archaeological evidence (or both) to argue for continuity over the Middle-Upper Paleolithic and Neanderthal-AMH transitions in Europe (Drell 2000). This tradition is evident in the early interpretations of Schwalbe and Gorjanovič-Kramberger (Spencer 1984), who suggested evolutionary continuity from Neanderthals and the Mousterian to later times. Indeed, Boule's and Breuil's claims can be seen as reactions against these claims of continuity. Hrdlička (1927), for whom the Neanderthals represented a stage in a continuous process of human evolution, was one of several influential workers who interpreted European AMH and their industries as at least mainly the evolutionary descendants of Neanderthals and their industries (e.g., Coon 1962; Solecki 1971). Hrdlička specifically suggested that the invasive "Quina" retouch on Mousterian scrapers from that eponymous site provided a cultural link with the also characteristically invasive "Aurignacian" retouch, indicative of in situ cultural development from Middle to Upper Paleolithic that paralleled biological evolution from Neanderthal to modern humans. Coon also stressed regional continuity, and attempted to explain Neanderthal features (such as nasal size and form) in terms of natural selection for glacial climates. Weidenreich (1943) was uncertain about European Neanderthal-to-AMH evolution, but as the "father" of multiregional evolutionary theory, did leave the general outlines of a theory of regional genetic continuity throughout human evolution, with regions linked by gene flow, upon which later workers built. His successors, such as Brace and Wolpoff (see below), were to advocate about evolutionary continuity between Neanderthals and succeeding European AMH. In this broad tradition, there were workers whose findings militated against extreme depictions of Neanderthal skeletal and behavioral difference and primitiveness. For example, Patte (1955) and Straus and Cave (1957) showed evidence that Boule's conclusions on these matters had been extreme and unwarranted by the evidence. And workers ranging from Bouyssonie (1954) and Blanc (1940) to Solecki (1971, based on his 1950s excavations at Shanidar) argued that the evidence supported attribution of ritual and symbolic behavior and even "spirituality" to Neanderthals, thus opposing strong views of Neanderthal behavioral primitiveness.

As Trinkaus and Shipman (1993) have noted, continuity arguments have often been propounded by workers in Central Europe (e.g., Müller-Beck 1965), where the fossil and archaeological records did not always seem to fit well with patterning claimed for western Europe. Furthermore, there were prehistorians in western Europe who argued for elements of continuity. Bordes (1972), for instance, in some respects followed a traditional paradigm, but argued that at least one facies of the Mousterian (Mousterian of Acheulean Tradition) had gradually developed into the earliest French Upper Paleolithic industry, the Chatelperronian (or Lower Perigordian). He furthermore thought that this cultural evolution was related to an in situ evolution of Neanderthals into AMH; thus the Chatelperronian, and at least the later assemblages of the Mousterian of Acheulean Tradition, would have been produced by modern humans. Continuity of some sort between Middle and Upper Paleolithic was accepted by a number of French prehistorians (e.g., Delporte 1963; Leroi-Gourhan 1965), though it was generally held that because of considerable geological disturbance (by erosion and cryoturbation) of deposits from the transitional period (e.g., Laville 1975), not much was known of the crucial period. The Aurignacian, however, Bordes perceived as an intrusive industry in Western Europe.

The "Modern Era"

Beginning in the 1960s, fresh interest arose in this arena of research. For example, in 1964, Brace published a controversial article reflecting the theoretical ferment in American anthropology at the time (the era of "New Archaeology" and the "New Physical Anthropology") in its concern to interpret the fossil and archaeological records in terms of commonly accepted evolutionary processes. After charging the incomplete penetration of Darwinian (as opposed to Lamarckian) evolutionary thought in French paleontology and prehistory, he characterized the traditional view of the Middle-Upper Paleolithic transition as a species of catastrophism. He stressed the extreme views of Boule and the empirical shortcomings of the archaeological evidence (often related to the primitive methods of early excavations of important sites) used to buttress the received Breuilian view of the fate of the Neanderthals and the cultural transition, and charged that accounts of these developments ignored principles of evolutionary biology in positing a catastrophic population replacement.

In 1971, Brose and Wolpoff identified European AMH as the descendants of Neanderthals, and located the evolutionary driver of this process in the Middle-Upper Paleolithic transition, whose technological improvements, they argued, had altered the selective pressures shaping the human skeleton. Thus Bordes' notion of in situ cultural and biological transition was explicitly linked to Darwinian theory in such a way that cultural developments among Neanderthals were viewed as engendering both the Upper Paleolithic and AMH. Like Brace's, this article was controversial; Howells (1974), for instance, accused Brose and Wolpoff of blurring real distinctions between fossils and between industries, and of presenting insufficient evidence to sustain their hypothesis.

Mellars (1973) also opposed gradualism, marshaling evidence from numerous sites in France to make the case that the archaeological records of the Middle Paleolithic and the Upper Paleolithic revealed major contrasts between the two—that Upper Paleolithic AMH were more numerous, with more complex and sophisticated lifeways and adaptations, than Middle Paleolithic Neanderthals. In Europe, the excavation of a number of important sites spanning the period of the transition (e.g., the Grotte du Renne at Arcy-sur Cure [Leroi-Gourhan and Leroi-Gourhan 1964] and Roc de Combe [Bordes and Labrot 1967]) stimulated further interest.

The developing controversy among these workers helped to recast the Middle-Upper Paleolithic transition and the fate of the Neanderthals as major paleoanthropological concerns, alongside the evolution of Plio-Pleistocene hominins, and marked the beginning of what might be called the modern era of research in this arena. This era has been marked by notably increased numbers of researchers at work (many from the U.S. and Britain), and a drive to apply new and improved research methods, as well as Darwinian and ecological theory. The study of the transitions of interest here has become during this period part of the larger worldwide issue of the origins of AMH and their relationship to earlier human populations, usually cast in terms of "Multiregional" versus "Out of Africa" models.

Several developments in particular have helped to shape the current state of research on the Middle-Upper Paleolithic transition since the 1970s:

Enhancement of the archaeological and fossil database: Excavations at numerous important sites such as El Castillo (Cabrera et al. 2005), Grotte XVI (Lucas et al. 2003), Saint-Césaire (Lévêque et al. 1994), and Lagar Velho (Zilhão and Trinkaus, eds. 2002), have added greatly to the database of the most reliably-recovered evidence. They have been accompanied by re-examinations and re-evaluations of important collections of human fossils and artifacts (e.g., Stringer 1974; Smith 1984; Trinkaus 1983; Hublin et al. 1996; Harrold 1989; Pelegrin 1995; Gravina et al. 2005).

Intensive studies aimed at ancient diet/subsistence: These include especially studies of archaeological faunas (e.g., Grayson and Delpech 2002; Stiner 1994; Kuhn and Stiner 2001; Patou-Mathis 2000), and stable-isotope analyses of human bone to infer aspects of diet composition (e.g., Richards et al. 2000, 2001; Hockett and Haws 2005; Bocherens et al. 2001; Bocherens and Drucker 2003; Drucker and Bocherens 2004). While much is still unknown or disputed regarding subsistence during OIS 3, faunal analyses such as those of Grayson and Delpech (2002, 2006), Adler et al. (2006), Gaudzinski and Roebroeks (2000), Marean (2005), and Kuhn and Stiner (2006) have put paid to the notion that Neanderthals were ineffective hunters. Yet the latter two studies find interesting indications that Neanderthal adaptive strategies may have fundamentally differed from those of later hunters in areas such as sexual division of labor, and level of risk, reward, and cost.

Skeletal studies of evidence of locomotion and habitual behavior, seeking to understand the effects of genetics, development, habitual behavior, pathology, and environment on Neanderthal and AMH skeletons (e.g., Trinkaus et al. 1999; Churchill 1998; Beauval et al. 2005; Spoor et al. 2003; Weaver 2003; Weaver and Steudel-Numbers 2005).

Improved chronology: For a long time, the conversion of a largely relative Paleolithic chronology to an absolute one was not a major issue for many French and other Continental prehistorians (Evin 2005). It did not help that the period of interest here lies at the extreme range of the most widely applied chronometric method, radiocarbon dating. In recent decades, there have been efforts to refine and apply alternative dating methods, such as thermoluminescence, optically-stimulated luminescence, ESR and uranium-series methods, and magnetic susceptibility, with some success (e.g., Schwarcz 1997; Rink et al. 2002; Harrold et al. 2003). There have also been major advances in radiocarbon dating, ranging from AMS dating, through vastly improved pretreatment methods to deal with contaminated samples, to, especially, calibration frameworks which appear to translate reliably radiocarbon dates into dates in calendar years well beyond 40,000 BP (van der Plicht et al. 2004; Fairbanks et al. 2005; Mellars 2006a), as well as programs to better date regional archaeological frameworks (e.g., Conard and Bolus 2003; Dujardin and Tymula 2005). Progress has been real, but disagreements over different calibration curves, the role of contamination in younger dates, and the validity of associations between samples and the materials they are said to date, still betoken problems to be resolved. Assuming an increasingly important role is the direct radiocarbon dating of human fossil remains (e.g., Rougier et al. 2007); one effect has been to remove from the table some long-accepted associations between human fossils and Aurignacian industries (e.g., Vogelherd; cf. Trinkaus 2005).

Studies of paleoenvironment and climate change: Along with continued sedimentological and palynological analysis within, and correlations between, sites, major team efforts have gone into linking changing climate as inferred at European sites with the highly detailed and precisely dated records of glacial ice cores in Greenland (Mellars 2004b, 2006c; Van Andel and Davies, eds. 2003; Vermeersch 2005). Already, conceptions of the amplitude and wavelength of climatic changes in Europe during Oxygen Isotope Stage (OIS) 3—and of their implications for human biocultural evolution—have been radically affected (e.g., Mellars 2004b; Stringer et al. 2003; d'Errico and Sanchez Goñi 2003; Finlayson 2004; Stewart 2005). Considerable progress has been made toward an accurately dated, detailed chronometric framework for OIS 3 climate change in Europe, into which fossil and archaeological sites can be fitted, though we are cautioned (Van Andel 2003) that important but brief climatic events on a scale of less than 1,000 years (like the sharp and perhaps evolutionarily important Dansgaard-Oeschger events) cannot yet be dated with sufficient precision to test some suggestions of association between particular climatic and evolutionary events.

DNA studies: Since the 1980s, this work has added a new line of evidence, alongside skeletal analysis, for the course of human evolution and, particularly, the relationships and divergences among modern and ancient populations. Most studies have compared DNA variations (mainly of mitochondrial DNA, but also including nuclear DNA) among contemporary human populations in analyses seeking to establish regions of origin, divergence times, and population histories related to the emergence of modern humans. Recently, mitochondrial DNA (Krings et al. 1997, 1999, 2000; Schmitz et al. 2002; Caramelli et al. 2003) and even nuclear DNA (Noonan et al. 2006; Green et al. 2006) has been isolated from Neanderthal fossils and sequenced, then compared to that of modern humans. To make a complicated and contentious story short, the numerous studies of the modern DNA (e.g., Forster 2004; Serre et al. 2004; Current and Excoffier 2004) tend to indicate a relatively recent, and probably African origin of the ancestors of contemporary human populations (though not in an uncomplicated or unambiguous way [Templeton 2002; Relethford 2001; Carroll 2003]), while the studies of Neanderthal DNA so far underline the genetic distinctiveness of Neanderthals, indicative of a separation from the line leading to modern humans back in the Middle Pleistocene—though they do not rule out a Neanderthal role in the ancestry of later Europeans.

After a period of increasing interest and research in the biological and cultural transitions to modern humanity, a series of conferences and ensuing publications beginning in the mid-1980s (perhaps most prominently the above-mentioned Cambridge conference) brought these issues to a wide scientific and lay audience (Trinkaus and Shipman 1993; Stringer 2002; Stringer and Gamble 1993; Wolpoff and Caspari 1997; Wolpoff et al. 1994). The transitions in Europe became set in a worldwide context, and a long-running debate, often acrimonious and polarized, ensued between proponents of "Out of Africa" and "Multiregional" models of modern human origins. In the European context, the debate was often set in terms of the worldwide origins issue, but still tended to pit those who saw the Middle-Upper Paleolithic transition as involving biological and cultural discontinuity against those who interpreted the record in terms of at least considerable continuity.

Current Perspectives

Over the past two decades, the modern human origins issue has continued along recognizable lines, but it is important to recognize that novel elements have been introduced. As detailed elsewhere (Harrold 2007), three main models of the transition to Upper Paleolithic and AMH in Europe can be discerned (although, as we will see, by no means can all workers' views be accommodated within them). I have termed them the population dispersal, mosaic, and indigenist models.

Before briefly characterizing these models, I should note that in recent publications one can find evidence of some convergence among their proponents over one crucial question: the fate of the Neanderthals and the origins of anatomically modern populations in Europe. One can by no means speak of unanimity, but one can find some agreement among proponents of all three models that what (at least primarily) occurred in Europe during OIS 3 was the replacement of indigenous Neanderthals by AMH of extra-European, and probably ultimately of African, origin (Trinkaus 2005). Some authors insist that this replacement was effectively total, equating to Neanderthal extinction, with no gene flow of any significance between Neanderthal and AMH populations, and thus no Neanderthal ancestry for later populations (e.g., Klein 2003; Tattersall and Schwartz 2000). Others insist that significant admixture and ultimately, absorption occurred, so that the resulting European populations, while clearly anatomically modern in total morphological pattern, preserved a Neanderthal contribution in their DNA, manifested in the continuing occasional occurrence of some Neanderthal skeletal traits. Thus it is argued that the Neanderthals did not actually become extinct (e.g., Smith et al. 2005; Frayer 1992; Zilhão and Trinkaus, eds. 2002; Zilhão 2006b).

This quasi-consensus is significant in that a view of continuity commonly expressed at the beginning of the modern era, and traceable back a century or more in the literature—that Neanderthals had simply evolved into moderns (e.g., Brose and Wolpoff 1971)—is no longer widely accepted as viable. It is broadly perceived that too much reasonably well-dated fossil and archaeological (and DNA) evidence is inconsistent with such a view. Evolutionary continuity is often still advocated, but not simply as anagenetic transformation of Neanderthal populations.

The most widely-held of the three models that we will discuss is the population dispersal model (e.g., Mellars 2004a, 2005; Klein 2003; Stringer and Gamble 1993; Hublin and Bailey 2006). This model had already appeared in its main lines by the latter 1980s (e.g., Mellars 1989; Stringer 1989), and has not undergone great modifications since. It explains the Middle-Upper Paleolithic transition primarily in terms of the movement across Europe of AMH, bearing artifacts of the Aurignacian industrial complex (but see below for qualifications regarding this term), characterized—compared to the Mousterian—by novel lithic technology and forms, artifacts of bone and antler, and items of ornament such as pierced shells and teeth.

There are also several reasonably well-characterized, non-Aurignacian, regional industries of the early Upper Paleolithic, such as the Chatelperronian in southwestern Europe, the Uluzzian, centered in Italy, and the Szeletian and Bohunician in central Europe, which typically show some technological and typological similarities to regional Mousterian assemblages. The Chatelperronian is associated with Neanderthal remains in at least two cases, and such an association is suspected for the other industries (but see Bar-Yosef [2006], who resurrects the argument that the Chatelperronian and other such industries are associated with modern humans). These "transitional" industries, as they are often called (but see Riel-Salvatore in this volume), suggest that the Middle-Upper Paleolithic transition did not involve a simple scenario of industrial replacement of the Mousterian by the Aurignacian. They also imply that neither was population replacement simple and straightforward. The model explains the Chatelperronian (and by extension, the other "transitional" industries) in terms of the impact on indigenous Neanderthals of incoming AMH through acculturation and/or stimulus diffusion.

This model can accommodate either total replacement of Neanderthals, or some degree of admixture (Trinkaus 2007), but implies in any case that incoming AMH populations had some competitive advantages(s) over Neanderthals that explained their replacement. A wide range of such factors has been suggested, including reproductive, physiological, cultural, and cognitive ones. All have proponents, none can claim to have been really well-tested, and one, regarding superior hunting abilities among moderns of the early Upper Paleolithic, has not so far fared well in such testing as has been done (see references cited above, and Harrold [2007])—but see Hockett and Haws (2005) on comparative diet breadth between Neanderthals and AMH, Kuhn and Stiner (2006) on distinctive Neanderthal adaptive strategies, and Marean (2005) on the hypothesis that Neanderthal adaptive strategies were distinctively higher in risk, return, and cost. The most controversial is the suggestion that AMH had a cognitive advantage over Neanderthals, such as fully phonemic, syntactical language, a more effective working memory, better abilities to plan subsistence activities logistically, or other neuropsychological factors (e.g., Klein 2003; Noble and Davidson 1996; Coolidge and Wynn 2004;

Lewis-Williams 2002; Mithen 1996; Binford 1989; Lieberman 2007).

As Klein (2003) has pointed out, the Chatelperronian represents a potential problem for population dispersal advocates who hold that the AMH advantage over Neanderthals was a cognitive one. If Neanderthals were capable of producing an Upper Paleolithic industry that featured bone and antler tools, objects of adornment, nonutilitarian use of red ocher, clear structures (shelters) in archaeological sites—an artifactual range and complexity rivaling that of the Aurignacian—then, even if all of this resulted from cultural diffusion, one might infer that they did not lack the cognitive wherewithal to achieve an Upper Paleolithic level of culture. Model proponents can argue for AMH competitive advantages unconnected with cognitive abilities (due to physiological advantages, or an Upper Paleolithic "*cultural* (rather than biological) revolution" [e.g., Hayden 1993]). Or they can argue, as Klein does, that the archaeological record still supports the imputation of cognitive differences—that Neanderthals may have been capable of imitative behavior but still at a cognitive disadvantage; but the potential problem is there. Indeed, before the 1979 discovery of a Neanderthal at Saint-Césaire in Chatelperronian deposits, it was often thought (on equivocal evidence) that this early Upper Paleolithic industry must be associated with AMH.

It should be noted that there are researchers who agree with population dispersal advocates that Neanderthals became extinct, and that moderns spread through Europe during OIS 3, but who see no need to postulate a causal relation between the two events. Finlayson (2004) argues that the two are essentially independent—that Neanderthal extinction was related to the strong and often rapid climatic oscillations of OIS 3 and their negative effects on the Neanderthals' favored environments, and would have happened with or without AMH in the neighborhood. In a similar vein, Stewart (2005) concludes that Neanderthal extinction was probably inevitable, like that of several other species of Pleistocene fauna, in the vicissitudes of OIS 3. These views have been stimulated by the paleoclimatic work cited above that links terrestrial deposits to the detailed Greenland ice core evidence, and it will be interesting to see if they are supported by future work.

The population dispersal model seeks to explain a great deal of archaeological, fossil, and other evidence from a broad swath of time and space, and to link developments in Europe to the worldwide Out of Africa model of modern human origins. Though more ambitious and detailed than Breuil's 1913 scheme, it shares with it the basic elements of population replacement and AMH competitive superiority. It also shares the basic notion of a Paleolithic industry as representing shared, learned toolmaking behavior patterns and a cultural network at some scale, probably well beyond that of "identity-conscious groups." Industrial traditions thus might (or might not) be associated with distinctively different human populations.

Developed in reaction to aspects of the population dispersal model, the model I have termed "indigenist" has the shortest history of the three, dating in its first published manifestation to 1998 (d'Errico et al. 1998; see also, e.g., Zilhão 2001; d'Errico and Sanchez Goñi 2003; Zilhão 2006a, 2006b; Zilhão et al. 2006; but see also Mellars et al. 2007). This model accepts several of the main tenets of the population dispersal model—that AMH replaced Neanderthals (though, it is argued, with significant admixture); that Aurignacian industries represent the spread of AMH; and that the Chatelperronian and other "transitional" industries (and the Mousterian, of course) are the work of Neanderthals. However, in other respects, it turns the population dispersal model on its head. It charges that widely-accepted dating frameworks pointing to millennia-long regional temporal overlap between the Aurignacian and Chatelperronian (and by extension, between AMH and Neanderthals) were wrong. Chatelperronian sites are all older than Aurignacian sites, it is argued, and the Chatelperronian therefore could not have been in any way the result of Neanderthals' contact with AMH. The perceived overlap between the industries is argued to be due to numerous radiocarbon dates on contaminated samples that appear too young, as well as by failure to recognize disturbed deposits in several important excavations. Rather, in this model the Chatelperronian (like other "transitional" industries) represents the independent flowering of a Neanderthal Upper Paleolithic, and demonstrates that Neanderthals were the cognitive and cultural equals of AMH. As noted above, the essential replacement of

Neanderthals by AMH is accepted, with the proviso of significant admixture. It is argued that the replacement was related to extreme and rapid climatic oscillations within OIS 3 and/or the linkage, after AMH arrival in Europe, of the Neanderthal gene pool with the much larger AMH pool, spread over a large part of the Old World (e.g., Zilhão and Trinkaus, eds. 2002; d'Errico and Sanchez Goñi 2003; Zilhão 2006b). In the latter case, the Neanderthals were genetically swamped by linkage to a much larger gene pool, but left their genetic mark in Upper Paleolithic populations—e.g., in the Lagar Velho child (Zilhão and Trinkaus, eds. 2002; Trinkaus 2005).

The indigenist model has been criticized, especially on the basis of its chronological arguments, which many see as strained and overreaching (Straus, and Mellars, in Mellars et al. 1999; Mellars 2000, 2005; Harrold and Otte 2001; Conard and Bolus 2003; Gravina et al. 2005; Straus 2005b, 2005c), but here our concern is with tracing the intellectual strands of the model rather than with evaluating the arguments and counter-arguments in detail. Like population dispersal advocates, indigenists conceive of industries as groupings reflective of shared cultural patterns, representative of social networks at a large scale, which may represent biologically different human populations. Though traditional in that sense, they set forth a radical reinterpretation of Neanderthal cultural capabilities, and the proposition that we must seek the origins of "modern behavior" (to cite that ill-defined but much-used term [McBrearty and Brooks 2000; Harrold 2007]), not in the Upper Pleistocene, but among the common ancestors of Neanderthals and AMH in the Middle Pleistocene or even earlier (Zilhão 2006b). Like the dispersal advocates, indigenists set forth a "big answer"—an ambitious scheme to trace large-scale patterning in human biocultural evolution in much of the Old World. And, like a number of population dispersal advocates, they are quite confident in the data patterning they find and the explanations they propose for it. Their model includes elements from both sides in the old replacement-vs.-continuity dispute: on the one hand, replacement, but on the other, Neanderthal cognitive equality rather than primitiveness and inferiority.

Finally, there is the "mosaic" model, which in several respects stands in contrast to the other two models. This model took form in the later 1980s, around the same time as the nascent population dispersal model (e.g., Clark and Lindly 1989; Straus 1987), but it shows intellectual linkage with gradualist and continuity thinking of the past: Brose and Wolpoff, Smith, Brace, Hrdlička, etc. (sources cited above). The mosaic model has been allied to some extent with the multiregional theory of worldwide human evolution (especially with Smith's assimilation model [Smith et al. 2005]) against the similarly allied Out-of-Africa and population dispersal models outlined above.

The mosaic model is set against the opposing models at two levels. First, its proponents find many empirical holes in the models—or, more precisely, charge that large-scale generalizations of the other models are not nearly as well supported as is supposed. To take one example, consider the human population-to-industry associations accepted in the other models (e.g., AMH = Aurignacian). While it is true that all diagnostic human remains found in clearly Aurignacian contexts are anatomically modern, it is also true that the earliest Aurignacian components lack diagnostic remains, while some modern human remains long thought to be associated with the earlier Aurignacian have recently been shown by direct dating to be much younger (Trinkaus 2005). Thus, they ask how we can be sure that *all* Aurignacian sites, especially the crucial early ones, were left by AMH. How can we be sure that at least some were not left by Neanderthals, or transitional, or hybrid populations? They note similarly a lack of good human associations for most of the "Transitional" industries, like the Bohunician. They thus consider unwarranted the inference that Aurignacian assemblages were left by AMH, and Middle Paleolithic and "Transitional" ones were always left by Neanderthals. In general, they feel that the variability of the complex OIS 3 archaeological and fossil record cannot be encompassed by the simplistic "big answers" of the other models. The available evidence, they charge, does not bear the inferential load placed on it by these models.

At a deeper level, the mosaic model reflects skepticism over received notions of the reality and significance of conventionally recognized Paleolithic industries (e.g., Straus 2007; Clark in this volume), and over the very notion that we should ever expect constant associations between industries and species or subspecies of fossil hominids. In a similar vein, Riel-Salvatore and Barton (2007) suggest that conventional Middle and Upper Paleolithic systematics obscure significant interassemblage variability, and make genuinely fruitful research into the period of interest more difficult. Clark, in particular, argues that the other two models, and paleoanthropological research in general, exhibit epistemological naiveté, and fall far short of acceptable scientific standards of hypothesis formulation and testing, and theory building (Clark 2001, 2002a, 2002b, 2007), manifesting a prescientific "Old World Paradigm."

Mosaic model proponents are far more tentative than their rivals tend to be about what actually happened during the period of interest. Some of them, at least, do not dispute that AMH, broadly speaking, replaced Neanderthals (Straus 2005c; Smith et al. 2005), but they see a role for local evolution, gene flow, and complex local processes that they think cannot be easily subsumed under grand theories. They emphasize regional and local variability in the archaeological and fossil records, and the adaptive flexibility of Upper Pleistocene humans of all populations (e.g., Straus 2005a, 2005b, 2005c; Clark 2002a). They are skeptical of claims of cognitive difference for Neanderthals, and think that there was a broad distribution of knowledge of the technology and forms of stone and organic artifacts, and that people chose techniques and artifact forms that met their needs. The assemblages that people left behind thus would have been variable according to such factors as site activities, mobility, and seasonality. They argue that the Middle-Upper Paleolithic boundary was certainly an inflection point of adaptive change, but that it was followed by perhaps a greater inflection point, the one to the complex systems of the Late Upper Paleolithic during and after the Last Glacial Maximum.

This model is in no small part a product of American "New Archaeology" (and subsequent theoretical developments) in its self-conscious concern with epistemology, scientific procedure, and the testability of current propositions about the past—although, interestingly, its proponents have reached very different conclusions about Middle Paleolithic behavior than did Binford (1989), the seminal figure of that movement. It exemplifies the intellectual impact of the encounter between American anthropological archaeology and European prehistory (see essays in Straus, ed. 2002).

The mosaic model does receive some support from European workers. For instance, Cabrera et al. (2005, 2006) have argued, based especially on their work at El Castillo, that the Mousterian-Aurignacian transition, at least in Cantabria, was an autochthonous development engendered by the encounter between Neanderthals and moderns. This argument for Mousterian-Aurignacian cultural continuity is an interesting echo of a somewhat similar argument by Hrdlička (1927) noted above, and reflects earlier Spanish suggestions of Neanderthal-modern contact, cultural mixing, and continuity (e.g., Jordá Cerdá 1955). Roebroeks and Corby (2001) charge that claims of complex behavior by Neanderthals (e.g., human burial) are routinely subjected to much stronger scrutiny than similar claims for AMH. The resulting double standard, they argue, serves to preserve artificially a perceived behavioral gulf between the two groups, and to undergird the population dispersal model. (This argument, though, could serve the indigenist model just as well as the mosaic).

In sum, the mosaic model owes much to both traditional emphases on continuity in the prehistoric record, and theoretical developments in American anthropology in the latter half of the twentieth century. It offers a much less definite account than the other two models of what happened during OIS 3, mainly because of a conviction that the "big answers" proposed by the other models are theoretically suspect, simplistic, and unsupported by available evidence.

It should be noted that a goodly number of researchers, especially Continental workers, are not adherents of any of the models described above. As a broad generalization, these uncommitted workers believe that available evidence simply does not allow a simply-stated, "big-picture" generalization of the significance of the Middle-Upper Paleolithic transition and its relation to the fate of the Neanderthals. Though few if any of them seriously dispute a broad replacement scenario, they tend to stress the incomplete and fragmentary nature of the available archaeological record as a shaky basis for large-scale generalizations, or the complexity of local and regional archaeological records (e.g., Vaquero et al. [2006] in Iberia; Svoboda [2006] and Nigst [2006] in Central Europe; and Usik et al. [2006] in Transcarpathian Ukraine), or both. They often stress as well the need to avoid unwarranted assumptions of unvarying associations between particular industries and particular human populations. Their skepticism, and their concern that the population dispersal and indigenist models are premature and/or simplistic, are reminiscent of the mosaic model. However, they generally take their positions from a traditional Continental theoretical perspective that Clark (cited above) would doubtless regard as typical of the prescientific Old World paradigm.

Earlier, we discussed the quasi-consensus on the (at least predominant) role of population replacement in the emergence of European AMH—and noted that all models had been able to incorporate this development without doing violence to their basic tenets. A similar development can be seen in the nuancing of models in response to an increasing perception of the heterogeneity of the industries traditionally grouped together as Aurignacian. Though a number of artifact forms (keeled and nosed scrapers, blades with scalariform retouch, retouched bladelets, split-base bone or antler points, etc.) are broadly distributed among "Aurignacian" components, it has long been recognized that there was a great deal of differential occurrence and interassemblage variability. This recognition is not new (cf. Sonneville-Bordes [1960] on Aurignacian 0 and I), but the increasing salience of this variability has led to significant reformulation. Mellars (2006b), for instance, now speaks of the Aurignacian (the "classic" Aurignacian I) spreading into western Europe via the Danubian corridor; while the Fumanian (the "Protoaurignacian," with retouched bladelets but few classic Aurignacian types) spread west through the Mediterranean zone (see, for instance, Bon [2002] and Teyssandier [2006] for similar formulations). Mellars suggests for these industries a common Southeastern European origin—and ultimately, one in the Near Eastern Initial Upper Paleolithic—as would be expected for industries borne by westering AMH. More radically, Bar-Yosef (2006) proposes that it is a mistake to regard the classic Aurignacian anywhere as the industry of the earliest AMH. For him, the classic Aurignacian developed in central and western Europe from earlier initial Upper Paleolithic industries ("Fumanian," Chatelperronian, Bohunician, etc.), all of which were produced by AMH. He would thus sunder the widely-accepted Neanderthal-Chatelperronian association, with its manifold implications noted above. For Zilhão (2006b), however, the analysis of relevant radiocarbon dates shows that the "Protoaurignacian" is simply the earliest Aurignacian. For a mosaic model advocate, the increasingly complicated dispute over the Aurignacian would presumably illustrate once again that the industries defined by prehistorians are reifications invested with too much significance. In short, proponents of all three models will probably incorporate this development without fatal harm to the models.

Concluding Remarks

To a significant extent the study of the Middle-Upper Paleolithic transition and the origins of modern humans in Europe has long been characterized by opposing views of these processes as having been either continuous and gradual, or sharply discontinuous—as evolutionary or revolutionary. It has been noted before that such opposing tendencies are seen, more broadly, in the disputes in evolutionary theory between gradualists and punctuationalists. These tendencies have persisted across generations despite great changes in methods of research, and in the available database, as their proponents have shown ingenuity in adapting them to changing circumstances.

Yet this persisting conflict does not necessarily equate to a lack of progress, as illustrated by the degree of consensus discussed above regarding the primacy of replacement in the emergence of European AMH. There is less agreement on the behavioral significance of the Middle-Upper Paleolithic transition, and on its relation to the emergence of European AMH. Continued progress in this area will require more and better-quality data, particularly as regards chronology. Continuing development of regional sequences in crucial areas (e.g., Iberia, southeastern Europe), and the comparative study of patterning in these regional sequences, will also be important. But attention to theoretical and interpretive issues is required as well. Probably the main theoretical challenge will be the significance of the culture-stratigraphic units or industries that Paleolithic specialists conventionally recognize. Without clearer shared understandings of the behavioral significance of these units, it is hard to foresee a narrowing of differences between, for instance, proponents of the mosaic model and others.

The opposing tendencies highlighted in this chapter clearly affect strongly how researchers perceive and explain new evidence. For instance, as a thought experiment, one might try to imagine what sort of evidence would be needed to persuade a main proponent of any of our three models that their favored model had been disconfirmed. Yet the partial consensus that has emerged on the fate of the Neanderthals indicates that new evidence and new modes of analysis can indeed change predominant interpretations. There is reason to hope that in the future, improved, well founded, and broadly shared understandings of the Middle-Upper Paleolithic transition will emerge.

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From the Middle to the Later Stone Age in Eastern Africa

Pamela R. Willoughby

Abstract The Middle to Later Stone Age transition in sub-Saharan Africa occurred sometime between 50,000 and 20,000 years ago. It is supposed to be the period in which (already) anatomically modern *Homo sapiens* became behaviorally modern "Upper Palaeolithic" people. It is said to occur prior to the dispersal(s) out of Africa which brought modern humans into Eurasia and elsewhere. Various evolutionary models have been applied to this period, most notably Richard Klein's idea that some Africans went through a sudden neurological transformation that resulted in the development of symbolically-based language and culture. This made the dispersal possible, and almost inevitable. What is less well known is that there are few archaeological records in the African continent which can be used to test these models. This paper reviews the evidence for the Middle to Later Stone Age transition in East Africa. While genetics and geochronology point to an African origin of our own species, it is still difficult to conclude what happened during the Upper Pleistocene that led to the spread of anatomically modern humans out of the continent.

Keywords Modern human origins • Behavioral modernity • Lithic analysis

P.R. Willoughby (✉)
Department of Anthropology, University of Alberta, Edmonton, Alberta, Canada

Introduction

A revolution in palaeoanthropology, the study of human origins and evolution, has occurred in the last two decades. It is now clear that our own species, *Homo sapiens,* originated in Africa almost 200,000 years ago (Cann et al. 1987; Clark et al. 2003; Gamble 1994; Howells 1976; McDougall et al. 2004; Stringer 1990; Stringer and Andrews 1988; White et al. 2003; Willoughby 2007). The descendants of this founder population migrated out of the continent following a southern route to east and south-east Asia and into Australia prior to 60,000 years ago (Macaulay et al. 2005; Rose 2004a, 2004b, 2006). Another probable route taken was through the Levant into Europe (Bar-Yosef 1992). These models are grouped under the term "Out of Africa II," or "replacement," and were originally defined using data from mitochondrial DNA sequences obtained from living people (Cann et al. 1987) and the great apes (Gagneux et al. 1999). It is also supported by new dates from fossil and archaeological sites (Wintle 1996) that allow us to begin to reconstruct when and where key events occurred. "Anatomically" modern people are found throughout Africa and at two sites in the Levant, the Mugharet es Skhul and Jebel Qafzeh, well before they appear elsewhere in the Old World (Stringer 2002). But it leaves Middle and Later Stone Age archaeologists, the researchers who study the (sub-Saharan) African cultural record of the last 200,000 or so years of prehistory, with a new problem. Is it really possible that the evolution and dispersal of modern humans occurred without any fundamental change in adaptation or technology? If

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not, how did people become modern, and what was the role of Africa in this transformation?

The archaeological record in Africa spans the entire Pleistocene and the latest Pliocene, beginning as it does around 2.6 million years ago (Semaw et al. 1997). This also dates the appearance of our own genus, *Homo* (Wood and Collard 1999). Normally when new hominid species appeared, their technology also changed, leading some researchers to see a feedback relationship between the two (Foley 1987). The appearance of the first *Homo sapiens* in Europe between 30,000 and 40,000 years ago corresponds to one of these biocultural changes, from the Middle to the Upper Palaeolithic. Here the indigenous Middle Palaeolithic Neanderthals were replaced by, or interbred with, Upper Palaeolithic modern humans (Stringer 1990, 2002). The appearance of *Homo sapiens* in Europe is associated with a number of major technological innovations which are seen by most archaeologists as the hallmarks of true behavioral modernity. These include some of the first blade tools, composite tools, organic tools, figurines, and personal adornment (jewelry) (Bar-Yosef 2002; Mellars 1991, 2005, 2006). This is seen as the creative revolution, one of the key events in human history.

The earliest anatomically modern *Homo sapiens,* however, are African and are associated with Middle Palaeolithic (MP) artifacts in the north and with Middle Stone Age (MSA) ones south of the Sahara (Goodwin 1928, 1929). As is the case in Europe, MP/MSA assemblages tend to be dominated by flake tools produced using radial or Levallois core technology. Diagnostic tools are scrapers as well as Levallois, unifacial and bifacial points. The size and shapes of points vary widely across space and time (Brooks et al. 2006; Henshilwood and Marean 2003; McBrearty and Brooks 2000, 498; Shea 2006). They were standardized in order to be hafted on to shafts in order to function as projectile points. Their formal variation possibly reflects functionally equivalent or isochrestic choices (Sackett 1982), the beginnings of the ability to express ethnicity in material culture (Willoughby 2001b). But otherwise, the basic lithic technology is quite similar to that of coeval humans in Eurasia, such as the Neanderthals. As a result, many replacement advocates place Middle Palaeolithic/MSA modern Africans into a behavioral group with the Neanderthals, despite their obvious anatomical affinity to Upper Palaeolithic Cro-Magnons (as discussed in Willoughby 2000). All are said to be missing something in their basic adaptation. It cannot be biological, since MSA Africans already represent the same species as us today; so it must be a cultural difference. It is culture itself. It is generally assumed that there was an absence of symbolically-based language and culture in all humans prior to 40,000 years ago, regardless of which species was involved (Klein 1992; see also Chazan 1995; Ingold 1995). Klein argues that sudden neurological transformation led to the equivalent of the Upper Palaeolithic revolution (in Africa, the LSA), and to the Out of Africa II dispersal. While this idea is partly supported by data from the FOXP2 gene in extant human populations (Enard et al. 2002; Lai et al. 2001; Krause et al. 2007), it remains to be seen if it can be tested with African archaeological data. While there are many African archaeological sites belonging to the Upper Pleistocene, they tend to be clustered in limited areas of the continent. Additionally, where the MSA is best known, there is little evidence for what happens afterwards.

The Middle to Later Stone Age transition in sub-Saharan Africa is supposed to have occurred sometime between 50,000 and 20,000 years ago. Occasionally referred to as the Second Intermediate period, it corresponds to a time when extremely cold conditions seem to have disrupted human settlement throughout the continent (Potts 2001). North Africa seems to have almost been totally abandoned after the final Middle Palaeolithic (Close 1986), and only a handful of sites elsewhere were occupied. There was loss of tropical rainforest and deserts expanded (Adams et al. 1997; Ambrose 1998a; Bonnefille and Chalie 2000; Gasse 2000). In parts of East Africa, however, the effects of Upper Pleistocene glaciations may not have been severe enough to cause local extinction of human populations. While some lakes, such as Victoria, dried up completely in the Last Glacial Maximum (Hamilton 1976, 1982; Johnson 1993; Johnson et al. 2002), others may have provided a refuge for stressed human populations. Since it is only in East Africa that people may have persisted throughout the last glacial (Klein 1992, 12, 1999, 492), it is the perfect region to test the idea that there was a cultural revolution at the end of the MSA, one which preceded any dispersal of moderns out of Africa. But this environmental scenario can be debated. Recently published palaeoenviromental research at Lakes Nyasa (or Malawi), Tanganyika, and Bosumtwi, an impact crater in Ghana, show that environmental stresses were present as far back as 135,000 years ago (Cohen et al. 2007; Scholz et al. 2007). The geologists who documented this record said that the cold, dry period from 135,000 to 75,000 years ago was even more extreme than that of the Last Glacial Maximum. In contrast, the increased rainfall after 70,000 years ago may have created inland corridors for dispersals of people out of Africa, such as along the Nile Valley (Rose 2004a, 2004b, 2006; Van Peer 1998).

East African Evidence for the Middle and Later Stone Age—Kenya

The Stone Age archaeological record in Africa south of the Sahara is divided into three phases: the Early Stone Age (Oldowan and Acheulean), Middle Stone Age, and Later Stone Age. The Oldowan represents the earliest evidence of stone tool production, one which involved the removal of flakes from pebble cores using hard hammer or bipolar technology. Either the cores or the flakes could have been the desired end product (Toth 1982; Toth and Schick 1986). Acheulean assemblages are marked by distinctive types: bifacial tools of variable size and shape, which are manufactured on cores or flakes. They are classified as handaxes, cleavers, picks, and other types, using their overall shape (McBrearty 2001). MSA assemblages are marked by the production of points, scrapers, and other flake tools struck from radial, discoidal, or Levallois cores (Goodwin 1928, 1929). The flakes are classically described as triangular with convergent dorsal flake scars and faceted (prepared) striking platforms (Volman 1984, 194), but in fact the shapes and production methods can vary greatly. These are first manufactured when Levallois technology appears during the Acheulean; and when large bifacial tools largely disappear around 200,000 years ago, the “leftovers” continue as the Middle Stone Age (Clark 1988). Depending on the region, the Later Stone Age begins sometime between 50,000 and 20,000 years ago and is defined by the introduction of blades, bladelets, scrapers, and/or geometric tools, including microliths (Van Riet Lowe 1929; Ambrose 2002, 10; Kusimba 2005; Van Noten 1977). Later Stone Age assemblages can be macrolithic or microlithic, and are produced on a variety of raw materials including quartz, cryptocrystalline silica, and obsidian.

Many East African sites have records of both the Middle and Later Stone Age. Until recently, however, most Stone Age research here concentrated on the earliest archaeological record. Only a few researchers focused on the later periods here, among them Ambrose (1998a, 1998b, 2002), McBrearty (1986, 1988, 1993, 2001), and Mehlman (1989, 1991). This changed once it was revealed that East Africa could be critical for the understanding of modern human origins and dispersals. In this section, I will review the kinds of evidence that come from sites in Kenya and Tanzania as well as bordering areas of Ethiopia, eastern Uganda, and the Democratic Republic of the Congo.

East of Lake Turkana in northern Kenya (Fig. 1), MSA sites have been uncovered in open-air localities in the Galani Boi Formation (Kelly 1996). Artifacts consist of chert, chalcedony, quartz, and lava, and these seem to vary with distance from the lake, as well as with degree of transport and reduction of cores (Kelly 1996, ii; Kelly and Harris 1992). In southern Ethiopia, where the Omo River flows into Lake Turkana, a number of Middle Stone Age localities have been identified in the Kibish Formation. These include sites where fossil modern or near modern remains have been uncovered. These have recently been redated to as much as 195,000 years old (McDougall et al. 2004). West of Lake Baringo, in the Kapthurin Formation, McBrearty (2001), Deino and McBrearty (2002), and Tryon and McBrearty (2002) have uncovered a whole series of occupations, ranging from the Acheulean through the Middle Stone Age. At the transition between the two technologies, there are assemblages with the handaxes which are typical of the Acheulean, but others without. Another at GnJh-03, between 20% and 30% of the cores were used to produce blades. Fully one-quarter of the excavated flakes are blades, produced by Levallois or non-Levallois

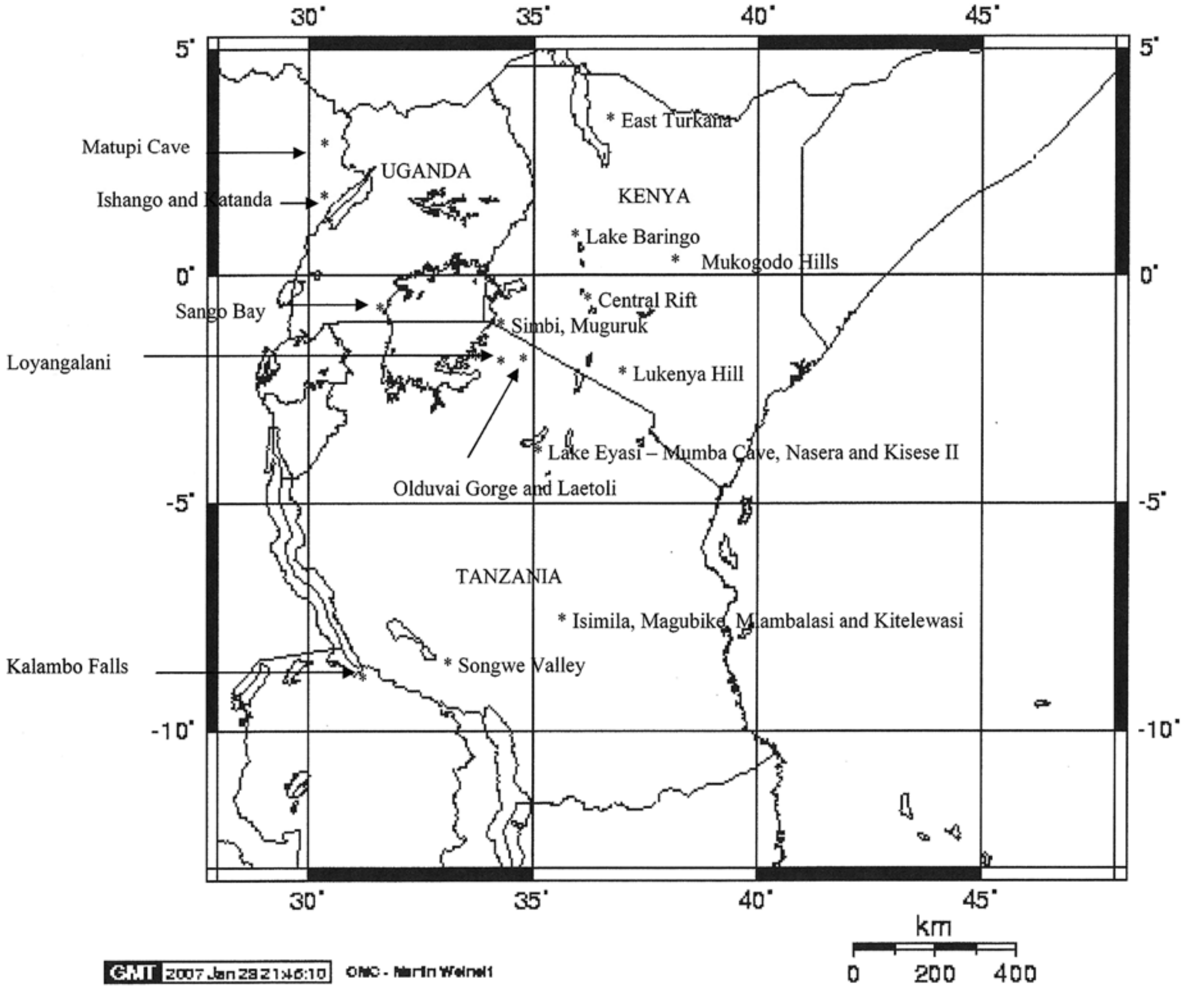

Fig. 1 Map of East Africa showing sites described in the text

production methods (McBrearty 2001, 89; Deino and McBrearty 2002, 185, 208).

In earlier research, McBrearty uncovered MSA sites in the Lake Victoria Basin at Simbi and Muguruk (McBrearty 1986, 1988, 1993). Early work on the Ugandan side of the lake led to the recognition of the Sangoan (from Sango Bay). It was considered to be the first MSA, as it contained elements characteristic of the Acheulean (core axes, picks, core scrapers), as well as MSA types (Mehlman 1989, 5). The Sangoan was initially explained by J. Desmond Clark (1988, 281) as a product of the first movement of people into the tropical forest. But McBrearty's (1988, 388) discovery of Sangoan tools at Simbi, along with fauna and other palaeoenvironmental indicators of grasslands, showed that this was not a valid generalization. Stratified above Sangoan assemblages at a number of African sites is the Lupemban Industry, a Middle Stone Age with distinctive lanceolate points. At Muguruk, there is a sequence of Sangoan, Lupemban, and then more typical MSA tools. The earlier material is grouped into the Ojolla Industry. It is associated with lanceolate point fragments, big retouched tools, and flaking debris, mainly in Omo phonolite, a volcanic rock (McBrearty 1988, 395). Above this is the Pundo Markwar Industry, a typical MSA with artifacts made of a variety of materials, including obsidian, which came from a long distance away (McBrearty 1988, 403).

In the Mukugodo Hills of central Kenya, Dickson and colleagues have excavated at two rock shelters, Shurmai and Kakwa Lelash (Dickson and Gang 2002; Kuehn and Dickson 1999; Pearl 2001). Shurmai rockshelter (or GnJm-1) is one of four cavities on the north side of the Shordika inselberg, at an elevation of 1280 m (Dickson and Gang 2002, 3–4). It includes an archaeological sequence stretching from the late Middle Stone Age through to modern times. The MSA artifacts include backed blades, other blades, denticulated flakes, and a variety of scrapers (Kuehn and Dickson 1999, 63). The main raw material employed was basalt (Pearl 2001, 91). The LSA here is microlithic, and is associated with pottery, and therefore is of Holocene age (Pearl 2001, 94). Kakwa Lelash rockshelter (GnJm-2) is located on the top of the east face of a granitic gneiss inselberg, 5.5 km northwest of Shurmai. The earliest occupation is an undated Later Stone Age, estimated to be more than 40,000 years old (Dickson and Gang 2002, 6). Lithic artifacts from both sites were examined and compared (Dickson and Gang 2002, 1). The most common raw materials are basalt, chert, obsidian, and quartz; quartz and basalt come locally from sources within 5 km of the site. The nearest obsidian source is Mount Kenya, 70 km away (Dickson and Gang 2002, 9–10).

While there are many MSA sites in East Africa, the MSA to LSA transition is only well known in the Central Rift, at sites like Enkapune ya Muto (Ambrose 1998b, 388). Ambrose sees the Sakutiek Industry as a late MSA or a transitional industry; it contains thumbnail scrapers, scalar pieces (*outils écaillés*), some backed microliths, as well as more typical MSA items (small knives, discoids, and faceted platform flakes). Sakutiek artifacts are stratified above the Nasampolai Industry, which is described as typically LSA (Ambrose 1998b, 383, 388). It contains large backed blades and geometric microliths, and a few *outils écaillés,* scrapers, and burins (Ambrose 1998b, 384). Below this is the Endigi Industry which includes flakes with faceted platforms; this is the first true MSA (Ambrose 1998b, 384, 2002, 14). Other sites in the Central Rift have produced a similar record (Ambrose 2002). At Nutmot or Ntuka River 2, there is a 9 m thick stratigraphic sequence. In the deepest level, there is a transitional industry, with radial and blade cores, small obsidian bifacial points, blades with faceted platforms, and some backed microliths. Above this are three LSA levels (Ambrose 2002; Ambrose et al. 2002; Brooks and Robertshaw 1990, 150).

Lukenya Hill is an inselberg in the Athi Plain 40 km southeast of Nairobi in southern Kenya (Kusimba 2001, 2003; Merrick 1975; Merrick and Brown 1984). Both MSA and LSA sites have been found within rockshelters on the hill. From one of them, GvJm-16, Merrick (1975, 34) reported MSA assemblages with scrapers, points, and discoidal cores. These were recovered from below a level with backed microliths, small core scrapers, convex end scrapers, and ostrich eggshell beads. The stone tools were made of local vein quartz, obsidian, and chert. In her research, Kusimba (2003, 170) described two LSA industries, the first of which could be up to 40,000 years old. It is dominated by small artifacts, mainly scrapers (up to 60% of the tools) and a few microliths. These were manufactured from local quartz. Occasionally more exotic materials, including chert and obsidian, were used to manufacture stone artifacts. The second LSA is younger, and shows similarities to the Naisiusiu Industry of Olduvai Gorge (Skinner et al. 2003). Assemblages contain more exotics (obsidian and chert), and microliths become more common (Kusimba 1999, 174, 2003, 172). Kusimba suggests that this represents increasing mobility among the people who made the tools, in response to worsening climatic conditions around the last glacial maximum (Kusimba 1999, 180).

The Eastern Part of the Democratic Republic of the Congo

Some research has been done in the eastern part of the Democratic Republic of the Congo, at sites like Katanda and Ishango, near the Semliki River. In the 1990s, A. Brooks and J. Yellen reported the recovery of bone harpoons in three open-air MSA sites. These were possibly as much as 90,000 years old, and were associated with many fish bones, especially catfish (Brooks et al. 1995; Yellen et al. 1995). At one of the sites, Katanda 9 (Yellen 1996), Middle Stone Age artifacts were produced on quartz, quartzite, and brown chert. The tools were mainly scrapers, some bifacially modified pieces, and core tools (Yellen 1996, 918). LSA sites are also present at Ishango.

They are also associated with barbed bone points, and are estimated to be between 20,000 and 25,000 years old (Yellen 1996, 918).

Matupi Cave is located 70 km west of Lake Albert, in the Mount Hoyo limestone massif. At an elevation of 1,450 m, this site is now part of the Ituri rainforest (Van Neer 1984, 60; Van Noten 1977; Cornelissen 2002). Van Noten (1977) conducted excavations here in 1973 and 1974, and described a sequence of modern material, the Iron Age, then a long LSA sequence, extending from 25 to 210 cm below the surface (Van Noten 1977, 39). Tools include notched flakes and chunks, scrapers, borers, burins, as well as a few backed flakes and bladelets and geometric microliths (Van Noten 1977, 35; Van Neer 1984, 60). The deepest levels are dated to over 40,700 years BP (Van Noten 1977, 39). Palynological studies show that during the LSA, the cave was in a savanna environment, not a rainforest (Van Neer 1984, 60; Van Noten 1977, 40). More recent research in the same area by Mercader (2003; Mercader et al. 2003, 48) led to the discovery of ten granite rockshelters with late Pleistocene and Holocene LSA occupations. Most of the stone artifacts are quartz, and retouched pieces include small core scrapers, side scrapers, small points, and microlithic pebble tools.

Tanzania

In northern Tanzania, MSA and LSA localities are present at Olduvai Gorge, and at an MSA occupation at Laetoli, above the famous human footprint volcanic tuff (Leakey and Hay 1979). A number of sites at Lake Eyasi, including Mumba Cave and Nasera rockshelter, have produced a long sequence of MSA and LSA occupations, which have been used to create a yardstick for the ordering of Tanzanian culture history (Mehlman 1989, 1991). Here, Mehlman has described transitional occupations from the Kisele and Mumba Industries. These are stratified underneath the Lemuta Industry, a Pleistocene LSA (Mehlman 1989, 368).

Three sites at Lake Eyasi (the Skull Site, Mumba Höhle, and Nasera) have produced a long cultural sequence extending from Sangoan to proto-historic times (Mehlman 1989, 1991; Mabulla 1996, 2007; Brooks and Robertshaw 1990, 148). The sites were first studied in the 1930s by Ludwig and Margriet Kohl-Larson, in the 1970s by Mehlman, and most recently by Mabulla (1996, 2007). The Skull site is an open-air locality northeast of Lake Eyasi at an elevation of 1,021 m (Dominguez-Rodrigo et al. 2007; Mabulla 1996, 159). Mehlman collected a number of artifacts from the site, including Sangoan core axes, choppers, and core scrapers (Mehlman 1989, 160; Mabulla 1996, 93). Mumba Höhle is a rock shelter located a few kilometers to the east of the Skull site; it was excavated by Margriet Kohl-Larson in 1934 and 1938 (N. Conard, personal communication), and produced over 9 m of cultural deposits, ranging from the Middle Stone Age to the Iron Age (Mehlman 1989, 11). Another site, Nasera, once known as Apis Rock, is found 90 km north of Mumba on the north side of the Soit Nasera inselberg (Mehlman 1989, 12). In 1932, Louis Leakey (1936, 59) discovered one of the first Middle to Later Stone Age sequences in East Africa (Mehlman 1989, 12). For him, "the culture becomes more virile and is characterized by the presence of very large numbers of backed blades often very well made, and by the tendency to make also many small crescent-shaped artefacts which are known as lunates" (Leakey 1936, 60). The cultural sequence derived from these three sites has become the yardstick for both the Middle and Later Stone Age in Tanzania. In order of age, from oldest to most recent, it is composed of the Njarasan, Sanzako, Kisele, Mumba, Naseran, Lemuta, and Silale Industries. The Njarasan is the local variant of the Sangoan. The Sanzako Industry from Mumba is an early Middle Stone Age with side and notched scrapers, concave scrapers, bifacially modified pieces, and heavy duty tools (small bifaces and choppers). Points are rare and are described as large, broad, and irregular (Mehlman 1989, 103; Mabulla 1996, 162). Most of the artifacts are quartz (Mabulla 1996, 162). This assemblage is associated with a uranium series date of 131,000 years old (Mabulla 1996, 162).

The Kisele Industry at Mumba is estimated to be about 90,000 years old, while at Nasera, it dates to about 56,000 years ago (Mabulla 1996, 162). It contains many disc and part peripheral cores, with a few radial and Levallois cores, mainly in quartz (Mabulla 1996, 163; Mehlman 1989, 207). At Nasera, there are retouched points, bifacially modified pieces, and a variety of scrapers (Mehlman 1989, 200–201). Radial cores are common, but bipolar ones are also present. Mehlman (1989, 266) suggests that there is a shift to bipolar flaking here, while at Mumba, bipolar methods are rare. The Mumba Industry at the site of the same name contains large backed flakes ("knives") and blades, trapezes, and short bifacial and unifacial points (Mehlman 1989, 272; Mabulla 1996, 163). Six radiocarbon dates on ostrich eggshell range from 23,600 to 65,700 BP (Ambrose 1998b, 379). Most of the cores are bipolar (Mehlman 1989, 272). Faunal remains include land snails, producing an *escargotière* (Mabulla 1996, 163). Side and end scrapers with irregular or straight edges are the most common tools (Mehlman 1989, 273). Over time, radial cores decrease in numbers, while platform and bipolar cores become more common (Mehlman 1989, 311). In the earlier levels, large backed pieces are as frequent as retouched points. In later levels, there are few points and backed tools, both large and microlithic (Mehlman 1989, 311). The Naseran Industry has been estimated to be between 23,000 and 27,000 years old. A date of 33,200 BP has also been reported (Mehlman 1989, 321; Ambrose 1998b, 379). It includes small convex and convex end scrapers. Most of the material is quartz. The relative percentage of points to backed pieces is the reverse of that at Mumba (Mehlman 1989, 318). The overlying Lemuta Industry has been dated between 14,800 and 21,600 years old (Ambrose 1998b, 379). It is found in levels 4 and 5 at Nasera, and is absent at Mumba (Mehlman 1989, 368). It differs from earlier industries, since radial and Levallois cores and retouched points are missing, while bifacial retouch is rare (Mehlman 1989, 368). Medium sized (20- to 30-mm long) backed tools, end scrapers, and small convex scrapers are the most abundant tools (Mabulla 1996, 165). Above this is the Silale Industry, a Holocene Later Stone Age (Mabulla 1996, 386).

Kisese II is a nearby rockshelter with paintings, which also may contain a transitional industry with a radiocarbon date of 31,480 on ostrich eggshell (Ambrose 1998b, 379; Brooks and Robertshaw 1990, 147; Inskeep 1962; Mabulla 1996, 91). The early Later Stone Age levels contain *outils écaillés* and convex scrapers, and later levels include backed microliths (Brooks and Robertshaw 1990, 147).

At Olduvai, MSA artifacts are found in the Ndutu Beds, while the overlying Naisiusiu Beds contain LSA assemblages (Merrick 1975, 325; Clark 1988, 275; Hay 1976; Leakey et al. 1972; Skinner et al. 2003). The former consist of olivine basalt flakes with faceted platforms and radial or convergent dorsal scar patterns. These are associated with discoidal and Levallois cores, as well as a few retouched tools (four scrapers, one bifacial discoid, and one chopper) (Clark 1988, 275; Merrick 1975, 325). A Later Stone Age site was found in the Naisiusiu Beds, just north of the second fault. In 1969, Mary Leakey excavated an LSA site and recovered ostrich eggshells, tools, debitage, and *Equus burchelli* teeth (Merrick 1975, 326; Skinner et al. 2003, 1361). All of this is now assigned to the Lemuta Industry (Ambrose 1998b, 379, 2002, 13). Electron spin resonance dates situate these assemblages much further in the past than expected. If accurate, they push the MSA to LSA transition back to earlier than 59,000 to 62,000 years ago (Skinner et al. 2003, 1365).

Lava and quartz artifacts have also been collected from the Ngaloba Beds at Laetoli, a stratum above the famous 3.75 million-year-old human footprint tuff. They are associated with the LH-18 skull, assigned to *Homo heidelbergensis* (Day et al. 1980; Clark 1988, 275).

Loyangalani is an open-air MSA site in the Serengeti National Park (Bower 1977, 1981; Thompson et al. 2004). The site was discovered in 1977 and two localities 200 m apart were test excavated in 1979 (Bower 1977, 20, 1981, 53). These produced both Later and Middle Stone Age occupations. Later Stone Age tools are mainly scrapers, and backed pieces are rare. They are associated with ostrich eggshell, including at least one bead, as well as bits of ochre and many fish bones (Bower 1981, 54). Bower (1977, 22) classified the Middle Stone Age occupation as the Loyangalanian Industry. It includes many scrapers and borers, few points or bifaces, along with disc and Levallois cores. Quartzite is the most common material, then quartz, and a little obsidian (compared to much more in the Later Stone Age) (Bower 1981, 54). More recent test excavations in 2000 and 2003 expanded on the study of both assemblages. The newer Middle Stone Age collections include a few bifacial pieces. There are also ochre "pencils," bone tools, ostrich eggshell beads, and fish bone (mainly catfish) (Thompson et al. 2004). MSA artifacts have also recently been reported from Sonjo Buri in northern Tanzania, near the famous Later Iron Age complex of Engaruka (Seitsonen 2007).

The only other part of Tanzania where Stone Age sites have been studied is in the south, in the Iringa and Mbeya Regions. Twenty kilometers west of the modern city of Iringa in southern Tanzania is the Acheulean site of Isimila, which also has evidence of Middle and Later Stone Age occupations (Cole and Kleindienst 1974; Hansen and Keller 1971; Howell 1961, 1972; Howell et al. 1962). Within a 150 km radius of the capital city are many granite outcrops, some of which contain rockshelters. On a brief visit in the summer of 2005, the District Cultural Officer for Iringa Rural, Ms. Joyce Nachilima, showed me three rockshelters, all of which showed surface signs of repeated occupation. Along with two of my PhD students, Katie Biittner and Pastory Bushozi, I returned in July and August 2006 to excavate test pits at two of them.

Mlambalasi, located 50 km northwest of Iringa on the road to Ruaha National Park, is best known as the burial place of Chief Mkwawa (1855–1898), the leader of the Wahehe in the 19th century. In 2005, I was shown a large rockshelter with a number of chambers above the burial site. There were numerous artifacts present on the surface, including Iron Age pottery, iron and slag, Later Stone Age quartz lithics, and Middle Stone Age pieces in a variety of crypto-crystalline materials eroding out on the slope in front of one room. Organic material, including bone and shell, seems to be well preserved. Test excavations have documented a sequence from the historic period, then the Iron Age, then a microlithic Later Stone Age. Under this are numerous fragmentary human remains, representing part of a Later Stone Age cemetery. Initial radiocarbon dates put these remains between 11,000 and 13,000 years BP. Below the human remains is a macrolithic Later Stone Age belonging to the late Pleistocene (Biittner et al. 2007). It resembles the large backed blade industries seen at Mumba (the Mumba Industry itself) and Enkapune ya Muto (the Nasampolai Industry). We did not reach the bottom, but a second test pit on the slope outside the site shows that the (most recent?) Middle Stone Age is preserved underneath. If so, the macrolithic industry may represent the transition between the Middle and Later Stone Age.

Magubike rockshelter is located within a village of the same name about an hour's drive outside of Iringa. In 2006, we excavated three one-meter-square test pits in 10 cm levels. Test pit 1 extended to a depth of 180 cm and contained the Iron Age and a low density Stone Age occupation; under all of this were hundreds of Middle Stone Age artifacts in a gravel deposit between 110 cm and bedrock. Test pit 2 was excavated in a separate chamber, still under the roof of the modern rockshelter, to a depth of 50 cm when a large rock was encountered, but also the same Middle Stone Age bearing gravels. We then excavated test pit 3 just to the east of it, and this extended to bedrock at a depth of 210 cm below the surface. Both test pits 2 and 3 contain the Iron Age in the top 50–60 cm, and the remainder is an extremely rich Middle Stone Age occupation, with thousands of flaked stone artifacts in a wide range of raw materials. Associated with them are many fossil bones and shells, as well as six fossil human teeth. A shell bead was also recovered from near the bottom of the deposit. Below the rockshelter, in a tobacco field, is evidence of another Middle Stone Age occupation, and the slope in between may preserve other Stone Age deposits. Both of these sites, and a third rockshelter, Kitelewasi, from which we took surface samples, show the association of Middle and/or Later Stone Age artifacts with animal bones and shells. The preservation of such material is a rare occurrence in East Africa, but is essential if we wish to determine the diet of people during this period, as well as the environment in which they lived. Taphonomic analysis of the faunas will also help determine site formation processes. Just a surface collection was also taken from the third, Kitelewasi, and it is mainly represented by quartz and rock crystal lithics which appear to be a mixture of MSA and the macrolithic LSA (Biittner et al. 2007).

I have recovered similar assemblages from the surface of open-air and rockshelter sites in the Lake Rukwa rift valley in southwestern Tanzania (Willoughby 1993, 1996a, 1996b, 2001a, n. d.; Willoughby and Sipe 2002). Rukwa is northwest of the Kalambo Falls area next to Lake Tanganyika in northern Zambia. Kalambo Falls has produced a long sequence of open-air archaeological occupations ranging from the late Acheulean to historic times. It was the focus of extended fieldwork in the 1960s (Clark 2001; Clark and Kleindienst 1974), and provides another comparative sequence for examining all periods of the Stone Age. Along the Songwe River Valley in the Mbeya Region of southwestern Tanzania, I have collected both MSA and LSA artifacts from surface sites and rockshelters. Desmond Clark visited this area in September and October, 1966, while conducting an archaeological survey in northern Malawi (Clark 1970, 1988; Clark et al. 1972; Haynes 1970), and McBrearty and others in 1976 (McBrearty et al. 1982, 1984). I first visited this area in 1989, and returned in 1990 to survey the Songwe River valley. Middle Stone Age material was collected from the surface of deflated sediments, and eventually from rockshelters near the village of Njelenje. Typical tools are scrapers, points, burins, and occasional choppers and bifaces; some large geometric crescents or segments are occasionally recovered. They are manufactured on a wide range of raw materials including quartz, quartzite, crypto-crystalline silica, and various volcanic rocks. Some of the raw materials used by MSA people in the Songwe may come from IdIu-19, a quarry site located 7 km north of the village of Njelenje at an elevation of 1,265 m. Here a thick quartz pebble horizon containing MSA artifacts in a variety of materials caps a deep sequence of fine-grained sediments. When compared to each other, the MSA sites show general similarities. The same kinds of retouched tools are present, and they are produced using the same methods. Heavy duty or core tools are more abundant in the northern sites. There are differences in raw materials, probably depending on what was locally available. Milky white quartz is a preferred material, and was collected in the form of pebbles. Many of the northern sites also contain distinctive volcanic and tabular crypto-crystalline silica rocks which could have come from the quarry site of IdIu-19. Some of the silica could also have eroded out of veins and fissures in volcanic rocks. In the southern Songwe MSA sites, there are usually more volcanic materials, perhaps reflecting their proximity to the volcanic highlands that make up the southern boundary of the Rukwa Rift Valley. No obsidian, however, has ever been observed. The MSA cores recovered are mainly what Mehlman calls peripheral; this involves flaking around the circumference of a sphere, on one or both sides of a pebble. Other peripheral cores are worked on both surfaces, and are classified as radial (if thick in cross-section) or discoidal (if flat in cross-section). "Classical" Levallois radial cores, with their distinctive final flake removal, would also be considered to be a kind of peripheral core. LSA cores, on the other hand, are either single platform blade and bladelet cores, or bipolar. Songwe LSA assemblages are dominated by backed pieces and microliths (crescents, triangles, trapezes, truncations, straight and curved backed pieces), small scrapers, and *outils écaillés,* often associated with bipolar technology. Raw materials employed are usually small white quartz pebbles or fragments of crypto-crystalline silica.

Middle and Later Stone Age Sites in East Africa: What Do They Say About the Origins of Behavioral Modernity?

While archaeological research has been conducted for almost a century in East Africa, it is only in the last two decades that researchers have focused on the Middle and Later Stone Age. Partly this is a result of a focus on the Early Stone Age record, representing the longest cultural sequences in the world. But with the new focus on the African origin of anatomically and behaviorally modern humans, the later sites have become critical. While there are many sites which contain this record, few record the transition. So how does the evidence from either period stack up in terms of the European model of Upper Palaeolithic innovations? Blade or bladelet technology is present in a number of East African MSA sites and is even present in one version of the late Acheulean of Lake Baringo (McBrearty 2001; Tryon and McBrearty 2002). LSA industries are dominated by blades and bladelets, as would be expected in artifacts produced by truly modern people. At some places, a macrolithic LSA precedes a microlithic (Holocene) one, and may help us understand the technological changes at the end of the MSA. But in others, such as Matupi Cave, microlithic LSA technologies extend back well into the Pleistocene (Van Noten 1977). The oldest organic tools in East Africa are the bone harpoons from Katanda (Brooks et al. 1995; Yellen et al. 1995).

Composite and standardized tools are also supposed to be signs of Upper Palaeolithic innovations, but many MSA assemblages contain points that meet both criteria. Levallois reduction methods were employed to produce standardized points and other items that were probably hafted. There are also geometric pieces in the MSA that could have been part of composite hunting tools, as they were in the LSA. More evidence of curation of tools, saving them for future use, can only be seen through a regional analysis of archaeological sites. Differences in tools and debitage can show when items were produced, resharpened, and discarded. Evidence of personal adornment (jewelry) can be seen in ostrich eggshell beads in MSA contexts in Kenya (Enkapune ya Muto), Tanzania (Mumba, possibly Loiyangalani), and elsewhere. Long distance transport of raw materials and tools reflect exchange and information networks. In many East African sites of both periods, there is obsidian obtained from central Kenya. Regional variation in stone tool assemblages, reflecting ethnicity or regional cultural variation, is better seen in items such as the tanged points of the Aterian and the flake-blade and Howieson's Poort Industries of South Africa. But the scalloped or denticulated retouch of tools we have observed in Mbeya and Iringa might also be an ethnic signature. Whether or not MSA sites are more structured spatially can be studied through the three-dimensional piece plotting of individual artifacts. Binford's (1980) notion of a collector rather than forager pattern of mobility can be addressed through the *chaîne opératoire* of lithics, as well as using seasonality data from fauna. Expansion into new territories includes the tropical rainforests of central Africa as well as deserts. Through geomorphology and enhanced dating, we can reconstruct the environmental context of our sites, and whether or not they were still occupied during the harshest glacial episodes. Finally, the association of the MSA with anatomically modern humans is well established, especially at sites greater than 100,000 years old. In general, some signs of behavioral modernity are well expressed in the MSA, while others appear only in the LSA. The search for transitional sites continues, as it is only in this way that researchers can test Klein's model of a sudden transformation of culture just immediately prior to the Out of Africa II dispersal or dispersals.

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Comparing Middle to Upper Paleolithic Transitions in the Middle East and Egypt

Deborah I. Olszewski

Abstract Transitions in the lithic archaeological record are subject to diverse questions. These include whether this record is characterized by gradualism or by punctuated changes; how different terminologies (for example, the Middle Stone Age and the Middle Paleolithic) affect interpretations; at what point a lithic assemblage is classified as Upper rather than Middle Paleolithic; and if the lithic transitions from the Middle to Upper Paleolithic for both modern humans and Neandertals are similar or different.

In the Middle East, there are several instances of lithic transitions from the Middle to Upper Paleolithic—the best known are Ksar 'Akil (Lebanon) and Boker Tachtit (Negev Desert). Less well known is the transition in the Zagros, where the Zagros Aurignacian facies emerges from the Zagros Middle Paleolithic, with subsequent changes in this Early Upper Paleolithic industry to one that shares similarities to the Evolved Aurignacian of Western Europe.

In contrast to the Middle East is the lithic record of the Egyptian Paleolithic. Formal tools here are quite scarce in both Middle and Early Upper Paleolithic assemblages. Various researchers have used either Middle Stone Age or Middle Paleolithic terminology, dependent in part on their view of the relationship of Egyptian industries to those of sub-Saharan Africa. Finally, the rarity of Early Upper Paleolithic sites, and thus the scarcity of available data, limits understanding of the transition in Egypt.

D.I. Olszewski (✉)
Penn Museum & Department of Anthropology, University of Pennsylvania, Philadelphia, PA, USA

Keywords Middle East/Egypt • Lithic transition • Paleolithic • Paradigms

Introduction

The concept of a transition from one state to another has long fascinated archaeologists, particularly in the context of transitions believed to herald major transformations—the origins of hominins, the origins of behaviorally modern humans, the origins of food production, the origins of civilization, and so forth. It is no surprise that the transition between the Middle and Upper Paleolithic also captivates research agendas because this specific transition, correctly or not, has been linked to the beginnings of modern human behaviors, and in some instances, to the advent of modern humans in a region (e.g., Europe). Moreover, the antiquity of the Middle to Upper Paleolithic transition often has meant that evidence for it is limited to a handful of data sets—lithics, symbolic items, absolute dates, subsistence patterns, and intra-site spatial patterning. Of these, it is lithic assemblages that form the most prevalent archaeological signatures, and which form the basis of the discussion that follows on the transition from the Middle to the Upper Paleolithic for the Middle East and Egyptian regions.

As described elsewhere (Olszewski 2007), one of the fundamental issues in the recognition and analysis of Middle to Upper Paleolithic transitional lithic assemblages is the idea that lithic transitions are gradual in character, with incremental changes occurring over time. These incremental changes (often discussed in technological and less often in

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typological terms) are detected usually in the sequence at a single site.[1] Although this paper follows the model of gradualism in lithic transitions, it is worth noting that there are any number of examples that suggest "punctuated appearances," at least for certain lithic types, such as backed microliths in the Near East or Clovis points in the Americas.[2] While the appearance of these types might be the result of incremental changes, such changes could be masked by the fact that archaeological time scales often are too coarse-grained to monitor these increments.[3] On the other hand, there may indeed be instances in which innovations are rapid, and the only "gradualism" present is the time it takes for the innovation to spread geographically over small (or somewhat larger) regions (e.g., perhaps the European Aurignacian as modeled by Davis 2001).

An additional issue in conceptualizing transitions is the notion of whether a transition is a single, unique event, or the result of multiple events potentially widely distributed in time and space. This is especially pertinent to the Middle to Upper Paleolithic transition, where there has been a tendency on the part of some researchers to promote a unique event that marks the advent of behavioral modernity (e.g., Bar-Yosef 1998, 2002; Bar-Yosef et al. 2006; Tostevin 2003), despite widespread evidence for a mosaic evolutionary trajectory (e.g., Henshilwood and Marean 2003; James and Petraglia 2005; McBrearty and Brooks 2000; Vishnyatsky and Nehoroshev 2004). Several researchers also have suggested that the origin of the Aurignacian is not a unique event, but the result of multiple origins (e.g., Olszewski 2001; Straus 1990; Svoboda 2004). Even were a transition in lithics alone an adequate marker for behavioral modernity, it would be fitting to question why such a transition should be a unique event given the numerous instances of independent invention of concepts and technologies that mark the course of prehistory and history associated with hominins—for instance, bifacial technologies of Central Europe in the late Middle Paleolithic and bifacial technologies in Paleoindian North America (Kelly 1988; Kozlowski 2000).

If lithic transitions from the Middle to Upper Paleolithic[4] occurred independently in several regions—which may be the case, for example, for Neandertal related Middle Paleolithic industries transiting into Upper Paleolithic-like industries in Europe (Harrold and Otte 2001; Vishnyatsky and Nehoroshev 2004)—it is expected that the specific characteristics of these transitions will vary from place to place (e.g., Copeland 1986, 11, 2000, 87). Complicating this, as shown in the examples below, is the differential nature of the lithics database from region to region—some areas have longer and more consistent histories of research than others, while there are relatively more or fewer excavated sequences for particular regions—as well as the terminologies used to describe assemblages and types.

The Middle East

Although major Paleolithic research began at approximately the same time in both the Levant and the Zagros, their historical trajectories departed radically after the early 1930s, with intensive archaeological research concentrated primarily in the Levant.[5] As a result, it is the Levantine region where transitional industries or aspects of transitional industries have been more frequently

[1] Theoretically, there could be numerous sites with evidence for these gradual changes, although in practice most of the current evidence comes from a sequence at only one site.

[2] There are many who would argue that the appearance of the Aurignacian in Europe is an example of "punctuated change," due in this instance to the in-migration of modern humans to areas of Europe. But, of course, this is not change within an industry, but change due to an introduction from elsewhere. If one were adhering to a biological sense of "punctuated," it would be necessary to have the rapid change within an industry.

[3] For example, the abrupt appearance of backed microliths and microburin technique is found in the Early Epipaleolithic at Tor Sageer in the Wadi al-Hasa ~ 22,590–20,330 uncal bp at the same moment that late Upper Paleolithic finely retouched Ouchtata bladelets are found at Ayn al-Buhayra and Yutil al-Hasa Area A in the Wadi al-Hasa, ~ 23,500–19,000 uncal bp (Olszewski 2003). In the Americas, the appearance of Clovis fluted points also seems abrupt, beginning at 13,400 cal bp, and lasting as a tradition for only a relatively brief 400 years (Fiedel 1999).

[4] See Clark (this volume) for a perspective on the utility of the terms Middle and Upper Paleolithic.

[5] Exceptions are research by Solecki (1955, 1963) at Shanidar Cave, Iraq, and by Braidwood and colleagues (Braidwood and Howe 1960; Braidwood et al. 1961) in Iraq and Iran in the 1950s and early 1960s.

discussed. One potentially intriguing aspect in the Middle East is the fact that it is known to have included two hominin groups, the Neandertals and modern humans.[6] There is thus some potential for addressing the question of whether Neandertal associated assemblages "transit" into Upper Paleolithic assemblages, although the lack of hominin fossils in the earliest Early Upper Paleolithic presents problems in definitively attributing certain assemblages to specific hominins.[7]

The Levant

The two best known proposed transitional sequences in the Levant are from the open air site of Boker Tachtit in the Negev (Marks 1983a, 1990, 1993; Volkman 1983) and the rockshelter site of Ksar 'Akil in Lebanon (Azoury 1986; Marks 1983a; Ohnuma and Bergman 1990). Another example proposed is the open air site of Umm el-Tlel in Syria (Boëda and Muhesen 1993; Bourguignon 1998). The case also has been made that some Levantine transitional industries include specific types, such as the Emireh point (Copeland 2000; Garrod 1951, 1955; Volkman and Kaufman 1983) or chamfered pieces (Azoury 1986; Copeland 1986).

Boker Tachtit contains four thin archaeological levels ($\leq$ 5 cm each) that are separated by sterile deposits; these are overlain by a considerable depth of overburden (Marks 1983b, 22). Additionally, the four levels do not cover the same area (Marks 1983b, 26). In the case of Ksar 'Akil, the archaeological deposits are quite significant ($>$ 22 m), and include Middle Paleolithic, Upper Paleolithic, and Epipaleolithic levels (Azoury 1986; Bergman 1987). The levels discussed as "transitional" are Levels XXV–XXI, which each vary in thickness, but together comprise about 2 m. At Umm el-Tlel, the stratigraphic sequence includes Middle and Upper Paleolithic deposits (Bourguignon 1998, 709). The archaeological levels (IIbase' and III2a') with the transitional industry are $\sim$ 30 cm thick when taken together.

Trajectories from the Middle to Upper Paleolithic in the Levant sometimes involve the assumption that there is a transition from Levallois to prismatic blade reduction technology: that is, as Demidenko and Usik (1993, 13) state, there are "intermediate links in the change from 'convergent flake point' Levallois industries to 'bidirectional blade point' ones." This trajectory has been exemplified best in the sequence at Boker Tachtit, using extensive core refitting (Volkman 1983). Technological changes between Level 1 (the oldest) and Level 4 (the youngest) are said to document a shift in which pointed blades identified as Levallois points are made using a Levallois technique in Level 1, but made using a prismatic blade technique in Level 4 (Marks 1993, 6–12; Volkman 1983). Technically speaking, the points of Level 4 therefore are morphologically similar to Levallois points, but are not technologically Levallois points. The typology of all four levels is mainly Upper Paleolithic in character, including, for example, endscrapers and burins (Marks and Kaufman 1983) (Table 1; Fig. 1). Interestingly, Levels 1–3 also contain Emireh points, which have long been identified as a marker for transitional Middle to Upper Paleolithic lithic industries (Copeland 2000).

At Ksar Akil, the Phase A assemblages of Levels XXV–XXI also have been examined for evidence of a technological shift during the transition (Azoury 1986; Copeland 1975, 1986). In early work, these levels were described as containing an "evolved" Levallois technology that was marked by Upper Paleolithic tool types made on Levallois blanks (Marks 1983a: 58).[8] Subsequent research on the

[6] It is not possible in the context of this paper to consider the debates regarding whether there are Neandertals in the Levant or not (e.g., Arensburg and Belfer-Cohen 1998), whether the Middle Paleolithic assemblages made by Neandertals and by modern humans are essentially similar or not (e.g., Shea 2003), or whether Neandertals and modern humans were present at the same time in the Levant (e.g., Lindly and Clark 1990). Suffice it to say that Neandertals are definitely present in the Zagros region (Shanidar Cave), and that there are claims for transitional assemblages in both the Levant and the Zagros.

[7] One example of this is by Henry (2003), who attributes the "Tabun B-type" lithics of Tor Faraj in Jordan to Neandertals, despite the lack of hominin fossils at Tor Faraj and associated problems with the Tabun sequence and its applicability to the greater Levant, as pointed out by Hovers (2005).

[8] Copeland (1986, 11–12) disagrees with Mark's (1983) position on the status of Ksar Akil Phase A.

Table 1 Tool typologies of Levantine transitional assemblages (in percentage)

Tools	Boker Tachtit Level 2	Ksar 'Akil XXIII	Umm el–Tlel IIbase'
Endscrapers	12.4	11.1	22.5
Burins	21.6	16.6	6.0
Special Tools			
Sidescrapers	1.6	0.9	2.5
Chamfered pieces	–	55.9	–
Emireh points	8.0	–	–
Levallois points	18.8	–	–
Umm el-Tlel points	–	–	3.7
Borers	0.4	0.2	–
Backed Pieces	0.8	3.7	–
Notch-denticulates	19.6	3.5	25.0
Truncations	0.8	4.8	2.5
Multiple tools	1.2	0.2	–
Retouched pieces	11.5	0.2	35.4
Varia	3.2	2.9	2.4
Total	(250)	(542)	(80)

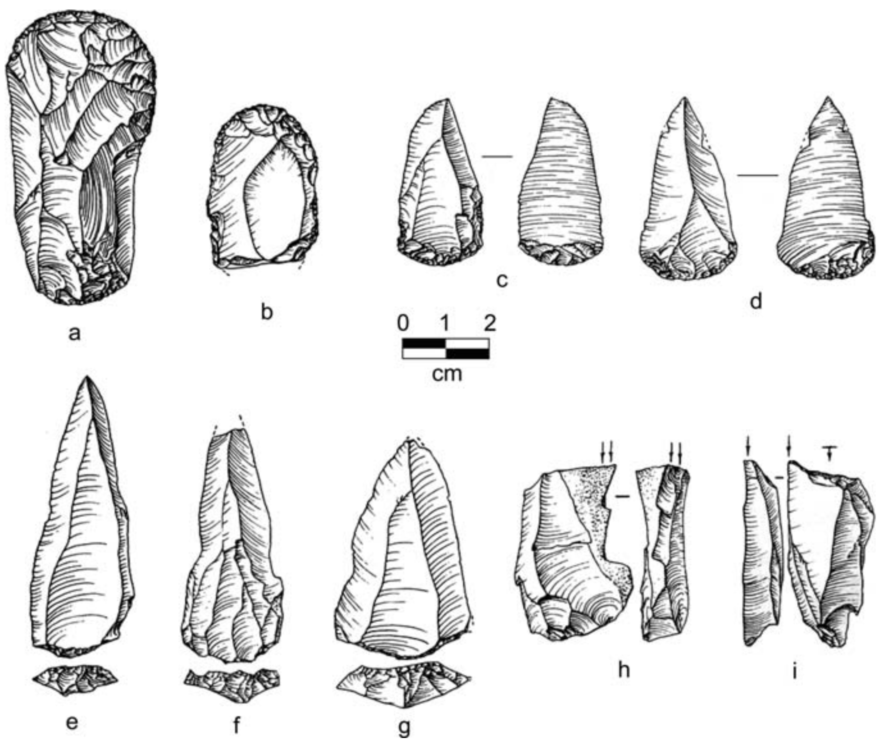


Fig. 1 Examples of Level 2 artifacts from Boker Tachtit: endscrapers (**a**, **b**); Emireh points (**c**, **d**); Levallois points (**e**, **f**, **g**); burins (**h**, **i**) (cf. Marks and Kaufman 1983)

assemblages has suggested to some researchers that blade technology is a feature of all of Phase A, so that there is not a transition from Levallois to prismatic blade technology, but rather changes in blade technology within Phase A (e.g., Ohnuma and Bergman 1990, 133–134). This sequence is thus seen as analogous to Boker Tachtit Level 4, or a technological transition within the Early Upper Paleolithic.[9] Chamfered pieces are characteristic

[9] Other assemblages that feature transitions in blade technology early in the Early Upper Paleolithic have been reported from Wadi Aghar and Tor Sadaf in Jordan (Coinman and Fox 2000; Coinman and Henry 1995, 182–191; Fox 2003; Fox and Coinman 2004).

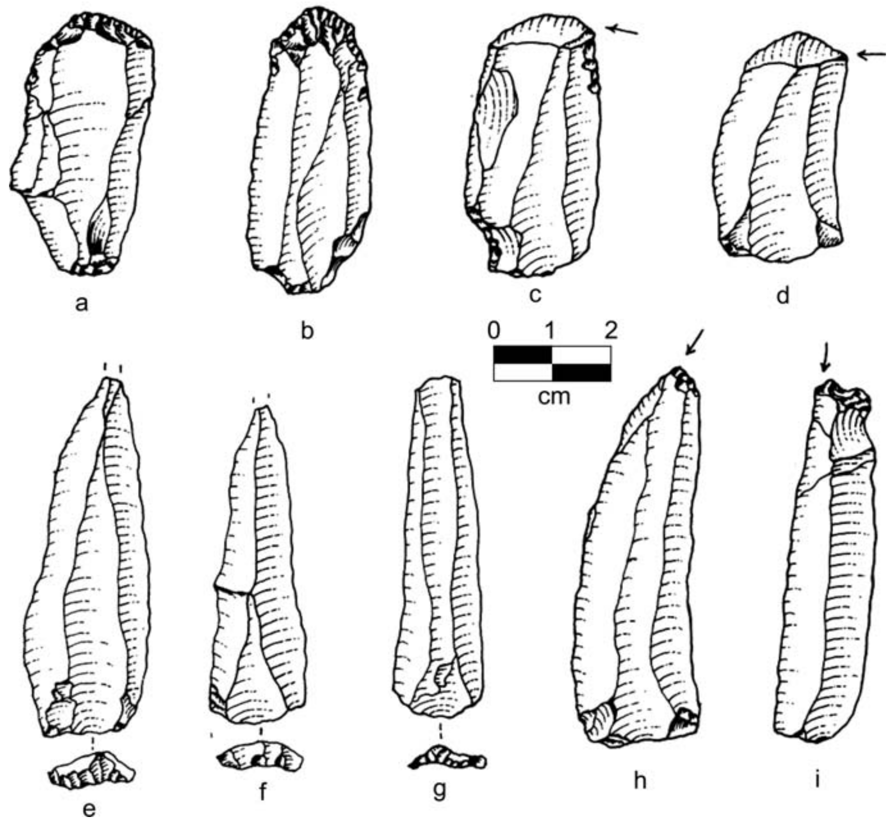


Fig. 2 Examples of Level XXIII artifacts from Ksar 'Akil: endscrapers (**a**, **b**); chamfered pieces (**c**, **d**); Levallois points (**e**, **f**, **g**); burins (**h**, **i**) (cf. Azoury 1986)

of Phase A (Azoury 1986), but appear to be restricted to Lebanese sites of this temporal range (see Table 1; Fig. 2).

More recently, it has been suggested that Levels IIbase' and III2a' at Umm el-Tlel have a transitional industry in which a volumetric Levallois point technology is associated with Early Upper Paleolithic tools (Boëda and Muhesen 1993; Bourguignon 1998, 711–712). While these levels do not document a technological shift in the sense of a sequence from Levallois to prismatic blade technology, they might be considered by some researchers analogous to Ksar Akil Phase A, in having a combination of Levallois technology and Early Upper Paleolithic tool types (see Table 1; Fig. 3).

There is considerable variability in these transitional sequences (Table 2), and each is not without its critics and counterclaims. As discussed above, in the case of Ksar Akil, there is disagreement over whether or not the Phase A assemblages contain a type of Levallois technology (Copeland 1986, 11–12; Marks 1983a; Ohnuma and Bergman 1990, 133–134). For Boker Tachtit, some researchers would argue that Levallois technology is not present in Level 1 and thus the sequence merely represents technological transition within the Early Upper Paleolithic (e.g., Bar-Yosef 1998, 154). Others have claimed that Levallois technology at Boker Tachtit is different from that present in cave and rockshelter sites farther to the north (Sarel and Ronen 2003, 77–78). The Umm el-Tlel transitional assemblage could be seen as problematic because it is situated between two Upper Paleolithic occupations, rather than between Middle and Upper Paleolithic horizons (Olszewski 2007).

Setting aside these disputes for the moment, the general impression is that transitional industries can be monitored by discovering sequences that show changes from Levallois point/blade to Upper Paleolithic blade technology. There are no claims for

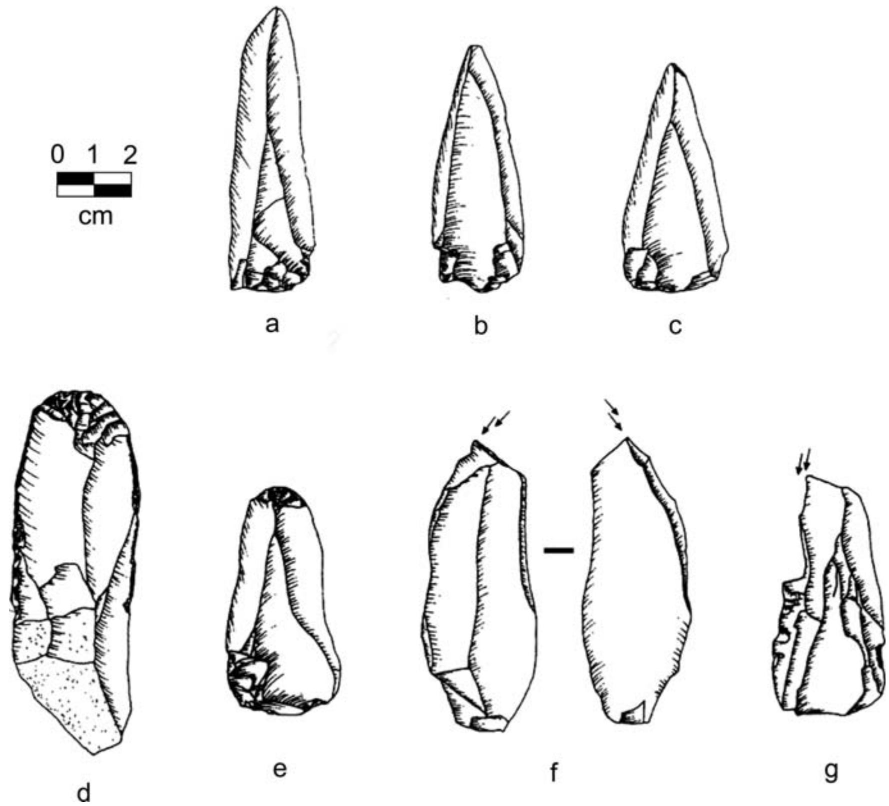


Fig. 3 Examples of Levels III2a'/IIbase' artifacts from Umm el-Tlel: Umm el-Tlel points (**a**, **b**, **c**); endscrapers (**d**, **e**); burins (**f**, **g**) (cf. Bourguignon 1998)

Middle Paleolithic tools manufactured on Upper Paleolithic blanks or Upper Paleolithic tools made on Levallois blanks (except perhaps at Ksar 'Akil). This creates an interesting situation of gradual technological change and "punctuated" typological change (Olszewski 2007).

Table 2 Transitional characteristics proposed for various Middle Eastern sites

Site	Technological description	Typological description	References
Levant			
Ksar Akil Phase A	"evolved" Levallois technology; tools made on Levallois blanks	Upper Paleolithic tool types (e.g., endscrapers, burins); presence of chamfered pieces	Azoury (1986); and Ohnuma and Bergman (1990)
Boker Tachtit Levels 1–4	Levallois technology to produce Levallois points shifts over time to Upper Paleolithic blade technology that produces points shaped like Levallois points; tools made on elongated blanks	Upper Paleolithic tool types (e.g., endscrapers, burins); presence of Emireh points in Levels 1–3	Marks and Kaufman (1983) and Volkman (1983)
Umm el-Tlel Levels IIbase, III2a	Volumetric Levallois point technology	Mainly Upper Paleolithic tools, e.g., endscrapers and burins; presence of Umm el-Tlel points	Boëda and Muhesen (1993) and Bourguignon (1998)
Zagros			
Warwasi Levels AA–LL	Upper Paleolithic blade/bladelet technology; flake technology; tools made on non-Levallois blanks	Middle Paleolithic tool types, e.g., sidescrapers and truncated faceted pieces; Upper Paleolithic tools, e.g., endscrapers, burins, and microliths	Olszewski (2001, 2007) and Olszewski and Dibble (1994; 2006)

The Zagros

In the Zagros region, the rockshelter at Warwasi (Iran) has been proposed as a site containing a transitional sequence represented by Levels AA–LL. Warwasi contains archaeological deposits (~ 5.4 m deep) including Middle Paleolithic (Levels MM–ZZ and AAA–CCC), overlain by transitional (early Zagros Aurignacian[10]) (Levels AA–LL), overlain by late Zagros Aurignacian (Levels P-Z), overlain by Zarzian Epipaleolithic assemblages (Levels A–O). In this case, the transition is from a Middle Paleolithic industry to a facies of the Aurignacian, called the Zagros Aurignacian (Olszewski 1999, 2001, 2007; Olszewski and Dibble 1994, 2006).

The transitional materials from Levels AA–LL (~ 10 cm levels for a total of 1.2 m) contain no evidence for Levallois technology or for point production (morphologically similar to Levallois or other). Technologically, cores are either blade/bladelet or are flake cores. The typology, however, is an interesting combination of Middle Paleolithic—in particular, numerous sidescrapers and some truncated faceted pieces—and Upper Paleolithic types, such as endscrapers, burins, and Dufour bladelets (Figs. 4 and 5). Examination of the cores from the lower transitional levels (FF–LL) shows little evidence for blade/bladelet technology, instead focusing on subradial and single platform flake cores (Olszewski 2001, 2007).[11] In Levels AA–EE, there is a combination of both flake and blade/bladelet cores. The presence of blade and bladelet debitage in Levels FF–LL, despite a near absence of cores for these blanks, suggests that core reduction strategies shifted over time. For example, as cores were reduced in the early part of the transitional sequence (FF–LL), they may have begun as

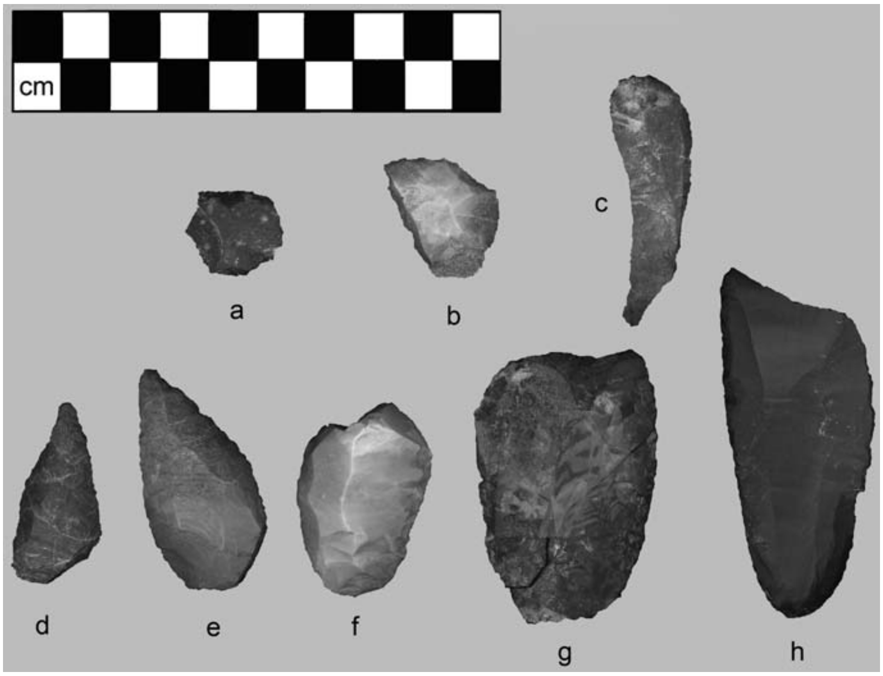
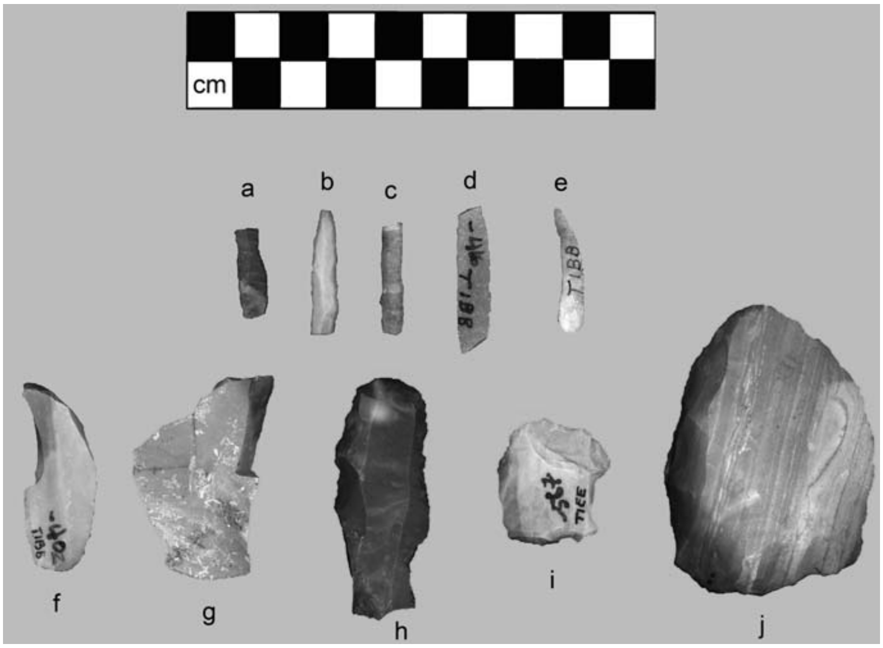


Fig. 4 Examples of early Zagros Aurignacian artifacts from Warwasi: flake endscrapers (**a**, **b**); blade endscraper (**c**); convergent sidescrapers (**d**, **e**); single sidescrapers (**f**, **g**, **h**)

[10] What name to use for transitional industries has been an open question (Olszewski 2001, 81; Sarel and Ronen 2003, 68), with various researchers alternatively choosing names that are more generic, e.g., the Initial Upper Paleolithic, to more specific, e.g., the Early Zagros Aurignacian. This topic will be taken up in the discussion section of this paper.

[11] The underlying Middle Paleolithic levels also are characterized by high laminar frequencies, and quite interestingly, this occurs despite the fact that the core types increasingly become subradial and radial through time (Dibble and Holdaway 1993, 77).

Fig. 5 Examples of early Zagros Aurignacian artifacts from Warwasi: abruptly backed microliths (**a**, **b**. **c**); inversely retouched bladelet (**d**); Dufour bladelet (**e**); burins (**f**, **g**); burin-endscraper (**h**); truncated-faceted pieces (**i**, **j**)



blade/bladelet cores and finished their use-life as flake cores.[12] Such changes in core use are not uncommon events, and have been documented, for example, as a strategy in some Middle Paleolithic assemblages (e.g., Baumler 1988; Dibble 1995). By the later transitional levels (AA–EE), core reduction strategies appear to stress use-life as blade/bladelet cores throughout the reduction sequence, producing higher frequencies of bladelet debitage as a result.

Given the deep sequence at Warwasi, with several temporal periods represented, there might be questions of whether or not some mixing of temporal periods has resulted in the creation of the transitional assemblages. The fact that there are no Levallois products in Levels AA–LL, however, makes it unlikely that the sidescrapers and truncated-faceted pieces in these levels are derived from the underlying Middle Paleolithic assemblages. Additionally, the similar frequencies of various tool classes in Levels AA–EE and Levels FF–LL (Olszewski 2007) also argue for the relative integrity of the transitional assemblages at Warwasi (Table 3).[13]

Dates for the Zagros Aurignacian (Early and Late phases) have not yet been obtained. Recent excavations at Yafteh Cave in the Zagros Aurignacian levels, however, have yielded dates of ~ 35–33,000 uncal bp (Otte et al. 2007); importantly, the Yafteh excavations have not yet reached the bottom of the Zagros Aurignacian levels, so the antiquity of this industry is likely to be greater that the dates currently in hand. The Yafteh assemblage associated with these dates is most similar to the Late Zagros Aurignacian at Warwasi, suggesting that the Warwasi Early Zagros Aurignacian transitional assemblage is earlier in time.

Egypt

The region of the Nile Valley corridor and its surrounding high desert is of interest as one of the possible routes for Out-of-Africa 2 (Bar-Yosef and

[12] This suggestion also has been recently made by Bordes and Shidrang (2006) for the Zagros Aurignacian levels at Yafteh Cave, Iran.

[13] The presence of three geometric microliths in Levels AA–EE is almost certainly an example of displaced artifacts. Increases in burins and in nongeometric microliths, on the other hand, may reflect change over time toward a more stereotypic Upper Paleolithic assemblage.

Table 3 Comparison of tools in Warwasi levels AA–EE and levels FF–LL (in percentages)

Tools	AA–EE	FF–LL
Scrapers		
Blade endscrapers	1.7	1.1
Carinated scrapers	2.1	1.1
Flake and other scrapers	5.2	4.0
Burins		
Carinated	1.7	0.4
Other burin types	8.9	2.7
Nongeometric microliths	15.2	4.8
Geometric microliths	0.6	–
Special tools		
Sidescrapers	20.8	28.2
Truncated faceted pieces	0.4	1.5
Other	0.2	–
Borers	1.7	4.8
Backed pieces	0.2	0.2
Notch-denticulates	21.8	24.2
Truncations	1.4	1.5
Multiple tools	2.5	2.1
Retouched pieces	15.4	22.7
Varia	–	0.6
Total	(518)	(475)

Table 4 The Upper Paleolithic in Egypt

Age in uncal bp	Sites/industries and characteristics	Attribution
20–17,000	Fakhurian, Kubbaniyan, Idufan: numerous microliths, especially Ouchtata bladelets	Late Upper Paleolithic
GAP		
25,000	Shuwikhatian: endscrapers, burins, blades	Upper Paleolithic
GAP		
35–30,000	Nazlet Khater 4 and other sites: denticulates, blades, a few endscrapers and burins	Early Upper Paleolithic
GAP		
60–37,000	Taramsa I and Nazlet Safaha 1 and 2: Levallois points and Levallois blades	Middle Paleolithic: Nubian and Lower Nile Valley Complexes

Belfer-Cohen 2001; Carbonell et al. 1999; Mithen and Reed 2002; Van Peer 1998; Vermeersch 2001). Lithic assemblages of this area have relevance to the question of transitional assemblages wholly within the context of modern human populations.[14] The greatest difficulties, however, in attempting to address the transition in Egypt are that few sites currently are known and that there is a relative dearth of retouched tools for many Middle and Early Upper Paleolithic assemblages (Table 4). Unlike the Levant and the Zagros, where the transition can be examined for either or both technological and typological changes, few available retouched tools in Egypt mean that consideration of the transition must rest mainly on potential technological shifts over time.

Middle Paleolithic assemblages along the Nile Valley corridor and its surrounding high deserts contain both Nubian Levallois and radial

[14] For example, the burial of an anatomically modern human child with Middle Paleolithic assemblages at Taramsa Hill is dated to between 49,800 and 80,400 bp (Vermeersch et al. 1998).

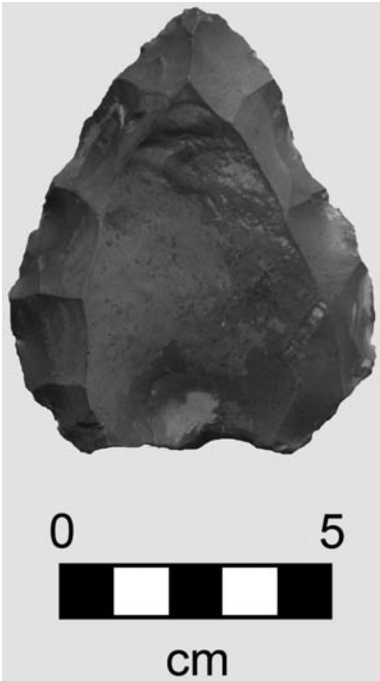


Fig. 6 A Nubian Levallois point core; note that the core is radially prepared (ASPS project)

("classical") Levallois techniques (Olszewski et al. 2005; Van Peer 1991; Van Peer and Vermeersch 1990). The Nubian Levallois technique, in particular, appears focused on the production of pointed Levallois flakes (Fig. 6), and thus is a situation analogous to the Levantine Middle Paleolithic, which also contains numerous examples of either elongated ("Tabun D") or shorter ("Tabun B") Levallois points (Henry 2003; Jelinek 1981; Lindly and Clark 1987). Quite interestingly, then, it is not the Nubian Complex sites which have been proposed as the industry from which Upper Paleolithic blade technology developed, but a Middle Paleolithic grouping called the Lower Nile Valley Complex, e.g., as known from the sites of Taramsa I and Nazlet Safaha[15] (Van Peer 1998, S126–S127). At these sites, Levallois technology has been modified so that relatively numerous blades can be removed from cores. Although there are no sites with a sequence from Levallois to Upper Paleolithic blade technology, the characteristics of the lithics from Taramsa I and Nazlet Safaha are thought to indicate this shift.[16]

Sites of the Early Upper Paleolithic are known from the Nazlet Khater region (Vermeersch et al. 1990, 92–97, 2002). All are open air chert mining locales characterized by the digging of ditches, shafts, and galleries into chert cobble deposits, and include Nazlet Khater 4 (with a series of radiometric dates between 35,100 ±1100 uncal bp and 30,360 ±2310 uncal bp), Nazlet Khater 7 (34,900 ±500 uncal bp), and attempts to re-mine (at 31,600 + 3600/-2500 uncal bp) the Middle Paleolithic site at Nazlet Khater 1. The most complete information is from Nazlet Khater 4. Initial work with the lithics from this site indicated that there is no Levallois technology, and Upper Paleolithic blade production used a relatively simple technology (Fig. 7). Elongated cobbles were struck to remove one large flake, creating the striking platform surface. From this core platform, a series of blades were removed, generally without further core preparation. The blade removals most often have plain platforms, and bidirectional blade cores are unusual in the assemblage (Vermeersch et al. 1990, 97). Some blades are missing and presumably have been transported elsewhere. Tools are extremely rare, and include mainly denticulates and a few burins and endscrapers.

Since then, however, a much more complete analysis of Nazlet Khater 4 has been published (Vermeersch et al. 2002). Using refitted cores, four reduction methods were identified, including use of single platform cores for elongated flakes and blades, opposed platform cores for elongated flakes, opposed platform cores for elongated flakes and bladelets, and opposed platform cores for blades. Of these, single platform cores consist of 53% of the core assemblage and opposed platform cores total 21% (Vermeersch et al. 2002, 240). Importantly, despite the presence of four different

[15] These two sites have been radiometrically dated to 38,100±1400 uncal bp and 37,200±1300 uncal bp (Van Peer 1998, S120), dates which are considerably later than the Levantine transition at Boker Tachtit.

[16] Note that, based on more recent excavations, Van Peer (2001: 48) claims that both Lower Nile Valley and Nubian Complex assemblages are likely to be present at Taramsa I. For the purposes of examining a transition from the Middle to the Upper Paleolithic, however, designating the exact complex giving rise to the transition to the Upper Paleolithic in Egypt is of less consequence than examining the characteristics of the transition.

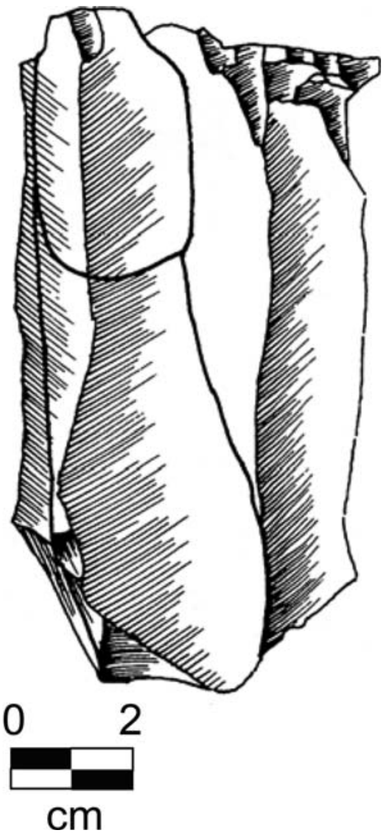


Fig. 7 Example of refitted core from Nazlet Khater 4 (cf. Vermeersch et al. 2002)

reduction strategies, there is very little evidence for extensive preparation of core surfaces or striking platforms. As a result, there are few instances of either crested blades or core tablets. Striking platforms on blanks are often plain for both blades and flakes (33.3% and 75%, respectively), while blades also have punctiform striking platforms (16.7%) (Vermeersch et al. 2002, 245). Very few tools are present; these are primarily denticulates, with rare examples of burins and an endscraper. Vermeersch et al. (2002, 271) contend that Nazlet Khater 4 is "isolated from the local Middle Palaeolithic antecedents, the eventual transitional industries and their successors, and also from the Late Paleolithic." They interpret Nazlet Khater 4 instead as an example of an introduction of blade technology from elsewhere.

Recently, in surveys of the high desert near Abydos, the Abydos Survey for Paleolithic Sites (ASPS) has documented the occurrence of numerous discrete blade flintknapping episodes.[17] Individuals or small groups were targeting a specific flint outcrop in this landscape, and the sites are essentially pristine, i.e., little to no disturbance is evident (Fig. 8). The core reduction technology is similar to that described at Nazlet Khater 4, as shown by refitting of ASPS locales' debitage to cores (Chiotti et al. 2007) (Fig. 9). One truncation (which refits to a core reduction sequence) and two endscrapers were recovered, otherwise tools are not present at these flintknapping locales. Some blades, however, generally about midway through the sequence of removals, are missing and are assumed to have been taken elsewhere in the landscape. While undated, some of these flintknapping locales may document Early Upper Paleolithic occurrences and thus serve as a further record of Early Upper Paleolithic blade technology in Egypt.[18]

Discussion

The above presentation of the characteristics of transitional or Early Upper Paleolithic assemblages in the Middle East and Egypt amply documents the high degree of variability from sequence to sequence both within and between regions. In part this may reflect problems with how researchers define or characterize technology, as noted by Tostevin (2003, 54), or how terminology itself is used (e.g., Vermeersch 2001). It is argued here, however, that this variability may also reflect independent transitions from Middle Paleolithic to Upper Paleolithic industries.

Researchers have long remarked on issues comparing the Middle and Upper Paleolithic that arise due to the use of differing terminology (e.g., Clark 2001, 2002a, 54–57; Harrold 1989; Olszewski 2007;

[17] ASPS recorded dozens of these in the high desert surrounding the Wadi Samhud, through which the modern rail line to Kharga Oasis runs. It is estimated that these discrete blade manufacturing locales number in the hundreds.

[18] The ASPS team is aware that some of these occurrences potentially are much later in time, e.g., the Predynastic or early Dynastic, and is currently examining the Predynastic and Early Dynastic literature to ascertain the characteristics of lithic assemblages of these periods.

Fig. 8 Close-up of a knapping locale in the high desert near Abydos (ASPS project)

Sackett 1988; White 1982). For example, compared to Middle Paleolithic typologies, those of the Upper Paleolithic essentially gloss over the presence of sidescrapers because these tools, which are given more than 20 type numbers in Middle Paleolithic typology, are classified instead in Upper Paleolithic typologies in Special Tools or listed within the Scraper class, thus masking their presence. While it is true that Upper Paleolithic assemblages overall tend to feature moderate to high frequencies in tool classes such as endscrapers, burins, and microliths—rather than in sidescrapers—there are examples of Early Upper Paleolithic assemblages in which sidescrapers occur in relatively high frequencies (e.g., Warwasi: Olszewski [1999, 2001]; Streletskian sites: Vishnyatsky and Nehoroshev [2004]; and sites in Central Asia: Vishnyatsky [2004]). These are not easily "seen" because there is no separate sidescraper class, and thus similarities to the Middle Paleolithic in this aspect often go relatively unnoticed. Typologies of technology can suffer from similar problems (Tostevin 2003, 56–57).

Assigning distinct names to either industries or to large temporal entities also plays a role in masking similarities. One example is the use of Middle Stone Age to characterize African lithic assemblages and Middle Paleolithic to characterize those of Eurasia. Africanists (e.g., Kleindeinst 2001, 1–4; McBrearty and Brooks 2000) argue for the use of Middle Stone Age for the entire African continent, in part because the origin of modern humans is African, and thus the use of Middle Stone Age carries the distinction of a uniquely human phenomenon. The same cannot be said of the Middle Paleolithic where either such industries are made exclusively by Neandertals (as in Europe) or by both Neandertals and modern humans (as in the Levant or the wider Middle East, including the Zagros). Early modern humans in the Levant (ca. 90,000 bp and earlier) migrated into this region from Africa, yet their lithic assemblages are described as Middle Paleolithic rather than Middle Stone Age. To what degree, then, are these assemblages, both made by modern humans (yet named as different lithic traditions), different or similar? Paradoxically, the Middle to Upper Paleolithic transition in the Levant is implicitly assumed to be linked to modern humans despite the lack of hominin fossils in the Early Upper Paleolithic. These "linkage" problems of hominin to lithic tradition are further exacerbated because late Neandertals also produced Upper Paleolithic

Fig. 9 Example of a refitted core from a high desert locale near Abydos (ASPS project)

industries, particularly in Europe (Chatelperronean, Bohunician, Streletskian, Szeletian, among others).

Terminological semantics are involved in what the transitional assemblages are called (Olszewski 2001, 81). Most often these are categorized using names such as Initial Upper Paleolithic or Early Upper Paleolithic (Kuhn et al. 2003; Marks 1993, 15; Olszewski 2001), ostensibly to avoid the "baggage" carried by a term such as "transitional." Labeling transitional assemblages as Upper Paleolithic (initial or otherwise), however, creates its own baggage by finding a transition from one period (Middle Paleolithic) to another (Upper Paleolithic) apparently within the context of one of those periods (Upper Paleolithic).

On the other hand, Tostevin's (2000, 2003) quantitative approach to measuring the transition with comparisons of behavioral divisions of the chaîne opératoire sequence[19] is a noteworthy addition to how technological transitions might be conceptualized. Importantly, Tostevin is searching for antecedents in the Middle Paleolithic, rather than necessarily examining transitional assemblages, e.g., he uses Kebara Cave Unit VI (late Middle Paleolithic: 48,300±3500 uncal bp [Valladas et al. 1987]) and Boker Tachtit Level 1 (Early Upper Paleolithic: 47,280±9050 uncal bp [Marks 1983a], although Marks characterizes this assemblage as Levallois, and thus the last gasp of the Middle Paleolithic). Tostevin's results are quite illuminating, as the difference between these two assemblages is so great as to indicate that they are not related, and that the materials from Boker Tachtit Level 1 are not Middle Paleolithic in character (Tostevin 2003, 64). This would mean that by the time of Boker Tachtit Level 1,[20] the transition from Middle to Upper Paleolithic had already occurred and that the Boker Tachtit Levels 1–4 sequence represents change within the context of the Early Upper Paleolithic rather than a transition from the Middle to Upper Paleolithic, a point also made by Meignen (1996) in separate analyses.

The most curious feature of Tostevin's results (2000, 2003), however, is that *there are few antecedents for the Upper Paleolithic in the Levantine Middle Paleolithic,* at least based on the site (Kebara) he studied. Yet, paradoxically, he maintains that the Levant is the single origin area for the transition to the Upper Paleolithic, which then diffuses into Europe (Tostevin 2003, 65).[21] It is possible that the rarity of antecedents in his Middle Paleolithic study are related to the fact that the two sites examined are from different environmental and contextual settings, which may have influenced the types of

[19] Tostevin (2003, 58) uses the following divisions of the chaîne opératoire: core modification, platform maintenance, direction of core exploitation, dorsal surface convexity system, and tool manufacture.

[20] Tostevin (2003, 61) notes that as the majority of the Boker Tachtit Level 1 artifacts were unavailable for study because they were refitted, his sample for this level from this site is 100 artifacts from five squares. To what extent, if any, this affects the representative characterization of Level 1 overall is unknown.

[21] This model of an Upper Paleolithic—prior to the Aurignacian—that originates in the East, specifically the Near East, also is proposed by Bar-Yosef et al. (2006, 57).

activities and thus the components of the lithic assemblages. Kebara is a cave in the Mediterranean forest and Boker Tachtit is an open air site in the Negev (which was wetter and cooler during the Pleistocene). Examining the transition also is complicated by the fact that Middle Paleolithic assemblages in the Levant are known to date as late as 33,300±2300 uncal bp (Richter et al. 2001). Thus, to some degree Levantine Middle and Upper Paleolithic lithic assemblages overlap in time and space, raising the possibility that not all sites containing Middle Paleolithic lithic assemblages are a record of assemblages that transition into the Upper Paleolithic.

One way to test a transition from the Middle to Upper Paleolithic might be to apply Tostevin's approach or an analogous technological study to the sequence at Warwasi, Iran. The Middle Paleolithic, the transitional (Early Zagros Aurignacian), and the Late Zagros Aurignacian levels could be characterized technologically according to the chaîne opératoire divisions Tostevin uses or other measures, and then compared statistically. Industries such as the Aurignacian must have developed out of the Middle Paleolithic somewhere in Eurasia,[22] as did other types of Early Upper Paleolithic industries.

Comparison of the Middle to Upper Paleolithic transitions in the Levant, the Zagros, and Egypt suggests that the Levantine and Egyptian contexts are more similar to each other than they are to the Zagros. As discussed above, in both the Levant and Egypt, researchers have argued for a transition from Levallois to prismatic blade technique—Egyptian assemblages potentially document a Levallois blade to prismatic blade shift and the Levant exemplifies a Levallois point to prismatic blade shift. Additionally, both the Levant and Egypt yield Middle Paleolithic assemblages that overall have few retouched tools—indicating little reuse of flakes and blades—and both regions have widespread and abundant lithic raw material sources (e.g, Chiotti et al. 2007; Marks et al. 1991; Vermeersch 2002). Given that blade technologies are often presented as "efficient" use of lithic raw materials because of the production of more linear edge per volume of material, it is interesting that the consistent use of blade technology appears in contexts in which raw material constraints are not a limiting factor. This suggests that "linear edge efficiency" explanations for the origins of blade technologies may not be applicable in these two transition contexts. Rather, the transitions in both these regions reflect changes in the approach to linear removals which "transition" from Levallois to prismatic technology.

The Zagros region, on the other hand, serves as a partial contrast to the Levant and Egypt. In the Zagros, raw material availability appears to be limited to relatively small nodules, and retouched tools are frequent in the Middle Paleolithic of the region, suggesting that lithic resources were more intensively used, and that a notion of "linear edge efficiency" might be, at least in part, an appropriate explanatory framework. In this context, the Middle Paleolithic has a relatively high laminar index, even though the cores tend to be subradial or discoidal flake cores (Dibble and Holdaway 1993). The trajectory likely involves cores which begin their use-life as cores for laminar removals and end their use-life as flake cores. The transition in this region thus is one that focuses on maximizing use of lithic raw materials, and represents two alternative strategies to reach this goal. The Middle Paleolithic strategy is one in which, over use-life time, cores produce both laminar (blade-like) and flake products. In the Upper Paleolithic, the strategy is to gain further use of a core by reducing the size of the product—thus over the use-life of a core, first blades and then bladelets are produced.

All three of these transitions involve changes in how the use of a core is conceptualized—linear Levallois to prismatic blade in the Levant and Egypt (areas with little raw material constraint), and, in the Zagros (an area with raw material limitations), strategies to best capture the most from each individual core, which in the Middle Paleolithic is a laminar flake and blade to smaller flake trajectory, and, in the Upper Paleolithic, is a ("large") blade to ("small") bladelet strategy. The specific reasons for these changes in all three areas are ones that must be approached from detailed studies of as many other variables as can be ascertained, such as subsistence, mobility, environment,

[22] I would contend, as do Straus (1990, 1999) and Svoboda (2004), that there were multiple, independent origins for the Aurignacian. A view contrary to the origins of the Aurignacian in the Middle Paleolithic is that held by Bar-Yosef et al. (2006), who argue for its origins in already established Early Upper Paleolithic industries (which they attribute to modern humans rather than Neandertals), probably in West Europe.

and habitat. The best studied region providing the largest set of contextual data is currently the Levant; the Zagros region has a partial contextual set, but research there has been limited by geopolitical events; and the least number of data sets characterizes Egypt—there are few Early Upper Paleolithic sites and these are primarily from only one context, that of quarries.

The fact that the archaeological record contains several differing industries that are categorized as Early Upper Paleolithic, based on characteristics that most researchers would recognize as how the Upper Paleolithic is defined from a lithic standpoint, speaks to the high probability of multiple, independent transitions from the Middle to the Upper Paleolithic. It also might be contended that arguments for a single origin or transition from the Middle to the Upper Paleolithic—for what is a relatively generic technology, the production of blades, and one known to have been "invented" multiple times in earlier prehistory (Bar-Yosef and Kuhn 1999)—greatly underestimate the behavioral capacities of both modern humans and Neandertals. Neither the Middle nor the Upper Paleolithic is a monolithic entity,[23] and thus, a monolithic transition should not be expected. Measures of success in explaining lithic transitions likely will prove contentious, as differing research agendas and theoretical perspectives will continue to impact interpretations (Clark 1993, 2002b).

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[23] No pun intended.

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Through the Looking-Glass. The Most Recent Years of Cantabrian Research in the Middle to Upper Palaeolithic Transition

Alvaro Arrizabalaga and Maria José Iriarte

Abstract Using Carroll's book (Through the Looking-Glass and What Alice found there) as a suggestive guide, the current trends of the research on the Middle to Upper Palaeolithic Transition are described, for the Northern Iberian Peninsula. Some clear weaknesses are described in the patterns used to analyse the period, which should be corrected in order to improve the results of archaeologists' work.

Keywords Epistemology • Historiography • Mousterian • Aurignacian • Iberian Peninsula

The Cantabrian investigation of the Middle to Upper Palaeolithic Transition during the last few years follows various global scale trends: the increasing technification of the method, the regionalization of the scale of the studies, the shortage of human fossil remains, and the search of key sites to clarify the problem (including the reopening of old excavations). Other tendencies are more specific to the Cantabrian investigation, such as the weakness of the geochronological framework, the excessive geographical fragmentation of the regions and of the research teams, and the practical absence of open air Pleistocene records. The aim of this text is to outline which among the chosen methods of study can outline new hypotheses, and which drive us to a dead end, from a critical perspective.

A. Arrizabalaga (✉)
Área de Prehistoria, Departamento de Geografía, Prehistoria y Arqueología, Universidad del País Vasco-Euskal Herriko Unibertsitatea, Vitoria, Spain

Introduction

In 1865 and 1871, the English writer Lewis Carroll published, respectively, *Alice's Adventures in Wonderland* and *Through the Looking-Glass and What Alice Found There*. Carroll's innovative literary vision (oneirical, and occasionally close to the absurd) speedily turned both books into bestsellers. On the other hand, however, Carroll's tendency to include all kinds of physical and mathematical quandaries in the course of his tales allowed both books entry into the Philosophy of Science handbooks. Far from being mere children's literature, Carroll's stories allow for endless meta-readings. In this necessarily short text, we have tried to reflect on some of the most striking paradoxes in current discourse with regard to archaeological research: the transition between the Middle and the Upper Palaeolithic periods, colloquially shortened among specialists to "The Transition" (as if this were the only one Humankind had ever known). Specifically, the paper covers an area of Europe that is of great significance for the diversity of circumstances arising there: the Cantabrian corridor, in the North of the Iberian Peninsula. As in the tales of Alice (some passages have been selected from *Through the Looking-Glass and What Alice Found There* to illustrate this), we will set out on a short trip through the mirror in an essay that, rather than criticism, tends towards self-criticism. We feel that the nature of this text makes it advisable to avoid bibliographical citations and this, together with the presence of recent updates in the state of the art (as at the Altamira Debate in 2004, published in issue

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number 20 of the Monographs from the Altamira Museum and Research Centre in 2005), allows us to concentrate on its ultimate purpose.

The Destabilization of the Model

Tweedledum and Tweedledee
Agreed to have a battle;
For Tweedledum said Tweedledee
Had spoiled his nice new rattle.
Just then flew down a monstrous crow,
As black as a tar-barrel;
Which frightened both the heroes so,
They quite forgot their quarrel.

The architecture of the Middle and Upper Palaeolithic periods in Cantabria is, as in the Iberian Peninsula as a whole, organized in imitation of the model in force for southwestern France, basically revolving around the doctrines held at the *Institut du Quaternaire* in Bordeaux. The organization of the Cantabrian Transition sequence, until the last decade of the 20th century, was completely subordinated to the French sequence, almost a mirror image:

– Until the Spanish Civil War, the researchers (the Marquis of Vega del Sella, H. Obermaier, T. de Aranzadi, and J. M. de Barandiarán, among others) follow Breuil's proposal mooted at the Geneva Congress (1911). In this sense, they refer only to the Aurignacian period (Lower, Middle, or Upper).
– The earliest mentions of the Perigordian period arose in the 1950s, in the wake of excavations such as those at Cueva del Pendo.
– The "emancipation" of Chatelperronian and Gravettian periods in classification terms, or the emergence of such new terms as Proto-Aurignacian, will arrive at the end of the 1960s, almost in parallel with what was happening in southwestern France (excavations led by professors Delporte or Laplace), at sites such as Lezetxiki or Cueva Morín.
– Even the debate about the alleged interstratification between levels in the Aurignacian and Chatelperronian, initially posited by the French deposits at La Roc-de-Combe and Le Piage, once more has a Cantabrian correlate in the transition levels of the Cueva del Pendo.

From 1980 on, two factors began to destabilize Northern Iberia's "Transition model." One of these is of universal value and specifically deals with the finding of an individual of Neanderthal type within the Chatelperronian sequence in the Saint-Césaire cave. Another factor, originally regional in scope, is the reassessment of the geo-chronological framework of the phenomenon, in the light of the old datings obtained for level 18 in the Cueva del Castillo, promptly followed by others for the northern peninsula outside the Cantabrian area (L'Arbreda, Abric Romaní). In the same way as has happened with other Cantabrian technocomplexes (the Solutrean or Magdalenian), it is necessary to update and adapt all kinds of frameworks also for the start of the Upper Palaeolithic (which, including the Gravettian, went in a few years from being referred to as "the first third of the Upper Palaeolithic," to covering over half the period).

Jabberwocky

JABBERWOCKY
Twas brillig, and the slithy toves
Did gyre and gimble in the wabe;
All mimsy were the borogoves,
And the mome raths outgrabe.
"Beware the Jabberwock, my son!
The jaws that bite, the claws that catch!
Beware the Jubjub bird, and shun
The frumious Bandersnatch!"

As often happens in those periods where it is necessary to reconsider a scientific issue in its entirety, an increase in information does not lineally imply a better resolution of the problems. Over the last 20 years, the Cantabrian Region has seen a strong thrust in field work aimed at a better contextualization of the Transition between the Middle and Upper Palaeolithic. First of all, the proliferation of excavations has been very notable, affecting not only those sites already excavated in previous periods, but also new findings. The chronological placement of the end of the Mousterian and the start of the Upper Palaeolithic has taken on a sudden interest, as a result of which there are more than twelve excavations open for these periods right now, during the summer digs. The accumulation of all kinds of information about the "Transition" threatens to overwhelm the researchers' ability to absorb it (or even to read it, in view of the constant increase in publications). Right on their heels comes the organization of congresses and symposia devoted to the subject and subsequently published in the form of proceedings. On the other hand, lagging far behind is the production of complete reports and detailed summaries of this fieldwork, perhaps because this kind of publication is seen as the fruit of a certain old-fashioned positivist pruritus. Nonetheless, the impression is gaining ground that we now understand less than ever before the circumstances of all kinds that occurred in the reconstruction of the period 40–30 Ky BP.

We indicated earlier that we are on the verge of replacing hypotheses, of extending our analytical perspectives, and, we believe, of verifying alternative theoretical models. The paradoxes that cannot be resolved within the old paradigm emerged from two fields closely linked to the reconstruction of prehistory (the anthropological characterization of the inhabitants of the sites, and the geochronological framework for the process). However, they have each inescapably expanded to cover everything from the exploitation of mineral resources to the palaeo-environmental reconstruction of the sequence, or from the symbolic behaviour of Neanderthals and anatomically modern humans (AMH) to the spatial distribution of sites and activities on a regional framework.

We feel it is important to highlight that research outcomes are the fruits of activity by researchers, and that the passing years and the enormous increase in interest in this period have triggered a twofold effect: a generational changeover affecting a large number of the protagonists of earlier studies, and a speedy enlargement in the groups of archaeologists interested in these chronologies. Although both these factors together might represent a positive reading for the status of current investigations, this is not necessarily so, for various reasons. By way of example, let us mention the loss of influence of French as the lingua franca of Palaeolithic archaeology among the younger generation, who have only had access to English as a foreign language; in parallel, it has become more and more difficult to exchange points of view with a school of Palaeolithic experts who, apart from being the closest geographically, have traditionally provided the most points of reference for archaeology in Cantabrian Iberia.

At the same time, there are some elements in current research that are giving us cause for concern and self-criticism. First of all, we seem to be seeing a tendency towards transferring a large part of the responsibility for the debate to specialists in disciplines that are vital for archaeological reconstruction, but who are not archaeologists nor even necessarily familiar with the basics of our discipline (for instance, geochronologists). The process of sampling and, of course, the stratigraphic adscription of each sample, are the responsibility of archaeologists, as well as the subsequent contextualization of the results. Nonetheless, the research phase that we consider critical is precisely the part that escapes our direct control.

Secondly, in our opinion it would be appropriate to have a more precise view of the register limitations handled by each of us (we tend to be highly critical of those used by other colleagues, at the same time as we idealize our own, equally limited, sites): every archaeological site poses certain difficulties and requires severe criticism a priori; we know of no Pompeiis in the European Palaeolithic. It is not an obstacle to state that no one knows a site better than the person responsible for its excavation; and that comments about the sequence or stratigraphy made by someone who is not only unfamiliar with the site but also sometimes with the practical principles of stratigraphy applied to any site, are more than a little suspect.

On the other hand, since archaeology is an activity of increasing technification in which, as well as the field team, it is essential to plan on a group of specialists with tasks in the various studies and analyses to be carried out, we should consider whether so many teams working in parallel, each with their corresponding specialists, do not represent a certain scientific Lamarckism (once the need has been created, the organ will emerge) and whether, quite apart from the optimization of all kinds of resources, the multiplication of laboratories, teams, and specialists will not also, at times, be amplifying the “noise” compromising the results of the research. In the current circumstances regarding science policy in Spain, far from creating a “scientific fabric” for the networking of different groups, research is sometimes seen as a kind of competition between teams to achieve the most media-friendly results. One of the most worrying aspects of this trend is the limited character of the available register: practically all the sites conserved with notable sequences from this period that we know of in the Cantabrian region are undergoing excavation or re-excavation, thus restricting the scope of action of future researchers.

Finally, as a consequence of all of the above, research into the "Transition" in our region is acquiring tunnel vision (perhaps in multiple tunnels). The circumstances seen at individual sites tend to elevate each one to the category of benchmark, where it becomes difficult to find parallels. To this is added the administrative fragmentation of the management process for dealing with excavation permits and their subsidies (up to five different bodies for the territories of the Cantabrian region, each with its own criteria and priorities); plus that short-term tendency, so common in politics, to try to obtain tangible and newsworthy results as quickly as possible.[1] In this way, we begin to understand the growing difficulty in drafting summaries that can draw on the information provided by the same register from various sites on a single plane: the sites gain in significance, but it is very difficult to reflect on the period as a whole.

Nominalisms and Other Discussions: And What Are We to Call It?

> When you say "hill," the Queen interrupted, "I could show you hills, in comparison with which you'd call that a valley."
> "No, I shouldn't," said Alice, surprised into contradicting her at last: "a hill can't be a valley, you know. That would be nonsense—"
> The Red Queen shook her head, "You may call it 'nonsense' if you like," she said, "but I've heard nonsense, compared with which that would be as sensible as a dictionary!"

All too easily, the debate on the "Transition" ends up embroiled in endless discussions that are, in appearance, resolved by the criterion of authority. We have selected the nominalist paradox because it is one of the most frequent in this area: setting aside the ideological and conceptual apparatus underlying any classification of human groups (even in prehistory), the discussion focuses on whether this or that level deserves to be tagged with this or that label (Mousterian, Chatelperronian, Aurignacian, Perigordian). This is all built on the stubborn desire to rebuild a clearly structured sequence, in terms of succession, of regional value, so as to allow the excavation to go ahead without unforeseen situations. What should be important is to be able to reach agreements about the shared protocols that are going to be used to describe the occupations, so that we can later on establish whether two levels or settlements are similar or not, and which label should be assigned to each one. It seems more appropriate for a social and human science to describe a way of life, and how people from different periods in prehistory made the most of their surroundings, than to indulge our entomologist-like obsession to pin a name on the "cultures" observed and to discover "new unusual specimens." There are, however, certain inertias that have to be analyzed.

In summary, the following outline describes the general principles of the debate on the "Transition" in the Cantabrian region over the last few years:

– Geochronology: Incorporation of new methods (especially the AMS technique) and gradual slippage of chronologies, prior to their correction or calibration, by about three millennia. Aging amplified even further by the modern date calibration routines, that already border on the start of the Upper Palaeolithic.
– Chronocultural framework: Gradual definition of an indeterminate horizon between the archetypal Mousterian and Aurignacian (in Peyrony's sense, "classical," "typical," "old," "with split base bone points"). Mixtification of language (Late Mousterian, Proto-Aurignacian, Archaic

[1] Let us cite an example affecting us directly. When the authors of this article were returning on their way out of the looking-glass, towards everyday reality, they received a letter from the maximum authority responsible for archaeology in their administration. In the letter, at the same time as regret was expressed that they had not been able to consult or study the materials from their own excavations in the last twelve months because of purely bureaucratic complications, they were also informed that another twelve months, at the very least, would be needed before the situation could be brought back to normal. And their patience and understanding were greatly appreciated.

Aurignacian, Transition Aurignacian) and gradual implantation of the concept of *Transition*, inserted somewhere between what is considered "typical" (?) of the Middle Palaeolithic and Upper Palaeolithic "proper" (?).

- Palaeo-environmental evolution: Great diversification in the disciplines providing information, with no definitive hierarchy for the different degrees of resolution. Controversy between the universalist and regionalist perspectives for palaeo-environmental reconstruction, together with the above: the discussion is often marked by the limits and potentials of each discipline and by the type of sedimentary medium each one considers most reliable in terms of the register.
- Palaeo-ethnological vision of the material culture: Global reconsideration of both the methodological principles traditionally accepted and the reliability of the sets recovered in the past. Strengthening of technological and traceological studies, to the detriment of classically typological studies.
- Physical anthropology: Geochronological relocation of human fossils and detection of a notable void for the period in question (approximately between 40,000 and 30,000 BP, uncalibrated). Intensification of all kinds of work aimed at filling in this void, with little success so far.
- Reconstruction of how and where human groups made economic use of their surroundings: Once more a progressive blurring of the dichotomy between Neanderthal opportunists and Cro-Magnon specialists, with a grading being established between the economic behaviour of the groups on the chronological axes. Definitive incorporation of raw materials as traces of the "economic territories."
- Complex behaviours: General reconsideration of how symbolic cultural uses are implemented in this period (ritual burial of corpses, affinity for body decoration, practising drawing on rocks or other elements).

Speaking more generally, we could point out that the last 25 years of research into the subject have started from a reconsideration of the epistemological bases for work in Palaeolithic Archaeology, according to the following guidelines: subjection of old batches of materials and stratigraphic series to reassessment, questioning of the closed models in force in the past and the opening up of a new chronological and cultural window ("the Transition") in which no scenario is discarded (including the possibility of groups with very different filetic adscription living together for long periods in a single territory, interacting culturally with each other and with the same environment). In short, a more gradual outline of the Transition between the Middle and the Upper Palaeolithic, between the Neanderthals and the first AMH, at the expense of a great expenditure of energy to cut our ties with the many inertias of the past.

The Paradigm, Reconstructed or Deconstructed?

> Alice looked on with great interest as the King took an enormous memorandum-book out of his pocket, and began writing. A sudden thought struck her, and she took hold of the end of the pencil, which came some way over his shoulder, and began writing for him.
> The poor King look puzzled and unhappy, and struggled with the pencil for some time without saying anything; but Alice was too strong for him, and at last he panted out, "My dear! I really must get a thinner pencil. I can't manage this one a bit; it writes all manner of things that I don't intend."

We will begin by indicating that, in our opinion, we are facing a radical paradigm shift in the vision of the period (and not just in the Cantabrian setting), including many of the consequences formulated in the classical Kuhnian model for the substitution of paradigms. Over a relatively short period of time, we have gone from a closed, schematic model, with sealed-off sections in which all circumstances followed each other over time within a logical pattern that we thought we understood, to a much more open situation in which a range of options are available. In view of this new situation, some specialists, pining for the good old days, have tried to reconstruct a similar guiding thread, but adapting it to the new conditions; others, however, have tried to start with a "clean slate" regarding previous information, and want to create a whole new conceptual structure to explain the regional circumstances of the transition. Both groups may reach similar conclusions, along different routes and using different means. Yet both often feel (like the heroine in the text entitling this section) that they have to submit in their texts to certain tacit normative parameters, that they are not free to posit new hypotheses in the face of the "weighty inheritance received".

A good part of the arguing over this period is still based on excavations, data, and analyses that are contextualized in the preceding work period. It is true that not all that volume of information can be deemed old, but it must be reviewed critically in accordance with the new methodological and epistemological parameters if we intend to go further than the original diggers achieved. Nonetheless, it is necessary to highlight the gigantic tasks taken on by many pioneers in Cantabrian archaeology, in a setting totally bereft of material, institutional, and technological support. In any case, it is convenient to consider re-excavations in key sites whenever considered necessary and deemed possible.

The complete reconstruction of this or any other period within the Cantabrian area lacks, in our opinion, any prior consideration regarding the regional model we want to apply. As we have been insisting in recent times, without such prior consideration any regional framework is just as valid as the Cantabrian one, as the consideration of the unity of any region is arbitrary, derived solely from its greatest differences with respect to the other adjacent territories. An explicit reference must be given for the regional framework used, the limits we adopt for it, and the rationale that has led us to this choice. Otherwise it is impossible to organize consistently the archaeological reconstruction of the period in the Cantabrian or any neighbouring territories (Northern Meseta, Ebro Valley, Pyrenean foothills, or the Aquitaine Basin). The administrative fragmentation of the Cantabrian context is not going to be resolved from such a marginal world as that of archaeology, so we archaeologists must be the ones to restrict the harmful consequences of this phenomenon by learning to work with other routines: integrating workgroups and collective projects, sharing networking resources, with a better flow of up-to-date information—and even a certain amount of well-meaning corporativism.

We should do a close reading of the value of the negative record: "lack of evidence is not evidence of lack" runs a classic aphorism in archaeology. Let us ponder the effects on our perception of the register imbalance vis-à-vis sites between the coast and the hinterland, or between cave deposits and those in the open air. What estimate can we give for site destruction following Holocene marine transgressions? What criterion can be used to distribute the sites we know about in the various territories of Cantabrian Iberia? What kind of dating would we get on rock art if the engravings and red paintings could be systematically dated as well as many of the black ones are? Might we be able to locate some kind of deposit with exceptional conditions for preserving organic matter, for example, in wetlands or coastal areas? Are we taking measures, designing strategies, aimed at correcting in the medium term some of the distinctive phenomena mentioned? And, if not, are we not just heading deeper into a tunnel that leads to the most complete relativism?

Some of the most acrimonious debates ever known in the Cantabrian area have to do with the taphonomy of the deposits and the stratigraphic integrity of certain sequences (El Pendo or Cueva Morín, for instance). Micromorphology represents a relatively novel discipline (hardly included on the sampling protocol so far) that may resolve most of these discussions with a measure of objectivity. But the incorporation of this or any other analyses to the study protocol will not resolve anything if it is only applied to certain sequences considered by third parties to be "problematic." If such application is of interest, we should resolve to have this information available in future for each excavation under way (and, to be consistent, to provide the human and laboratory resources needed to deal with it). We might say as much again about the various methodologies contributing to this subject.

Over the last few years, we have witnessed a kind of lay pilgrimage to the geochronology laboratories in the hope that their dating would resolve the adscription of levels considered to be conflictive for one reason or another. Rather slowly, we have assimilated the gallimaufry of new terms our geochronologist colleagues have contributed to our discipline (^{14}C, OSL, AMS, TL, ESR, etc.), understanding the kind of samples needed, the limitations and potential of each method, or the level of resolution for each dating. But the most solvent laboratory in the world will not be able to resolve a sample contaminated due to improper handling, a questionable sample-labelling criterion, or the intrusion of an upper level bone through a tunnel dug out by a mole. Nor can they contextualize the sample we have sent them in the framework of the deposit and its sequence, much less control the process for publishing all the results obtained from a site, regardless of how much or how little they please the people responsible for it.

For some time we have observed worrying trends in various disciplines connected with prehistoric archaeology, namely the demolition of former conceptual structures by the expeditious means of setting up others to overshadow them, allegedly on a more solid foundation. When it comes to putting forward the replacement of *outmoded* typological views of material culture by innovative technological approaches, or the ever *problematic* palynological analyses in archaeological sequences by reference sequences of quasi-universal value, or the *classical* archaeozoological analyses for the supply of meat (whether in the wild or from domesticated herds) by more precise taphonomic studies, or *traditional* biometric anthropology by human DNA readings—several mistakes are, in our opinion, slipping through. To begin with, in practice, a large part of the last hundred years of research are being tossed overboard, along with the contributions of many of the researchers who are still able to provide substantial information in their disciplines. This trend overlies a Cainite vision of scientific work that affects our community and others in the realm of science. It is simple to see that our activity is becoming increasingly more technical, and we must make room for new records and methodologies for analyzing the same subject. On the other hand, it is inexplicable that disciplines and approaches that can provide well-founded contributions should have been expressly abandoned.

The second serious error in this behaviour lies in the fact that certain premises as yet unproven are being taken for granted. The limits of a new approach are more diffuse because the first efforts are aimed at exploring its potential, until it becomes consolidated. But this does not imply that these limits do not exist, or that they are any smaller than those of the so-called traditional disciplines, but rather only that there has been less time for them to be relativized. Let us take the example of the gradual displacement of lithic typology in favour of technology, which in fact represents a more enriching vision. But there are still two items pending clarification in this regard, already amply clear in the case of typology: the difficulty of establishing chronological parameters on the basis of technology, and the scant quantitative apparatus that accompanies technological studies (which usually pivot around information considered to be relatively or only qualitatively significant). In view of the evident and well-published limitations of typology, we should not discard this to devote ourselves exclusively to technology, just because the difficulties it poses are less well-known at the moment. Something similar occurred in the 1980s, with the emergence of use-wear analysis, which then had to moderate post hoc the expectations that the discipline itself had generated. Innovative visions must integrate what came before, or else they are condemned to generate a great deal of frustration.

In addition there is another factor, already mentioned above: the greater the degree of technification in the approach put forward, the larger the share of responsibility that falls to specialists unfamiliar with the way archaeology draws its conclusions, qualified by more than a century of accumulated expertise. It is true that certain graphical presentations are very striking and convey the sensation of confidence in a new language, a door that is opening towards expectations of new information. Not so long ago we lived through a revolution in this line, with the powerful combination of the AMS dating technique and date calibration routines. But no one would have understood then, nor do they now, the tossing of all previous datings (many of them impossible to repeat) into the trash; or if archaeologists who had been calculating their dates using the previous methodology had suddenly decided not to publish any more "modern" dates in favour of the geochronologists in the analytical laboratory, or a new generation of "only AMS-dating" archaeologists.

Why is this Transition such an attractive period for this debate? In other words, what makes this one similar to or different from other transitions? It is probably the human factor that distinguishes this one. The threshold between the Middle and the Upper Palaeolithic periods saw the last change in the human species in our history and, if that were not enough, it is precisely our species that imposes itself at the global scale. The rest of the factors are hard to distinguish from those affecting the transition between the Lower Palaeolithic and the Middle Palaeolithic, or between the Mesolithic and the Neolithic, to quote just two examples.

So it would be everything considered distinctive for our own species with respect to previous groups of Neanderthals that would become truly relevant for this discussion. It is no less a paradox, however, than it is a period in which we know scarcely anything of the human fossil register. For the period we have been talking about, in the whole of Western Europe (and all the more so in the Cantabrian area), there is a striking hiatus with regard to human fossil remains, a situation that persists until approximately the Gravettian period. For the context of the Cantabrian region, apart from the extraordinary record of recent Neanderthals in the Cueva del Sidrón cave (Asturias), we hardly know of more than a handful of isolated and dispersed human remains, generally not very diagnostic (and when they are distinctive, they tend to correspond to Neanderthals) in various caves (Castillo, Esquilleu, Cueva del Conde, Axlor, Lezetxiki, Arrillor, perhaps Camargo). Thus the paradox is consummated: how to assess what is considered typical of our species without being sure of whether the star of the show, with regard to the materials we are contemplating, is or is not AMH.

To sum up then, in conclusion: the frenzied pace of field work on this subject bears little relation to the speed with which the remaining changes can be assimilated, because of the limitations of all types that have been mentioned. Over the last 25 years, the debate about this period has been growing stronger, and it shows no sign of waning in the near future. As this is going to be a long-distance run, it might be appropriate for us all to agree on a respite in our work, not only to inform others about new datings or analytical findings (that would be a scant novelty), but to establish the bases on which to work effectively and in an organized manner over the next two decades, correcting some of the imbalances described. The economies of scale of all kinds that would arise from such a plan would deserve a collective podium and would lay the foundations for a true Cantabrian model. Otherwise, it will be up to the good fortune, and ability to improvise, of each individual that will determine the parameters we will be following in the medium term, which cannot but have very negative repercussions for the discipline.

The Transitional Aurignacian and the Middle-Upper Palaeolithic Transition Model in Cantabrian Iberia

Federico Bernaldo de Quirós and José Manuel Maíllo-Fernández

Abstract After reviewing the evidence from the past 25 years of excavation at Cueva El Castillo and re-examining sites such as Cueva Morín in Cantabrian Spain, we conclude that the long-held model of invasion by outsiders, specifically, anatomically modern humans, proposed for the introduction of the Upper Palaeolithic in Europe is no longer viable.

Characteristic elements of the Aurignacian appear in the new excavations of the Mousterian at El Castillo, and continue their development throughout the Aurignacian at the site, thus confirming a local transition to the Upper Palaeolithic in the Cantabrian region. It is hypothesized here that the Aurignacian has local origins all across Europe. We propose that the several transitional industries in which characteristic Aurignacian and other Upper Paleolithic features appear in a number of places between 40 and 35 ka reflect the widening of communication and contact networks by indigenous populations, which led to the homogenization of the Aurignacian into the first pan-European culture by around 35 ka. Rather than a great eastern invasion of AMH, bearers of a more sophisticated technology that allowed them to outcompete indigenous peoples, a more parsimonious scenario is proposed. We argue that the indigenous populations, those best acquainted with local fluctuations in resources and landscape, reacted to the influx of newcomers by consolidating deeply-rooted, widespread networks of communication and technological know-how.

F.B. de Quirós (✉)
Departamento de Estudios Clásicos, Universidad de Leon, Leon, Spain

Keywords Middle–Upper Palaeolithic • Transition • Transitional Aurignacian • Cantabrian Iberia

Introduction

For 20 years, the Transition between the Middle and Upper Palaeolithic has been one of the great debates in prehistoric studies (Vega Toscano 2005, 545; González-Echegaray 2006). It brings together two highly significant issues; the extinction of the Neanderthals and the appearance of modern humans, our species. Basically, the hypotheses about the Transition take two lines: rupture or continuity.

The rupture hypothesis argues that there was an abrupt separation between the Middle Palaeolithic and Upper Palaeolithic (the latter being represented by the Aurignacian). In this way, the Aurignacian is seen as bursting abruptly onto Europe and generating a process of acculturation among the last remaining groups of Neanderthals (Mellars 2004; Davis 2001; Otte 2006), characterised by transitional industries such as the Châtelperronian, the Uluzzian, and the Szeletian, etc. Nowadays, the big debate is about identifying the origins of Aurignacian technology, and precisely which human species was responsible for it. The Near East continues to be the original centre for some researchers (Mellars 2006), although radiocarbon evidence does not support this hypothesis; the Altai region has recently been suggested as the original cradle of the Aurignacian (Otte and Derevianko 1996; Otte and Kozlowski 2003; Otte 2004), and the Cirenaica region in Libya has also been put forward as a

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candidate (Belfer-Cohen and Goring-Morris 2003). Some researchers locate the origin of the Aurignacian in Europe as a whole (Teyssandier 2006) or, more specifically, in southern Germany (Conard and Bolus 2003) at the hands of modern humans who inhabited the region. This is the model known as *Kulturpumpe,* according to which the Aurignacian began in the region, already colonised by modern humans, around 40,000 BP. A similar hypothesis was put forward by J. Svoboda (2003, 2004) for the Bohunician in the Danube corridor. In this instance, the Bohunician would represent a technology derived from the Ahmarian which developed in the Near East in the same way, the Protoaurignacian (Mellars 2006). Recently, some authors have begun to consider that all transitional technology is the work of modern humans, and reject any possibility of "modern" behaviour among the Neanderthal groups (Bar-Yosef 2006a, b).

Alternatively, supporters of the continuity hypothesis consider that the Transition from the Middle Palaeolithic to the Upper Palaeolithic, at least during the first phase, could have its origins in the substratum of the European Mousterian (Cabrera-Valdés and Bernaldo de Quirós 1990; d'Errico et al. 1998; Straus 2005). This evolution was, in addition, multicentred and dispersed, occurring in different places and at a different pace in each of the different regions. In this sense, the Neanderthals did make, without the necessity for outside influences, a first step towards modern behaviour (d'Errico et al. 1998, 2003). Archaeological evidence would seem to support this hypothesis, as is shown by the examples of bone ornaments from Arcy-sur-Cure (*contra* Floss 2003), the Châtelperronian lithic industry (Pelegrin 1995; Connet 2002; Maillo-Fernández 2005), or the bone industry in Buran Kaya III level c (d'Errico and Laroulandie 2000).

Given what is known so far, we consider this an opportune moment to make some observations: Traditionally, the Aurignacian is related to modern humans. However, this presumption should not be taken as correct for the initial stages of the Aurignacian, given that the oldest dated modern human remains are those from Peştera cu Oase (Rumania), dated to >35,200 C-14 BP (OxA-11711) (Trinkaus et al. 2006), and which were recovered in a controversial taphonomic context. Besides, some European sites such as Geissenklosterle have yielded earlier Aurignacian dates (Conard and Bolus 2006). Therefore, given the empirical impossibility of identifying the author of the majority of transitional industries and the initial phases of the Aurignacian, the authors consider that it is essential to separate the cultural question (transition from Middle to Upper Palaeolithic) from the biological question (the replacement of Neanderthals by modern humans).

Transitional Aurignacian in the El Castillo Cave

General Introduction

El Castillo cave is situated in Cantabria (Northern Spain). It is situated on the slopes of the mountain also called El Castillo, overlooking the valley of the Pas River (Fig. 1a). This mountain is conical in shape, so it is a good landmark on routes linking the coast with the Meseta, the Iberian inland plateau. The presence of a network of geological faults gives rise to enclosed valleys like the one around Puente Viesgo. This means that from the cave it is possible to observe these routes and the movements of herds of animals along them.

The archaeological record at El Castillo cave allows us to study the transition between the Middle and the Upper Palaeolithic in closer detail than usual. The extensive stratigraphy comprises 26 levels with alternating sterile layers and layers relating to human occupation, reaching a depth of 18–20 m, according to the estimates made by H. Obermaier during the excavations carried out by the Institute for Human Palaeontology (IPH) from 1910 to 1914. To sum up, and in the light of checking undertaken by Cabrera-Valdés (1984), the following cultural levels are to be found relating to this period: two levels of old Middle Palaeolithic age, one of Upper Acheulian, two Mousterian, two Aurignacian, two Upper Perigordian, one Middle Solutrean, three from various stages in the Magdalenian and, finally, an Azilian level. It is of interest to highlight certain features of these old excavations. Since they took place in the early twentieth century, their methodology was not up to present-day standards. All the same, there was horizontal checking of layers, as

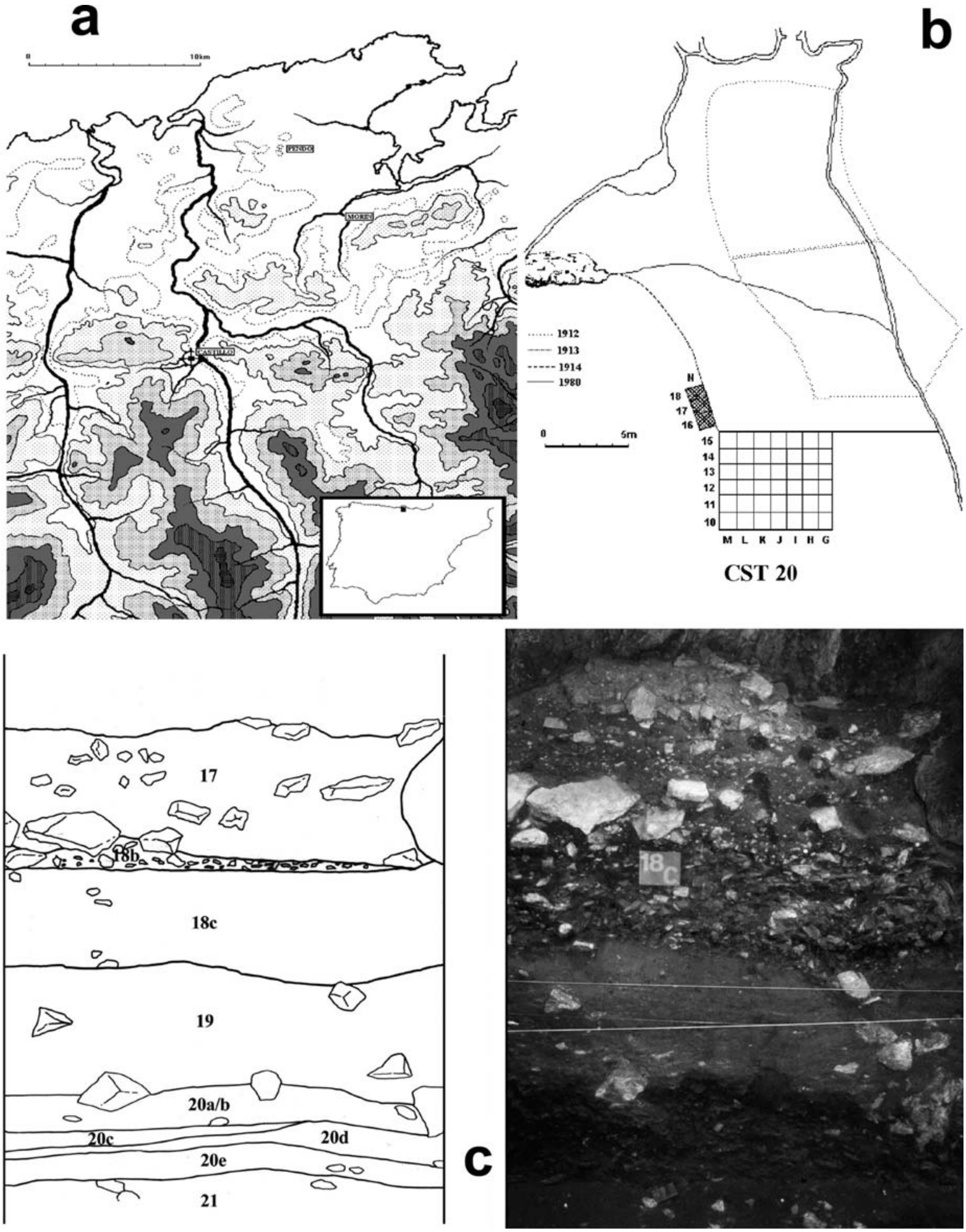


Fig. 1 (**a**) Plan of the central valleys of Cantabria with the location of El Castillo and Cueva Morín, (**b**) surface of El Castillo, (**c**) El Castillo stratigraphy, units 20–18

can be seen from the field logs and in the documentation in the form of photographs, drawings, and sketches produced during the digs, in which each human-created layer was taken to be a cultural unit (Cabrera-Valdés 1984). The stratigraphy at El Castillo was very clear, so the cultural levels, black in colour, were easily distinguished from the reddish sterile layers with which they formed an alternating sequence. Nowadays it is possible to separate out within them different periods of occupation that constitute archaeologically distinct levels.

In the course of the current excavations, the numbering of levels produced on the basis of the data provided by Obermaier (Obermaier 1925; Cabrera-Valdés 1984) has been respected. However, the various archaeological levels have been differentiated (Fig. 1c). Since 1980, horizontal excavations have concentrated on the outer zone mentioned, incorporating a surface area of 40 m^2, of which only 24 m^2 could be excavated at the start of Level 18, and rather less than 3 m^2 in the zone of the longitudinal section, because of the layout of the cave (Fig. 1b). The objective being pursued was to study the activities and different periods of occupation that might be found within level 18, so as to demonstrate, as far as possible, the existence of a transition from the Middle to the Upper Palaeolithic.

Stratigraphically, Unit 18 is situated between the two sterile levels caused by collapses of the cave roof (Fig. 2). Unit 19 seals off the Mousterian levels (Unit 20) and is made up of a large cone of thick blocks that form an outer buttress on which lie fine sandy clays of a yellowish-brown colour, with horizontal furrows at times because of water runoff, marked by discontinuous layers of gravel and sand in the same clay matrix. Above this sediment, humans occupied the site and in this way Levels 18b and 18c were formed (Fig. 2). This layer is of varying depth in different areas. At the junction between the two sections, the levels, specifically Level 18c, are composed of brown clays, rich in organic matter, that contain stones and angular limestone blocks, either scattered or forming irregular groupings. They are characterized by a greater abundance of organic material and a lessened presence of limestone detritus. The stratification, an outcome of rock-falls in the central area, is massive and irregular, tending to be parallel. The effects of human activity have made analysis of the sediments forming Unit 18 more complicated. This level is situated in the outer area and contains clays and a number of blocks resting on the outer buttress of Unit 19.

At the end of the sedimentation of Unit 18, a fresh fall of blocks from the cave roof can be observed to have occurred, bringing about a major retreat of the entrance archway and a considerable alteration in the morphology of the deposit. It created a new external buttress that was to affect the occupation area, causing it to change position and be restricted to the inside of the cave. It also affected the sedimentation of Layer 17, which was to fill up the holes and cracks that had formed between the blocks until later deposits fossilized this relief. The occurrence of such successive falls is constant in the sedimentary formations of the cave from this point onwards. The presence of the buttresses was to form a closed basin inside the cave, where detritus would be deposited with no possibility of being washed out of the cave. This led, in the first place, to a clear continuity in the layers of sediments without any chance of a hiatus; in the second, to the special physical and chemical conditions being considered, since whenever there was an increased presence of water, pools and flooded zones would form.

A complete series of dates is available for these levels in the El Castillo cave, both radiometric and geological, on which it is appropriate to comment. With reference to Levels 18b and 18c, with AMS C-14 a total of ten dates have been obtained from three different laboratories, these being Tucson (Cabrera-Valdés and Bischoff 1989), Oxford (Hedges et al. 1994), and Gif-sur-Yvette (Cabrera-Valdés et al. 1996a). Although they come from different laboratories and excavation zones, the dates show no significant disagreements for Unit 18 as a whole (Table 1). Electron spin resonance dates are also available and confirm the dates from C14 (Rink et al. 1995, 1997).

As may be observed, the base of Level 18c dates to approximately 40,000 BP, while Level 18b is to be assigned to some 38,500 years BP. These dates eliminate all doubt about the chronology of the levels. In the light of its interstadial climatic characteristics, Layer 19, which shows no continuity whatsoever with the lower part of Level 18c, might correspond

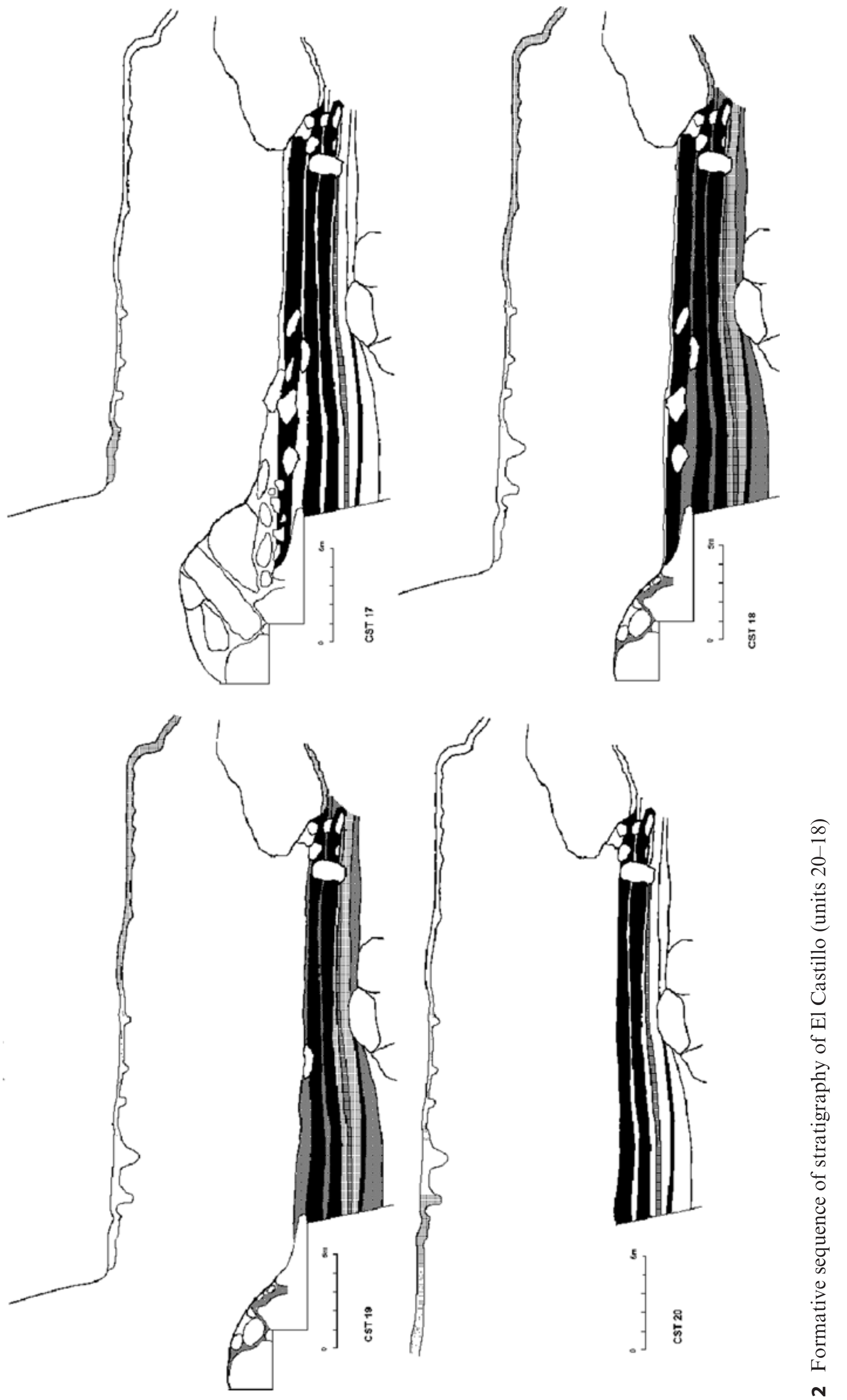


Fig. 2 Formative sequence of stratigraphy of El Castillo (units 20–18)

Table 1 Radiometric dates (AMS ^{14}C) of levels 18b and 18c at El Castillo (Transitional Aurignacian)

Level	Date	Result
18B	37,700 ± 1800	AA 2407
18B	37,100 ± 2200	OxA2473
18B	38,500 ± 1800	AA2406
18B	38,500 ± 1300	OxA2474
18B	40,700 ± 1600	OxA2475
18C	40,000 ± 5000	ESR
18C	40,700 ± 1500	OxA2476
18C	41,100 ± 1700	OxA2477
18C	40,000 ± 2100	AA2405
18C	39,800 ± 1400	OxA2478
18C	39,500 ± 2000	GifA89147

to the brief warm period known as the Hengelo Interstadial (Zone 15) dated as 40,000 ± 600 BP; while Level 20, with no break in sedimentation between it and Level 19, and showing cold-climate characteristics, would relate to the cold phase immediately prior to that (Cabrera-Valdés et al. 1996a).

Typological Composition

The retouched tools found on both levels show no great difference between them. On level 18c (Table 2), 175 retouched blanks were found. These include 42 endscrapers, the majority of which were made of quartzite (n = 35) and flint (n = 5), with one of ophite (Fig. 3.1). Of the endscrapers, those of Aurignacian type stand out (carinated and nose endscrapers), with 28 examples. Only 9 burins were found (Fig. 3.2), mainly dihedral, the majority also made of quartzite (n = 5), but it should be borne in mind that more than a dozen burin spalls were present, confirming the hypothesis that this was a "waste site" near the living area, where debris from stone working was deposited. Twelve perforators were found, also made of quartzite (n = 10) (Fig. 7), as were the two truncated pieces. There were 13 retouched blades, of which the Aurignacian ones (n = 5) followed the general pattern, generally made of flakes (Fig. 3.4), as they were in other, chronologically later, Aurignacian levels, such as Cueva Morín (Bernaldo de Quirós 1982). The most abundant pieces were sidescrapers, with 58 examples (44 of quartzite, 13 of flint, and one of limonite). The majority are simple, unlike those of the Mousterian (Fig. 3.5 and 6) or the denticulate tools (Fig. 3.7 and 8). So far, only one Dufour blade has been found.

Table 2 Typological groups from levels 18b and 18c at El Castillo (Transitional Aurignacian)

Typological group	18b (%)	18c (%)
Endscrapers	26	20
Borers	7.4	6.25
Burins	5.5	7.5
Backed tools		0.4
Truncated blanks	1.2	9.1
Retouched blades	8	7.5
Sidescrapers and denticulates	49	43.75
Dufour	0.6	

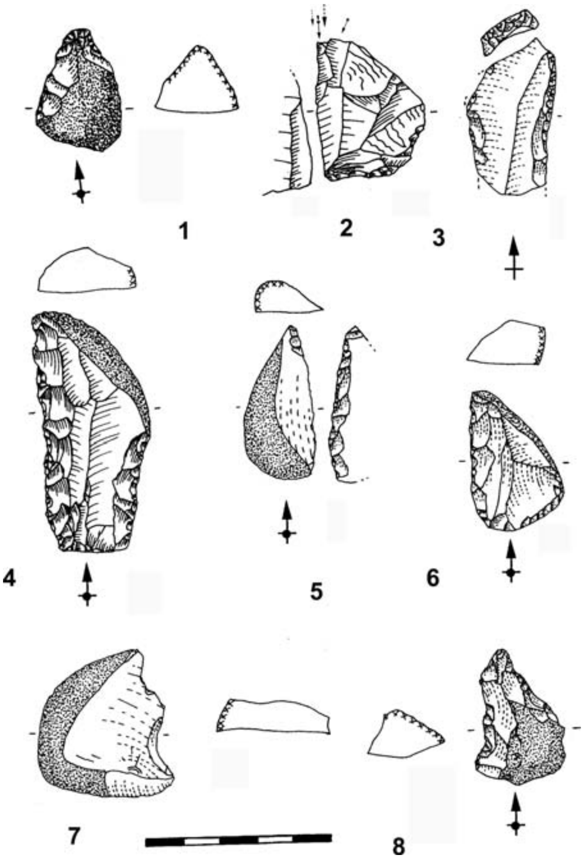
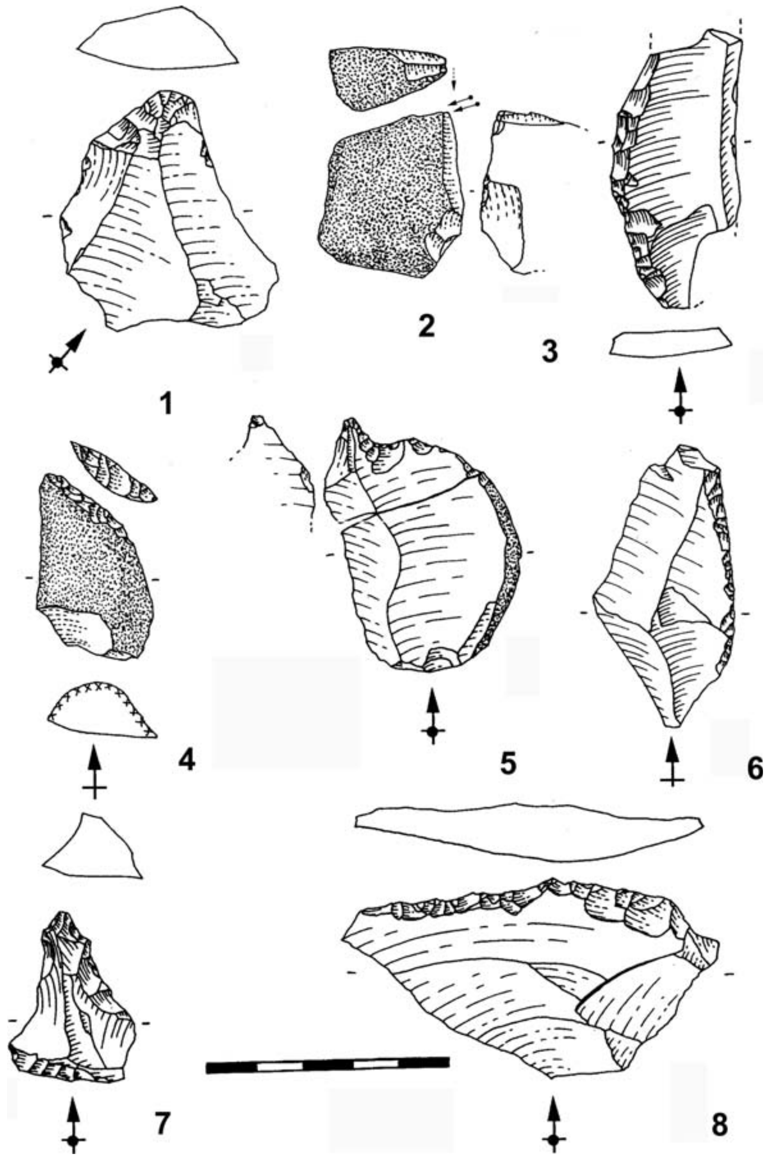


Fig. 3 Tools from level 18c: 1, endscraper; 2, burin; 3, truncated blank; 4, *lame aurignacienne;* 5-6, sidescrapers; 7-8, denticulates

Level 18b is richer and more varied (Table 2), and contained 240 retouched tools. As on level 18c, the most abundant material is quartzite, representing 76.14%. Regarding the types of tools, there were

Fig. 4 Tools from level 18b: 1, endscraper; 2, burin; 3, lateral retouched blade; 4, truncated blank; 5, borer; 6, sidescraper; 7-8, denticulates



48 endscrapers, 17 of which were Aurignacian (carinated and nosed endscrapers) (Fig. 4.1). There were 18 burins, both dihedral and transversal, or truncation (Fig. 4.2). Eighteen borers were found, the majority of which were made from quartzite (Fig. 4.5). A Châtelperronian point and five truncated pieces were also found (Fig. 4.4). As with level 18c, the most numerous pieces were the sidescrapers (72 examples), almost all of which were simple (Fig. 4.6–8), and the denticulate tools (Fig. 4.7). Finally, there were also 22 retouched blades, including Aurignacian quartzite blades (Fig. 4.3).

Technological Processes

There are several characteristic *débitage* patterns in the Transitional Aurignacian levels at El Castillo. The most common is a discoid *débitage* using a variety of raw materials: fine-grained quartzite and type flint in the form of small cobbles. Coarse-grained quartzite, limestone, limonite, and ophite in the form of larger cobbles, with ophite are the most abundant materials on level 18b (Cabrera-Valdés et al. 1996b). However, the development of a blade *débitage* pattern showing prismatic morphology carried out on fine-size quartzite cobbles and spherical, tending towards cubic, flint, is also present, with the exception of level 18c where flint cores do not form part of the archaeological record.

Flake Production: Discoid Débitage

Two methods of *débitage* were found: unifacial and bifacial, with the first being the most frequently found.

In those cores subjected to the unifacial method (Fig. 5), the *mise en forme* is simple: a series of secant, noninvasive extractions around the whole perimeter of the core in order to prepare the striking platform and thus adapt it easily to the angle formed by this surface and the *débitage* surface. This preparation could be entirely, or partially, peripheral. It is not unusual, when the relationship between the angles is suitable, to find cortical striking platforms. Both sides of the core have a clear role; one became the striking platform, while the other became the *débitage* surface. This hierarchy is maintained throughout the *débitage* sequence. These surfaces present circular morphologies, although to a lesser extent rectangular morphologies are also found.

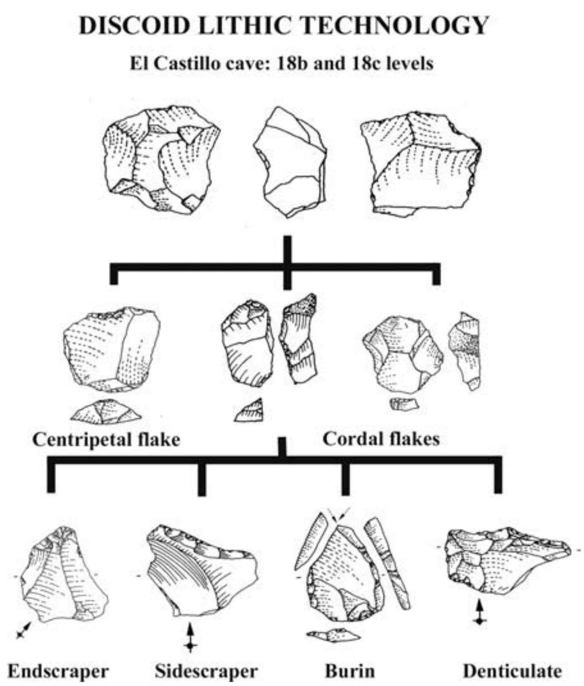


Fig. 5 Schematic process of the discoid method in Transitional Aurignacian

In bifacial cores, where both surfaces function as both striking platform and *débitage* surface, the *mise en forme* is not so easy to uncover, as both sides of the core have been flaked.

Lithic reduction of the surface begins with the extraction of *entame* flakes in a centripetal direction, gradually reducing the cortex. Reduction is eminently recurrent with these cores, and is carried out in two directions: centripetal and cordal. Both directions of *débitage* give the correct volumetric reduction of the core (Boëda 1993; Terradas 2003; Mourre 2003). These two forms maintain a paradoxical relationship, since centripetal removals eliminate the convexity required by the method, whereas cordal removals rejuvenate it.

It is interesting to observe how in thinner cores the negative scars are less sharp than in thicker cores. This is because in the former, it is not possible to achieve a reduction with sharp crests, so the *débitage* is subparallel to the edge which separates both sides of the core (Terradas 2003; Slimak 1998–1999). This fact means that the final morphology of the core is very similar to recurrent centripetal Levallois cores.

Typical centripetal flakes are wider than longer, and square in shape. Cordal flakes, in turn, are pseudo-Levallois points, *débordant* flakes, and *à dos limité* flakes (Boëda 1993), very common in these levels.

The technique employed throughout the sequence of *débitage* is exclusively direct percussion with a hard hammer.

The number of retouched tools is wide, and includes numerous “types” (Cabrera-Valdés et al. 1996b, 2001) such as the sidescrapers, denticulated pieces, and endscrapers on level 18b, and sidescrapers and denticulates on level 18c. There does not seem to exist, as a general rule, a search for a specific blank in relation to a retouched type, and neither is this the case for metrical aspects. All types of blanks would seem to be employed for all kinds of tools; centripetal flakes are used as sidescrapers, endscrapers, or burins, perforators, etc.; whilst pseudo-Levallois points are used as endscrapers or convergent sidescrapers, etc.

Exploitation of the cores is very intensive, and is only discontinued when exploitation has reached a very advanced stage. The dimensions of the last extractions are very small: in some cases, less than a centimetre.

Some cores are recycled: they are retouched in order to make tools. This is the case for some dihedral burins in quartzite on level 18b, or endscrapers, burins, and sidescrapers on level 18c.

Blade/Bladelet Production

The majority of cores are formed of quartzite, flint being very rare. The *mise en forme* is simple, where morphological preparation of the core is carried out according to the blank desired (Fig. 6). Negative scars on the cores, which could testify to the existence of anterior or posterior-lateral crests, are not apparent. *Débitage* begins with the extraction of an *entame* blade, as well as the extraction of certain pieces with a blade-like tendency which could very well serve the same purpose. On these blanks, the *débitage* surface opens out towards the lateral through the extraction of blanks, with a morphology tending towards laminar and presenting cortex. On level 18c all cores showed a single rectangular or square *débitage* surface, parallel to the longitudinal axis of the core, which could indicate that these cores were exploited in such a way as to produce the largest possible blades in relation to the core length.

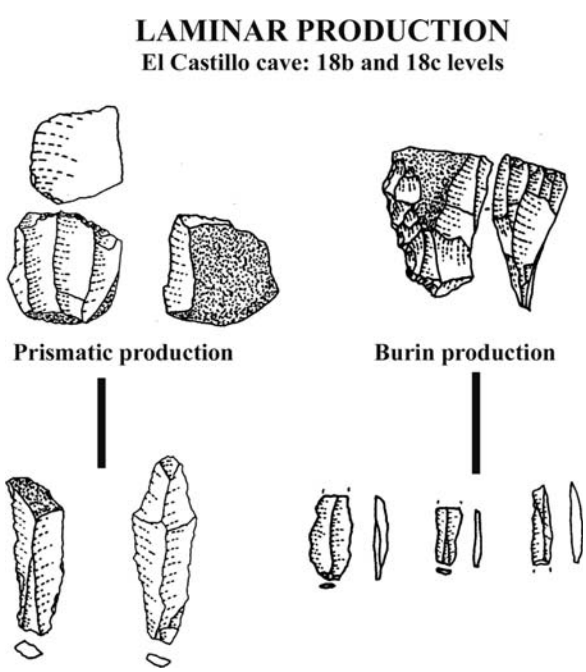


Fig. 6 Schematic process of the blade/bladelet methods in Transitional Aurignacian

The striking platform was produced by extracting a flake which detached the cortex or, when this was not possible, by making small extractions. Where the morphology of the cobble allowed, a cortical striking platform was created. This striking platform is oblique to the *débitage* surface of the core. This fact, together with the basal curvature, permitted a *débitage* exploitation of blades.

The cores present prismatic morphology and unipolar exploitation. Following the *entame* flake, the *débitage* surface opened out towards the laterals via semicortical blanks, whilst the latter were gradually reduced to the maximum width offered by the spherical or oval morphology of the core, thus forming the core *débitage* surface.

The blanks obtained through this method comprised bladelets or flake-laminar blanks, which were not very long but were relatively wide in some cases, in relation to their length. Two types of bladelets can be distinguished in relation to their position on the débitage surface, and their function as regards core maintenance.

On the one hand, there are rectilinear bladelets, with parallel and unipolar scars. These sometimes present a basal convergence, although this is infrequent. This happens when the *débitage* surface is formed from two adjacent planes instead of one, the latter being the more common form. This arrangement of a *débitage* surface with two planes joined to an oblique striking platform permits the development of basal convergence. This direction corresponds to the central area of *débitage* surface, and habitually has cortex in the distal portion. On the other hand, those blanks which are very similar to the foregoing, but with the exception that they present lateral cortex, represent a second type whose function was to maintain the *carénage* and above all the *cintrage* of the core by opening the *débitage* surface laterally in the form of a *débordant* flake.

The cores show a *semi-tournant* and unipolar débitage

The technique used was direct percussion with a hard hammer for tools produced from quartzite, and with a soft hammer for tools produced from flint.

The Bone Industry

The bone industry is in general scarce but significant. On level 18c, two distal fragments of spearheads made from deer antler (Fig. 7.2), a fish hook made from a bone fragment, similar to those found on the Aurignacian levels at Castanet (Fig. 7.3), a awl made from a bone splinter (Fig. 7.1), as well as some pieces with incisions and carving, were found, both on levels 18b and 18c. This bone industry demonstrates the relationship of these two levels with Unit 18 studied by V. Cabrera, and the collection of ten spearheads found during Obermaier's excavations (Cabrera-Valdés 1984). Of particular interest on level 18b is a deer antler handle (Fig. 7.5), and a bear's perforated canine tooth (Fig. 7.4).

Fig. 7 Bone industry from levels 18c and 18b. 18c: 1, tool made on bone, possible awl; 2, bone point; 3, double-pointed tool on bone fragment. 18b: 4, tip of a red deer antler, described as hafted tool; 5, pierced and grooved *Ursus arctos* canine

Mobiliar Art

The different levels of Unit 18, classified as Transitional Aurignacian, have provided diverse pieces whose artificial character justifies their inclusion here.

From level 18c, there is distal fragment of a chisel (Fig. 8.1) which has a series of short rectilinear

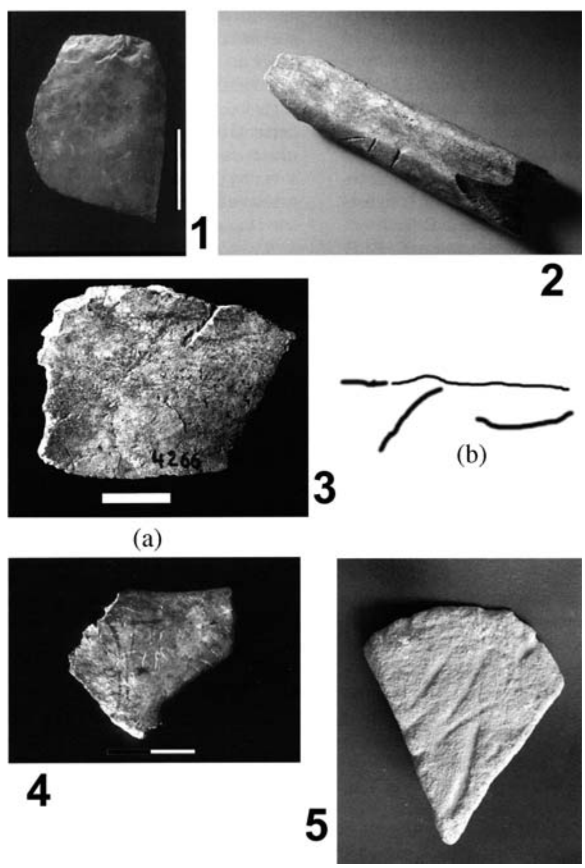


Fig. 8 Decorated material from levels 18c and 18b. 18c: 1, fragment of bone chisel with three series of incises lines; 2, fragment of red deer metapodial with three well-marked incised lines; 3, fragment of flat bone with painted lines. 18b: 4, proximal fragment of a hyoid bone of red deer, the lines scratched and painted in *black*, represents the foreleg of an animal; 5, sandstone plaque with four lines scratched

incisions along the left edge of the outer face, sloping obliquely from the longitudinal axis of the piece (Cabrera-Valdés et al. 2001; Tejero et al. 2005, 37). A mesial fragment of an ungulate metapod with a series of incisions on the upper face was also found (Fig. 8.2). The incisions consist of three deep and irregular marks. Two of them are parallel, and perpendicular to the longitudinal axis of the piece, whilst the third mark is oblique and diverges from the others (Cabrera-Valdés and Bernaldo de Quirós 1999; Tejero et al. 2005, 43). Even more interesting is a flat bone fragment with lines painted on the outer face (Fig. 8.3a and b). These comprise a figurative representation which has been interpreted as an animal head facing the right-hand side of the preserved bone fragment (Tejero et al. 2005, 43). Using SEM composition analysis, natural graphite has been detected.

Level 18b has produced several pieces, above all a proximal fragment of a hyoid bone (Fig. 8.4), possibly of *Cervus elaphus*. It is decorated by lines which have been scratched and painted on the upper face (Cabrera-Valdés et al. 2001; Tejero et al. 2005, 44). This decoration, carried out using lines scratched and painted in black, represents the foreleg of an animal (Cabrera-Valdés et al. 2001, 527). The pigment found on the interior of the lines indicates the presence of manganese. This fact allows the authors to suggest that the decoration was made using a "pencil" of this mineral, and the incision left behind the remains still present in the interior of the lines.

This level also produced a triangular fragment of a sandstone plaque with four lines scratched onto the flattest face (Cabrera-Valdés et al. 2001, 527; Tejero et al. 2005, 46). The incisions are U-shaped in section, and would seem to have been made with a thick-bladed stone tool.

Also within the category of incised bones, mention should be made of a fragment of deer metacarpus with a series of parallel incisions, V-shaped in section (Fig. 8.5). The distribution of these lines on the epiphysary surface does not seem to correspond to patterns of butchering (Tejero et al. 2005, 46). These pieces can be related to others which surfaced during Obermaier's excavations, showing extremely deep incisions on the upper surface (Cabrera-Valdés 1984; Corchón 1986).

Criticisms of the Transitional Aurignacian

Numerous critical comments have been made with regard to the above proposal about the transition and about the characterization of Levels 18b and 18c. These dissenting voices may be grouped around the following points: the integrity of the sequence of strata at El Castillo, the reliability and value of the radiometric dates, the composition of the lithic industry, and the validity and nature of the bone industry and symbolic elements (d'Errico et al. 1998; Zilhão and d'Errico 2000, 2003; Zilhão 2006).

The first criticism has had to do with the integrity of the sequence of strata at El Castillo. The argument has run along the lines that the collapse of the overhang at the entrance of the cave altered, and specifically mixed, several different archaeological levels. To this should be added the fact that there is certainly some small lateral variation in stratigraphy between the excavations by H. Obermaier and the dig being discussed here (Zilhão and d'Errico 2000, 28–29). Against this it must be countered, first and foremost, that the observations made by these scholars are based on the graphic documentation provided in reports written by the authors of this paper. Several of these publications explain the stratigraphic sequence, and the formation of the different levels composing it (Cabrera-Valdés et al. 1993, 2001, 2005). Furthermore, it should be noted that the fall of the overhang of the vestibule of the cave is not a matter of blocks splitting off at random intervals, but rather a general collapse, involving a single large fall. This process causes a compression of the levels, but not a deformation of so great an extent as to be able to bring about a mixing of materials to such a degree that they could not be distinguished during the process of excavation. Another line of argumentation against the integrity of the sequence is that the zone excavated by the authors of this paper is, in reality, a lateral variation in the strata, so that the level being dug would not be the same as Obermaier's. This claim is based on one of the publications mentioned above (Cabrera-Valdés et al. 1997), which in fact states that it is a marginal zone within the main vestibule, serving for activities such as cutting up meat or depositing the residues from the cleaning of hearths.

A different line of attack against the integrity of the collections from El Castillo refers to the nature of its stone industry. At one point it was claimed that these levels were simply Châtelperronian, perhaps with some admixture of Mousterian (d'Errico et al. 1998; Zilhão 2006, 22). All of this was based on no more than the appearance of a single Châtelperronian point in Level 18b. To classify a whole level as Châtelperronian just because one point of this sort appears in it is surely excessive. Nowadays it is clear that the Châtelperronian is in fact a great deal more than just the appearance in a collection of one or two Châtelperronian points (Pelegrin 1995; Arrizabalaga amd Iriarte 2006), so that the interpretation suggested must be taken as rather trivial. The fact is that many Aurignacian deposits present Châtelperronian points, but are not interpreted as Châtelperronian. Examples of this would be: Cierro 7 (n = 1); Arcy-sur-Cure 7 (n = 3); Roc-de-Combe 7 (n = 2); Labeko Koba 7 (n = 2); Morín 8 (n = 5 atypical); Morín 9 (n = 4); Vascas (n = 3 gravettes); and Gatzarria Cjn2 (n = 3). This same interpretation has also been put forward for those deposits exceeding the limit of 36,500 BP proposed by these authors for the arrival of the Aurignacian in Europe. This would be the case, for example, at L'Arbreda, one of the most important and best defined collections belonging to the Archaic Aurignacian in the whole Iberian Peninsula.

Attribution of Aurignacian characteristics in levels 18b and 18c is criticized in comments about the lack of elements diagnostic of series from the Upper Palaeolithic, because the endscrapers or burins that have been presented in a number of publications do not exceed these limits, or because there are no Dufour bladelets. It should simply be kept in mind that the archaic, classic, or typical Aurignacian is not precisely characterized by an abundance of this latter type of retouched tool. Moreover, it is argued that "Some [end-scrapers, burins, borers] are Upper Palaeolithic-like, but these types are common occurrences, albeit in small numbers, in Middle Palaeolithic contexts. After all, Bordes' type-list for the Middle Palaeolithic does include an 'Upper Palaeolithic group' of retouched tools" (Zilhão and d'Errico 2003, 317–318). Naturally, groups of Upper Palaeolithic type are known among the industries of the Middle Palaeolithic, but what is not familiar ground is the presence of a grouping, Upper Palaeolithic in type, that accounts for as much as 40.1% and 43.25% of the total, as happens with the levels 18c and 18b, respectively, these already having been published[1] (Cabrera-Valdés et al. 2001).

A further argument brought into play in an attempt to refute the coherence of the Aurignacian of Transition is that it has a high percentage of substrate pieces, specifically, 49% in 18c, and 43.7% in 18b. This fact is seen by some scholars as a reflection of the Mousterian nature of these levels. However, the view taken here is that it reflects not Mousterian identity, but rather Mousterian roots. In any case, epistemological questions notwithstanding, there are major Aurignacian collections in which substrate pieces form a major part, as happens with Morín 9 (44%), Morín 8 (24.7%), L'Arbreda H (18%), Rainaude or La Laouza 2b (± 17%); Pataud 12 (46%) or Pataud 11 (29%), to mention just a few examples (Chiotti 1999; Bazile and Sicard 1999; Maíllo-Fernández 2003; Maroto et al. 1996).

It is highly paradoxical that the arguments against an Aurignacian of Transition should be so muddled, for instance, in attributing an industry to the assemblages whose mixture triggered the initial, erroneous interpretation: Mousterian and Châtelperronian (Zilhão and d'Errico 2000, 29); Mousterian with some tools of Upper Palaeolithic type (Zilhão and d'Errico 2003, 317); or Mousterian and Aurignacian (Zilhão and d'Errico 2003, 317). In relation to this, it is also very paradoxical that the Aurignacian contributions in Unit 18 at El Castillo should be played down to such an extent (since these are pieces of Upper Palaeolithic type characteristic in Mousterian assemblages), while there is simultaneously so much stress on the fact that they are the product of a mixing between Mousterian and Aurignacian levels.

Finally, Zilhão and d'Errico (2003, 326) state that the term Transitional Aurignacian is infelicitous, arguing that it is confusing, and proposing two alternative names: *Evolved Mousterian* or *Transitional Mousterian*. The first response to this is that the very fact that they suggest alternative descriptions for the sets of finds from Unit 18 at El Castillo means that they are implicitly admitting their homogeneity and the need to give them some new

[1] The highest figure for a northern Spanish Mousterian collection relates to Morín lower 17 at around 20%; this was seen as surprising and exceptional in its day (Freeman 1973).

name. If, on the contrary, Levels 18c and 18b are the product of severe changes undergone by the sedimentary deposits after they were laid down, as some scholars have claimed in print on a number of occasions, then they simply should not have any specific label. With this distinction in mind, it should be commented that both *Evolved Mousterian* and *Transitional Mousterian* could equally well lead to confusions because of the implications that can be drawn from them, just as much as from the term being proposed here. The use of the adjectival term "evolved" implies that this is a "special" Mousterian, to be defined as having evolved in the direction of something that must resemble what is to be expected from an "upper stage," in this instance the Upper Palaeolithic. On the other hand, if "Transitional Mousterian" is used, it must be tied in with the question of towards what it is in transition. This means that it is not valid to assume that this label can be used to define an industrial assemblage that represents some sort of near-Mousterian or post-Mousterian that merely leads to a dead end. Such a name implies an intermediate step towards the Upper Palaeolithic just as much as does the one being put forward here. The fact that Zilhão and d'Errico would term the finds Mousterian and not Transitional Aurignacian must be linked to the commonly accepted, but not proven, axiomatic view that modern humans are the creators of the Upper Palaeolithic and the earliest Aurignacian in the southwest of Europe.

Model of the Transition from the Middle to the Upper Palaeolithic in the Cantabrian Region

The Cantabrian region contains some very interesting archaeological evidence relating to the transition from the Middle to the Upper Palaeolithic. Recent work on classical sites in the area, such as the El Castillo cave, Cueva Morín, Lezetxiki, or El Conde, together with sites excavated more recently, such as Labeko Koba, Covalejos, Sopeña, and La Güelga, has produced some very interesting information.

The Transitional Aurignacian has just been described as a transitional technological culture in the Cantabrian region, but it was not the only one. Based on excavations at Cueva Morín, the first stage of the Châtelperronian has been identified in the region (González-Echegaray and Freeman 1971). Following on from this, it has also been identified with certainty in Labeko Koba and Ekain (both in the Basque Country), and with reservations at other Cantabrian sites such as La Güelga, Venta Laperra, Polvorín, Cudón, etc. (see Maíllo-Fernández, 2007, for a synthesis).

After a recent technological study conducted at Cueva Morín (Maíllo Fernández 2003, 2005), we can state that the more common *schéme opératoire* is that of a discoidal conception, employing a unifacial method with one preferred striking plane and the other for removals. This mode of exploitation occurs on all of the raw materials.

From a qualitative point of view, laminar *schéme opératoire* is more interesting. Two different methods are used: unipolar prismatic and bipolar prismatic. The first one is made from cubic nodules in which reduction is initiated by a nucleus crest. From this point, the *débitage surface* is opened and framed on both sides to produce rectilinear blades.

On the other hand, the bipolar prismatic method has the same morphological requirements. This method also allows for rectilinear morphology blades used for the production of Châtelperron points. There is no specific bladelet production, and those found in this level are obtained in an accidental manner during the exploitation of blades.

In addition to the Châtelperronian, the Cantabrian region has remains from the Late Mousterian, with numerous distinctive elements which could be connected to the start of the Upper Palaeolithic. On the other hand, the Early Aurignacian, or Proto-Aurignacian, displays a series of techno-typological survivals demonstrating a dispersed transition, as has been pointed out by some of the researchers working in the region (Cabrera-Valdés and Bernaldo de Quirós 1990; Straus 2005). There are thus innovations and survivals which can be tracked down throughout the Transition from Middle to Upper Palaeolithic.

Innovations

The Late Mousterian at El Castillo (Unit 20), Cueva Morín (levels 11 and 12), Covalejos, or level IV at Lezetxiki (Cabrera-Valdés et al. 2000; Maíllo-

Fernández 2001; Martín and Djema 2005; Baldeón 1993) all show evidence of bladelet production, sometimes making use of natural edges produced while working other tools, but also using standardised exploitation strategies, as at El Castillo or Cueva Morín (Maíllo-Fernández et al. 2004). Some of these bladelets are retouched using semi-abrupt or inverse retouching; in other contexts these would be called *Dufour* bladelets (Sánchez-Fernández and Maíllo-Fernández 2006).

In this sense, the typological composition of the Transitional Aurignacian documented at El Castillo (Cabrera-Valdés et al. 2001, 2005) should be considered another of these innovations, given that the large number of pieces typical of the Upper Palaeolithic (above all, endscrapers and burins) points towards the Upper Palaeolithic.

The emergence of a bone industry appearing in transitional levels, such as the Transitional Aurignacian, confirms the remains which have appeared in some sites in Croatia and Slovenia, as well as the Szeletian bone industry (Karavanič 2000) at Buran-Kaya III, level C (d'Errico and Laroulandie 2000; Marks and Monigal 2000), or at Arcy-sur-Cure (d'Errico et al. 2003). It is interesting that in both Central Europe and Cantabria, motifs appear which make it possible to connect these industries to the Aurignacian: in Central Europe, spearheads with a cloven base; and in El Castillo, rhythmic lines on the level 18c chisel (Cabrera-Valdés et al. 2001).

As for symbolic behaviour: On the one hand, there are some signs which permit the claim that there was innovation in this field during the Mousterian or Transitional technological technocomplexes. Reference has already been made to the two series of Mobiliar art at El Castillo 18b and 18c (Cabrera-Valdés et al. 2001). In addition, during the Mousterian at El Castillo, Unit 21 yielded a quartzite cobble with a series of rhythmic pitted marks (four and one) which cannot be interpreted as the result of the various actions involved in débitage, and thus can only be interpreted as nonutilitarian (Cabrera-Valdés et al. 2004, 2006).

On the other hand, a small collection of malacofauna was discovered at Lezetxiki on levels III and IVc of the new excavations (Arrizabalaga 2006, 305). Of the two shells belonging to level III, although highly polished, it cannot be claimed with any certainty that they have been manipulated, but the purpose behind their selection and transport to the cave seems evident. As for the two seashells from level IVc, one of them could have been used as a pendant without any overt manipulation, whilst the other shell has a quartz pebble obstructing its helicoidal passage, and also shows signs of abrasion, which could have come from its use as a pendant (Arrizabalaga 2006, 306).

Survivals

From a technological point of view, survivals from the Middle Palaeolithic into the Upper Palaeolithic are shown by the numerous pieces sharing a *fond commun* in some of the Cantabrian collections. Clear examples are El Castillo or Cueva Morín. At these sites there is a high percentage of this kind of piece, both during the Transitional Aurignacian (levels 18b and 18c) and on level 16, which corresponds to the Archaic Aurignacian at El Castillo; and during the Châtelperronian and the Archaic Aurignacian at Cueva Morín (Cabrera-Valdés et al. 2001, 2002; Lloret and Maíllo-Fernández 2006; Maíllo-Fernández 2003, 2006).

Débitage from discoid *schema opératoire* shows the same method (unifacial); and the same raw materials were used during both the Middle and the Upper Palaeolithic. This would appear to be more than a coincidence. For the authors, the choice of one *schema opératoire* over another is conditioned by the cultural traditions prevailing within different prehistoric groups (Pelegrin 1995), as well as by the importance it has as a tool for social cohesion within the groups (Leroi-Gourhan 1971). Therefore, the authors would argue in favour of the existence of strong technological ties between groups initiating the Upper Palaeolithic, and Middle Palaeolithic groups, in the Cantabrian region (Maíllo-Fernández 2003).

Among retouched tools from Upper Palaeolithic industries in Cantabria, the percentage which shares a *fond commun* is significant. Sidescrapers, notches, and denticulate tools are common in these collections, and the percentage could also indicate a series of survivals of a traditional nature in the Middle and Upper Palaeolithic.

Finally, recent studies of the relationship between the seasons and the age and sex of captured species at the El Castillo, Cueva Morín, and El Pendo sites on Mousterian, Châtelperronian/Transitional Aurignacian, and Aurignacian levels do not seem to have produced many differences according to a diachronic reading of the results (Pike-Tay et al., 1999). Thus in El Castillo, deer hunting was carried out throughout the year, although with slight differences; the majority of the prey during the Mousterian was killed from the end of autumn to the spring, whilst during the Transitional Aurignacian they were killed in spring. In both periods, the age of the prey was similar (pre-adult). At Cueva Morín, the hunting of ungulates (with a much more varied selection of species than at El Castillo) was carried out at the end of autumn and throughout winter, both during the Mousterian and the Archaic Aurignacian, testifying to the continuity of territorial use during both periods (Cabrera-Valdés et al. 2005, 518).

Chronology

Caution should be exercised when studying the chronology of the Middle and Upper Palaeolithic in the Cantabrian region. In the first place, the limitations of dating methodology should be borne in mind. This is generally C-14, which has limited reliability at present. The second question is related to archaeology: When does the Mousterian end? Or, when exactly are the first signs of the Upper Palaeolithic located? There is no doubt that this, coupled with the inherent idiosyncrasies of the moment (the Transition), makes the research picture enormously complicated. The authors consider the end of the Mousterian to fall between 50,000 and 39,000 BP, based on results obtained at El Castillo and Cueva Morín (Cabrera-Valdés et al. 1996a; Maíllo-Fernández et al. 2001), although there are sites with much more recent dates, such as El Esquilleu (Baena et al. 2006). Overlapping with the end of the Mousterian, therefore, is the Transitional Aurignacian, dated at between 40,000 and 38,500 BP; and the Châtelperronian, which stratigraphically is positioned below the Archaic Aurignacian at Cueva Morín and Labeko Koba, although C-14 dating here has produced very recent dates: 34,215±1265 BP (UA-3324). The Archaic Aurignacian is dated as beginning in the Basque-Cantabrian region at around 36,500 B.P., at sites such as La Viña in Asturias (Fortea 1995), Cueva Morín, El Castillo, and Labeko Koba (Maíllo-Fernández et al. 2001; Cabrera-Valdés et al. 2002; Arrizabalaga 2000), and continuing until 30,000 BP.

Therefore, looking again at the different radiometric dates around the Transition, it can be seen that there is a certain amount of overlap: for example, the Châtelperronian at Labeko Koba and the Archaic Aurignacian at Cueva Morín. This may be due to two factors, a physical one and a cultural one. The first hypothesis, of a physical nature, is linked to the nature of radiometric dating methods. C-14 is at the limit of its use with any certainty, and its correlation with other methods (TL and ESR above all) is still not clear. There exists, therefore, the possibility that the situation described does not correspond to more than a mirage provoked by the methods used and their results (Cabrera-Valdés et al. 2004). The cultural explanation relates to the possibility that different technological cultures coexisted in this region during this temporary interval, either because of differing cultural traditions or because of economic *facies* within a larger technological culture. The kind of human responsible for each of the technological groups will not be considered here, especially because evidence from the fossil record does not permit the presentation of complete data.

Another interesting aspect of this period is the chronology of the Early and Archaic Aurignacian in this region. Stratigraphically, the Early Aurignacian is superimposed onto the Archaic Aurignacian in all of the studied region; C-14 dating also corroborates this finding, but shows a partial synchrony of both technological cultures in the region, not at the same site, but between sites. This situation, which could have the same causes as those described in the preceding paragraph, must also be analysed from the perspective of territorial occupation, and should, necessarily, go outside the regional limitations dealt with here (Bon et al. 2006). As has been mentioned previously, the Archaic Aurignacian was established in the Basque-Cantabrian region by around 36,500 BP, with some characteristic technological typologies which were very different to those which appeared in the Early Aurignacian, first manifest in the Brassempouy site and dated at 33,600± 240 (Gif-11034) for level 2DE. After this, overlapping is once again found, which could indicate the partial coexistence of both technological cultures. Such a coexistence would not have happened in the same territory, but would have been spread over adjacent regions. The two technological cultures do not occur in the same space (Bon et al. 2006).

Discussion

We consider that the Transitional Aurignacian has all the elements necessary in order to be regarded as a transitional technological culture. Recently, S. L. Kuhn (2003) put forward three conditions that should be fulfilled if an industry were to be considered transitional. The first was chronological position between the Middle and Upper Palaeolithic, that is, between 50 and 35 Kyr BP. The second was that objects from both the Middle and the Upper Palaeolithic should be present. And lastly, that cultural roots in the Middle Palaeolithic which point towards some of the cultural innovations of the Upper Palaeolithic should be identifiable. As has been argued above, the Transitional Aurignacian identified in El Castillo should be considered as one of these industrial transitions.

In addition, the Cantabrian coast, according to an analysis of the fossil record, has an extremely interesting panorama in terms of examining the Transition from the Middle to the Upper Palaeolithic. The coexistence of different technological cultures; the survival of traditions of a technological (flake production during the Archaic Aurignacian) or hunting nature; technological innovations (blade production) or symbolic ones during the end of the Mousterian—all lead the authors to propose the working hypothesis that the Transition from the Middle to the Upper Palaeolithic was, from a technological point of view, the fruit of a dispersed process with contributions and survivals from the different principle technological cultures involved. In this process, those industries called "transitional" (Transitional Aurignacian and Châtelperronian) form the hinges between both periods, which the discipline of palaeontology has always tried to keep separate due to different analytical approaches.

This model of a transition in mosaic, where, maybe, groups of Neanderthals can be responsible for this step towards modern behaviour, is not new. It was proposed for the Cantabrian coastal region nearly two decades ago (Cabrera-Valdés and Bernaldo de Quirós 1990), and similar interpretations have been put forward in different parts of Europe. Thus the data of a cultural nature which have been recapitulated here lead to the conclusion that the most plausible hypothesis is that the Neanderthals were decisive lead players in the gradual appearance of the technical complexes belonging to the Upper Palaeolithic, not excluding the Aurignacian. This process would seem to have had multiple focal points, and the north coast of Spain represents one of these cultural *foci* moving towards "modernity."

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Hard Work Never Goes to Waste: The Role of Iberia in the Mid-Upper Paleolithic Transition

Marta Camps

Abstract The present paper offers an assessment of a topic which is usually ignored in modern archaeological research: the importance of taking into account the data and information obtained by old studies and original fieldwork. While it is clear that standards were very different from the ones we use at present, this paper shows that each site must be independently evaluated, because in some cases, such as the one presented here, earlier work—part of it carried out one hundred years ago—has proved to be crucial for the advance in the study of the Mid-Upper Paleolithic transition, both in practical terms, regarding archaeological collections, as well as in the theoretical sphere.

Keywords Middle/Upper Paleolithic • Mousterian • Aurignacian • Abric Romani • Revision • Old collections

Introduction

Saying that the Mid-Upper Paleolithic transition is one of the most contentious topics in current paleoanthropological and archaeological research not only is a cliché, but it also defeats the main purpose of including this paper in this volume, as the idea behind it is to look at the many different Paleolithic transitions from various and innovative perspectives.

Suffice it to say that in the more than 30 years during which this subject has been studied (Camps 2009), it has unfolded as a phenomenon with countless facets and key points. Major methodological and epistemological questions meet at its core with laboratory and fieldwork data and results in need of interpretations, discussion, and ultimately, answers. The Mid-Upper Paleolithic transition combines paleoanthropological questions about many important topics: the fate of Neanderthals and the origins of anatomically modern humans (AMH), these species' authorship of the industries of the period, the supposed variability between and among those, the time frame within which this phenomenon took place, etc. All this, right on the edge of the chronological limit of radiocarbon dating. There is no need to wait for the conclusions section to announce that we have a topic (and research) that will be around for a long while.

In the following pages, I want to approach the transition to the Upper Paleolithic in Iberia progressively from a historiographical perspective, that will go from the mainly theoretical aspects of the transitional debate to the particular regional characteristics of this phenomenon. As an example, I will present a clear case study that illustrates the most important points of this research as it has developed in the Iberian Peninsula. I will conclude with an overview of possible future research lines, mostly applied to the Iberian Peninsula. Special emphasis will be placed on the contemporary role of old or classic Paleolithic archaeological works in

M. Camps (✉)
Department of Anthropology, George Washington University, Washington, DC, USA

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modern-day Spain, and whether they can be integrated with modern research avenues that are being developed at present or whether they need to be discarded as a whole.

The Mid-Upper Paleolithic Transition as a Research Topic

While interest and scientific research on the origins of our species (one of the many issues that form the general topic of the Mid-Upper Paleolithic transition) have been going on for many years and have captivated the attention of both scholars and lay people alike, the transition as a particular phenomenon emerged as a key debate in the early 1970s.

As I have explained in detail elsewhere (Camps 2006, 2009), it was then that the characteristics of this phenomenon were proposed (Mellars 1973), and as years went by and interest in the issue grew, they became a sort of check list (see Table 1) for all those performing research on this topic or trying to see if a particular layer of a site belonged to that particular period, or a moment during the transition.

What had started as a set of observations for a particular region, southwestern France, was soon to be used for other, very different regions of Europe during the 1980s and 1990s. This generalization process was the cause of why this set of characteristics trespassed the boundaries of the region in which they were originally observed and created, and became pan-European generalizations for some 15 or 20 years. These generalizations were accepted by most, until the record of the so-called "peripheral regions" (i.e., geographic areas around southwestern France) began to yield finds that were impossible to force into the original framework.[1] Before proceeding any further, it is crucial to examine why the aforementioned generalizing process took place for the transition, as it is an issue of importance for other factors discussed in this paper.

[1] It is important to mention that this is not the only thing that has undergone this generalization process. Other issues, like typological systematics and their careless application in many regions outside their original French niche, are good examples of a tendency that should be stopped.

Table 1 List of tenets said to characterize the Mid-Upper Paleolithic Transition in Europe (Mellars 1973)

A shift from "flake" to "blade" technology
An increase in variety, complexity, imposed form, and degree of standardization
Appearance of complex bone, antler, and ivory technology
An increase in *tempo* of technological change, degree of separation, and regional diversification
Appearance of personal ornaments
Appearance of complex naturalistic art
Presence of several socioeconomic parameters: systematic hunting
A sharp increase in population density
An increase in maximum size of social groups, highly structured forms of settlement

The origins of Paleolithic research are to be found in France, around the mid nineteenth century (Sackett 2000), when questions and ideas about the origins of humankind went from being looked up in the Mosaic tradition of the book of Genesis to being sought within the Darwinian writings in *On the Origin of Species* (1859) and more precisely in *The Descent of Man* (1871). The French archaeological record and the works of Boucher de Perthes in the Somme Valley were the major turning points to convince firstly British scholars, and right afterward their French counterparts, that the antiquity of humans was not quite as the Bible explained.

Ever since then, French archaeology has had a sort of "leading" role, the importance of which was emphasized not only by research carried out on French soil, but also thanks to socioeconomical conditions that were shaping the modern history of countries and regions that have been called "peripheral" above. While these developments were taking place, both Spain and Portugal went through a long period of political and economic instability, when dictatorial regimes ruled both countries. Moreover, the strong conservatism of the Roman Catholic Church prevented any ideological innovations from taking root and developing on the basis of the earliest archaeologists and their work, e.g., the Count of La Vega del Sella at sites like Cueva Morín and Obermaier at El Castillo in Spain, or Breuil and Zbyszweski in Portuguese sites). The dictatorships of Salazar and Franco ended only in 1974 and 1975, respectively; and although a few things had slightly and slowly changed during the previous decades, by that time the debate on the transition had already started. The more advanced research and knowledge from north of the Pyrenees was the object of admiration, and the initial influence of such a role model was more than welcome.

Key Points of Transition Research

The Mid-Upper Paleolithic transition, on a continental scale, and in a few rough brushstrokes, could be seen as a process that took the form of a wave of advance, from southern and eastern Africa, through the Near East corridor, and then spread through Eurasia. Roughly at c. 40 ky BP the Middle Paleolithic industries (namely the Mousterian in the Iberian Peninsula) were replaced by Upper Paleolithic ones (Chatelperronian and Aurignacian). Neanderthals disappeared and AMH spread throughout Europe, occupying not only former Neanderthal areas, but other regions too. But was it so simple?

Until the present, the debate about the transition has focused on three main points, and we can divide the history of scholarly interest and research on this phenomenon according to them (Camps 2003, 2009).

In the first phase, from the early 1970s and until the mid to late 1990s, attention was put on the characteristics of the change seen by researchers supporting the fact that the transitional process did occur at that time. These characteristics evolved from being specific to southwestern France into being applicable to all of Europe, though they suffered slight modifications, as shown in Table 2. It is important to note here that this list of characteristics has been analyzed and studied by different authors over the years (e.g., Klein 1992; White 1982); however, none of them

Table 2 The evolution of the characteristics of the Mid-Upper Paleolithic Transition across four seminal works on the topic (Mellars 1973, 1989, 1991, 1996)

1973	1989	1991	1996
A much wider range and complexity of tool forms	(a) Appearance of well-defined forms (endscrapers, burins) (b) Morphologically new artifacts (c) Remarkable speed of appearance (d) Greater standardization (e) Greater degree of imposed form	(a) Shift from flake to blade technology (b) Increase in variety, complexity, imposed form, and degree of standardization (c) Increase in tempo of technological change	(a) Improved blade technology (b) New forms of stone tools
Ability to shape bone/ivory/antler into complex forms	Appearance of complex bone and antler technology	Complex bone, antler, and ivory artifacts	Complex, standardized, and extensively shaped bone, antler, and ivory artifacts
Appearance of personal ornaments		Appearance of personal ornaments	Appearance of various types of personal ornaments
Specialized hunting (reindeer)	More systematic and intensive subsistence techniques	Systematic hunting	
Larger settlements (and possibly larger groups)		Increase in groups' sizes	
Modifications of natural conditions of settlements		Highly structured forms of settlement	
Long-distance contacts existence			Expanded distribution networks
Increase in population density		Sharp increase in population density	
	Appearance of symbolism/language	Appearance of art (complex and naturalistic)	Appearance of art (complex, sophisticated, representational), numerical systems, and calendars

have proposed alternative points by which to define the traits of the phenomenon.

McBrearty and Brooks (2000) convincingly proved that all the notions of "revolution" that accompanied the accounts of the transitional process during most of the 1990s (e.g., Klein 1992; Mellars 1991) are to be dismissed, as the African evidence shows that all of the "revolutionary" traits can be found separately and much earlier in the African record, a "peripheral area" no one working on the transition in Europe had looked into, even though several paleoanthropological studies (e.g., Klein 1989) pointed to the African continent as the place where AMH had originated.

Short of reaching a consensus on the characteristics of the process, in the late 1990s, the subject of acculturation—and who influenced whom—became the main research focus in this debate (d'Errico et al. 1998; Mellars 1999).

In the third and so far latest phase, which developed during the first decade of the twenty-first century, the transitional debate has centered on the stratigraphic sequences of some specific site (e.g., Grotte des Fées de Châtelperron) and the industrial attribution of very specific layers, as well as the location of these in relation to one another (Gravina et al. 2005; Mellars et al. 2007; Zilhão et al. 2006).

All three abovementioned focus points and the different views about each of them remain contentious, and no consensus on any of them has been reached to date.

The Epistemology of Post-Franco/Salazar Archaeology

J. Alcina-Franch, a Spanish anthropologist, characterized Spanish archaeology in the mid 1970s as set forth in Table 3 (Alcina-Franch 1975).

The lack of autochthonous innovative thinking was only corrected, albeit slowly and partially,[2] during the 1980s, both in Spain and Portugal. This was due to factors such as the wider acceptance of previously forbidden ideological perspectives (i.e., Marxist tendencies), the earliest meetings about prehistory in the Peninsula, and the input of foreign scholars, most notably from the United States (Bicho 2002; Vázquez, Varela, and Risch 1991). Nevertheless, leaving epistemological and theoretical aspects aside, it is important to highlight that fieldwork in some Paleolithic sites had been performed and was being carried out since the early twentieth century. Such activities suffered important pauses due to issues related to European conflicts affecting foreign scholars, such as H. Obermaier during World War I (1939–1945), and of course to internal conflicts, such as the Spanish Civil War (1936–1939), and their aftermaths.

Table 3 Characteristics of Spanish archaeology in the mid 1970s, according to Alcina-Franch (1975)

A complete lack of theoretical orientation and any coherent program of research
A ubiquitous adherence to a descriptive or "archaeographic" style
Focused on historicist interpretations exclusively
A deficient consideration of environmental factors and the absence of inter/multidisiciplinary studies

Until this point in time, the Iberian Peninsula had remained but a marginal area in which most researchers (foreign and not) expected to see a replica of processes observed in other areas where there was a longer tradition of research on the Paleolithic and more particularly, on the Mid-Upper Paleolithic transition. However, the 1990s brought—at the continental and peninsular levels—important discoveries that would answer the question posed above regarding the apparent simplicity of the Mid-Upper Paleolithic transition.

Modern Research and Divergent Traits in the Mid-Upper Paleolithic Transition in Iberia

In 1993, Lévêque published the study of the 1979 discovery of the Neanderthal remains associated with Chatelperronian tools and ornaments at Saint-Césaire (Charente-Maritime, France) (Lévêque 1993; Lévêque et al. 1993). Paleoanthropological research also produced some important advances that were intrinsically related to the transitional debate (Cann et al. 1987).

[2] The study of typological systematics is still deeply grounded in the French Bordesian systems (Bordes 1961; de Sonneville-Bordes and Perrot 1954), and Laplace's Analytical Typology (Laplace 1957, 1974).

In Iberia, the end of the twentieth century saw the culmination of the geographic research bias that had primed Middle and Upper Paleolithic research in the Catalan and Cantabrian regions; which, after a century of studies, displayed two very different—and completely opposed—scenarios for the transitional process. While the catch phrase "The 40 ky BP Crisis" was giving a name to important research workshops and scientific meetings (e.g., Capellades 1995) in Catalunya, where the transition is seen as an abrupt break between the Middle and the Upper Paleolithic periods (Carbonell et al. 1996; Bischoff et al. 1989; Maroto and Soler 1990; Maroto et al. 1996), the classic sites in Cantabria were thought to have witnessed a less abrupt and more progressively continuous episode of change. While in Catalunya, Neanderthals and Mousterian industries mysteriously disappeared as soon as AMH arrived in the area (bringing Aurignacian toolkits with them), Cantabrian Neanderthals slowly transformed themselves and their Mousterian industries into AMH and Aurignacian tools, respectively (e.g., Cabrera Valdés et al. 2000).

In the early 1990s, Zilhão (1993), hypothesized that the long coexistence of both AMH and Neanderthals in Iberia was due to the Ebro River being an ecological frontier that would split Iberia horizontally. It supposedly divided Iberia into a northern area with AMH, arrived from Africa via the Near East and the whole of Europe, and a southern Neanderthal *refugium*, where this species would have survived for some five to ten thousand years longer after the 40 ky BP dates that have been obtained for some of the sites in the Catalan and Cantabrian areas (see some examples in Table 4). We must bear in mind, however, that those areas are where research had been carried on for much longer; and thus the amount of information is far greater for the northern half than for the southern, and our interpretations of processes in Iberia at that time may well be affected by this usually ignored reality.

The 1990s also proved that, although it has been less explored than the French Paleolithic record, the Iberian record not only has nothing to envy in its French counterpart in terms of abundance of remains and sites, but is itself distinctive and needs data-oriented studies tailored specifically for it. Until then, most studies followed patterns cut for areas that do not bear much resemblance to the Iberian regions.

The above is confirmed not only by information gathered from the peninsular sites that we have already mentioned, but also that from many other smaller locations, sometimes with a more modern fieldwork history (see Table 5 for some examples). Almost always, however, this work is far less present in international publications, which is one of the issues that Paleolithic research in Iberia should try to correct. Moreover, a quick look at only a few of these sites and the dates they have so far yielded will show that some of the hypotheses proposed for Iberia (e.g., the 40 ky BP Crisis, the Ebro Line, etc.) are just not supported by the evidence.

Indeed, when a list of what could be considered "transitional" sites was mapped directly against some of the generalized characteristics of the transition (Table 6), the most striking result was not the total absence of art or the few appearances of personal ornamentation in the Iberian Aurignacian (as these are characteristics that would certainly have been scarce at the time), but rather the number of question marks indicating missing information (Camps 2003).

There is a sense of having too many loose ends to deal with, when one delves into the information

Table 4 Dates for the earliest Aurignacian in three well-known and widely published transitional sites (Cabrera Valdés and Bischoff 1989; Bischoff et al. 1988, 1994)

Catalunya	Abric Romaní	AMS (charcoal)	37,900±1000
			36,590±640
	L'Arbreda	AMS (charcoal)	39,900±1200
			37,750±1000
Cantabria	El Castillo	AMS	42,200±2100
			37,100±2200

Table 5 Dates for the late Mousterian layers at different northern Iberia sites (Maroto 1994; Martínez et al. 1994; Montes et al. 2001; Moure Romanillo and García de Soto 1983; Villar Quinteiro and Llana Rodríguez 2001)

Els Ermitons	^{14}C	36,430 ± 1800
	AMS (bone)	33,190 ± 660
Roca dels Bous	AMS	> 46,900
		38,800 ± 1200
Gabasa		> 39,900
		> 45,900
Peña Miel	^{14}C	37,700 ± 1300
		40,300 ± 1600
A Valiña	^{14}C (bone)	40,300 ± 1600
		34,800 + 1900/–1500
Cueva Millán	^{14}C (bone)	37,450 ± 700
		37,450 ± 600

Table 6 Selected Iberian sites mapped against five of the characteristics of the transition, to check if these are applicable or not, or if there is any data at all about the subject (Cabrera Valdés et al. 2000; Camps 2003; Corominas 1949; Cortés Sánchez and Simón Vallejo 2001; Fortea and Jordá 1976; González Echegaray et al. 1971, 1973; Maroto 1994; Montes et al. 2001; Vega Toscano 1988; Villaverde 1984; Villaverde et al. 1998)

	Blades vs. flakes	Standardization	Organic technology	Naturalistic art	Personal ornamentation
Abric Romaní	YES	YES	YES	NO	YES
L'Arbreda	YES	?	YES	NO	YES
Reclau Viver	NO	?	YES	NO	YES
Peña Miel	?	?	?	NO	NO
El Castillo	NO	?	Latest Mousterian	NO	NO
Cueva Morín	NO	?	NO	NO	NO
Mallaetes	?	?	?	NO	NO
Cueva Beneito	?	?	?	NO	Mousterian pendant
Cova Negra	?	?	?	NO	NO
Perneras	?	?	?	NO	NO
Bajondillo	?	?	NO	NO	NO

available to date about the phenomenon of the transition in general, and more specifically in the Iberian Peninsula. In order to redress this, it is crucial that future research devotes itself not only to making progress in new lines, sites, methods, etc., but also to filling in the gaps already present in research done until now—as well as studying and reanalyzing important information yielded by recent fieldwork.

Although it is true that the methods used in the past were far from ideal, and that in several cases crucial evidence has been lost forever, we should not underestimate the important progress achieved by scholars and research teams which carried out large amounts of work with the best methodology and technology available to them at the time. At the same time, modern research has been able to spot problematic "old" findings, and these need to be incorporated into the debate (i.e., El Pendo's record for the transitional period was disturbed by the action of a stream that flows through the cave intermittently, and is thus not valid to support claims of interstratification episodes between Chatelperronian and Aurignacian levels [Hoyos and Laville 1983; Montes and Sanguino 2001; both *contra* Butzer 1981]). Admittedly, the aforementioned problem regarding the distribution and diffusion of papers in Spanish and Portuguese that do not get translated into English or at least presented at major international events, does not help this situation. A good example of the importance of taking "old" work carried out in transitional sites into account is the case study with which I wish to illustrate many of the key points I have highlighted above.

Abric Romaní: A Century of Paleolithic Research

La Bauma del Fossar Vell, the original name of the rock shelter known nowadays as Abric Romaní, is one of the many travertine cavities found on a cliff overlooking the Anoia River, just below the modern day town of Capellades, some 60 km away from Barcelona (see Fig. 1). It is worth highlighting at this point that the original Catalan name of the site ("the rock-shelter of the old grave") indicates one of the multiple uses that the rock shelter had prior to the start of excavation. It had not only been used as a civil cemetery, but it had also served as a place to bury dead cattle, and even as a general garbage dump. A few of these activities must have surely affected the state of Abric Romaní's uppermost layers, which were the ones that were formed during the transitional process studied here.

Its rich archaeological contents were originally discovered by Amador Romaní, in whose honor the site was renamed, in 1909. Romaní was a businessman from an accommodating and learned middle class family, who had a passion for fossils and could afford the time to look for them around the area where he lived, as proved by the scientific diary/scrapbook he kept about the sites he visited (Bartrolí et al. 1995).

Archaeological work at this site started immediately after its discovery, mainly carried out by Romaní himself and under the guidance of experts associated with the Institut d'Estudis Catalans (Bartrolí et al. 1995) in Barcelona, such as N. Font i Sagué and

Fig. 1 Map of the Iberian Peninsula, marking the geographical location of the case-study site discussed in this paper

L.M. Vidal (author of the first research paper about Abric Romaní in 1911). Note that because these experts were based in Barcelona, the shipment of materials from this site to that city, which has caused the Romaní collection to be divided among different museums, started at this time.

After the publication of Vidal's paper in 1911, work at the site became sporadic, most likely because of the end of official funding and events in the life of Romaní, who moved from Capellades to Vilanova i la Geltrú in 1916. Romaní and Vidal had worked with classifications proposed by French researchers such as de Mortillet, Breuil, and Cartailhac, with the latter having the strongest influence through his correspondence with both Romaní and Vidal (Camps 2003).

The second stage of archaeological research at the site developed from 1956 to 1962, and was directed by the late E. Ripoll, who worked in close collaboration with H. de Lumley, and with G. Laplace. He himself was based in the Museu Arqueològic de Barcelona. The author was able to interview Ripoll during her Ph.D. research and he confirmed that boxes of unsorted material from the site were randomly transported to Barcelona, to be stored in that museum because of the lack of proper facilities for that purpose in Capellades. This material constitutes a separate collection from the one which Romaní had sent to different museums and institutions in Barcelona, although the latter is now also stored in the Museu Arqueològic de Catalunya, formerly called Museu Arqueològic de Barcelona. Both subcollections were kept separately, and the first batch of material was found among the boxes that were carried by trucks to Agullana, near the French border, in 1938, to protect archaeological materials from the blitz during the Spanish Civil War (1936–1939).

During Ripoll's time at Romaní, work affecting the transitional layers concluded, although remnant sections from those layers attached to the back wall of the site were left, as had been done in the earlier stage (Ripoll 2000, personal communication). Samples for dating were originally taken from these sections in the early 1990s (Bischoff et al. 1994), which resulted in dates of 40 ky BP for the Mid--Upper Paleolithic transition, despite the fact that Laplace's research during the late 1950s showed that these sections were mostly sterile, hence making their cultural attributions controversial, to say the least. This has been the cause of strong criticism (Zilhão and d'Errico 1999), which has affected the credibility and validity of the site for the study of the Mid-Upper Paleolithic transition.

Ripoll and de Lumley (de Lumley and Ripoll 1962; Ripoll and de Lumley 1965) applied Bordesian systematics to their typological study of Abric Romaní Mousterian layers, while Laplace applied his own Analytical Typology (1962) to his study of layer 2, the only Upper Paleolthic layer at the site. While French influence can be seen in the application of typological systematics originally designed in France for French sites (Bordes 1961), it is crucial to mention here that the practical application of that theoretical framework was less than orthodox, because de Lumley and Ripoll (1962, 47) decided to lump together layers 13–10, 9, and 8–2 [*sic*],[3] and treat these groups as one single layer in their analyses.

The third and current stage of excavations started in 1983, under the direction of E. Carbonell, and is being carried out by a team from the Universitat Rovira i Virgili (Tarragona). It deals mainly with the extraordinarily long Mousterian section of Abric Romaní, although they have also addressed the importance of this site in the debate regarding the transition in Iberia. The typology they use is the so-called Logic-Analytical Typology (Carbonell et al. 1983; Vaquero 1992) (Fig. 2).

The Mid-Upper Paleolithic Transition at Abric Romaní

The Materials

At the time when the author started to study the site of Abric Romaní, and more particularly its transitional[4] layers (2 and 4, currently named A and B, respectively), it was thought that the part of the collection taken by Ripoll to Barcelona was lost, and that there was no information whatsoever on the materials sent by Romaní to Font i Sagué and Vidal in the early decades of the twentieth century. This had been the status quo for several decades, as proved by the research works that were written during these years, which included the Mid-Upper Paleolithic transition at the site; all of them based their conclusions on the study of partial collections, mainly including the materials kept at the Capellades museum, or at the most, the handful of pieces exhibited in Barcelona since the mid 1980s as well (e.g., Laplace 1962; Soler 1986; Vaquero 1992).

Surprisingly, in reply to the author's request to access the materials from Abric Romaní's transitional layers stored in Barcelona, she received an invitation to examine several dozens of boxes

Fig. 2 Abric Romaní in the winter of 2001 (photograph by Marta Camps)

[3] While on page 47, layer 2 is included among the Mousterian layers that were lumped together and analyzed in groups, later on this is changed and instead of 2, layer 3 is quoted.

[4] By transitional I mean belonging to the transition debated here, i.e., Late Mousterian, Chatelperronian, and Early Aurignacian.

containing materials received from different museums in the city, still wrapped in newspaper pages dating to the first two decades of the last century, as well as the materials brought by Ripoll from the site. Real "detective" work carried out in the library and archives of this museum also showed that materials from transitional layers were stored at the small museum of Vilanova i la Geltrú, where Romaní had worked, and these were also included in the study[5] (Camps 2003).

The following analysis deals with three different collections, the materials from which were confidently ascribed to either layer 2 or layer 4 in Abric Romaní, and which are now divided according to the museums (see Table 7) in which they are still stored: the Capellades museum (Museu Molí Paperer), the Barcelona museum (Museu Arqueològic de Catalunya), and the Vilanova i la Geltrú museum (Biblioteca-Museu Víctor Balaguer).

Revising Previous Studies of the Transition at the Site

The aim of the present section is to illustrate the need to include archaeological sites which have been the focus of "old" excavations, and the materials that they have yielded, in the corpus of data that is currently used to analyze the transition.

There are indeed cases, such as that of Cueva de El Pendo mentioned above, where reanalyses have proven that information presented in old publications about a site need to be disregarded because of the lack of original information or the reassessment of conditions affecting both the site and the materials. This is not the case with Abric Romaní, as proven above, because the different researchers seem to have carried out their excavation work with the highest standards, and I was able to compile a lot of information about the post-excavation "adventures" that the several collections went through. All the new information summarized above, which I have described in detail elsewhere (Camps 2003, 2006), warranted the present revision. Prior to the present study, the following analyses had been performed on the transition at Abric Romaní; they are organized in Table 8 for greater clarity and for the purpose of comparison.

[5] It is not known how and when some materials from Abric Romaní arrived at the Museo Arqueológico Nacional in Madrid. Although this group of pieces reportedly contains a perforated shell of the kind found in layer 2 by Romaní himself (*Cyprea pyrum*), it seems that the lithic implements belong to nontransitional layers or have no stratigraphical provenance (Cacho 2001, personal communication), and hence they were not included in this study.

Table 7 Count of blanks, divided into three types, in the three museum collections containing the transitional assemblages from Abric Romaní (Camps 2003, 2006)

Museum collections	Layer 2	Layer 4
Capellades (Museu Molí Paperer)	96 flakes 11 blades 66 bladelets	148 flakes 19 blades 13 bladelets
Barcelona (Museu Arqueològic de Catalunya)	30 flakes 12 blades 113 bladelets	24 flakes 9 blades 1 bladelet
Vilanova (Biblioteca-Museu Víctor Balaguer)	0 flakes 1 blade 6 bladelets	1 flake 0 blades 0 bladelets

Present Study

Prior to beginning the typological analysis of the assemblages from Abric Romaní's transitional layers, it was important to decide which system was the most appropriate to use. In fact, originally, and as a comparative research experiment, the assemblages were studied and classified according to all three main systems that have been used in the research at this site: Bordesian systematics (including de Sonneville-Bordes and Perrot's Upper Paleolithic typology), the Analytical Typology, and the Logic-Analytical classification. Explanations of how all these systems work can be found at length elsewhere (Camps 2003). For the sake of clarity, it was decided that the final presentation would be done using Bordes and de Sonneville-Bordes' systems, as it is their terminology, as well as the overall process of the systems, that most researchers are familiar with.

It cannot be emphasized enough that this study does not seek the typological classification of the assemblages as a goal in itself. I have clearly stated the limited use of these kinds of studies, when they are an objective in themselves and not the means to an end elsewhere (Camps 2003). However, they are

Table 8 Previous work on the transitional assemblages (layers 2 and 4), quoting scholars, typological systematics used, and results obtained (references are all quoted in the first and second columns; please note that Cazurro [1919] could not found)

Researchers and dates	Typology used	Layer 2	Layer 4
Vidal (1911)	Pre-Bordesian sytematics: modified de Mortillet's cultural periodization by Cartailhac and Breuil (Breuil 1907)	Magdalenian	Mousterian
Cartailhac (1910? by private correspondence)		Aurignacian	
Obermaier (1916)		Magdalenian	
Romaní (1917)		Aurignacian	Mousterian
Cazurro (1919)		Magdalenian	
Ripoll (1959)	Bordesian Low/Mid Paleolithic typology		Final Denticulate Mousterian
de Lumley and Ripoll (1962) and Ripoll and de Lumley (1965)	Bordesian Low/Mid Paleolithic typology and de Sonneville-Bordes and Perrot Upper Pal. typology	Early Aurignacian with Dufour bladelets (Perigordian II of Peyrony)	Denticulate Mousterian (layers 8 to 3 grouped)
Laplace (1962)	Analytical typology	Mixed Aurignacian/ Gravettian	
Laplace (1966)	Analytical typology	Proto-Aurignacian	
Soler (1986)		Perigordian II (= Archaic Aurignacian or Aurignacian 0)/ mixed	
Canal and Carbonell (1989)	Bordesian Low/Mid Paleolithic typology		Non-Levallois Denticulate Mousterian (by defect)
Vaquero (1992)	Logic-analytical typology	Upper Paleolithic	Middle Paleolithic
Maroto (1994)	(from Vaquero 1992)	Aurignacian	
Carbonell et al. (1996)	Logic-analytical typology	Aurignacian	Mousterian

crucial here to show how our previous knowledge of the processes which took place at the site changed when a thorough and holistic analysis of the full collection was undertaken. Obviously, taking the results of the present study to the next level of analysis, and changing typological jargon into more meaningful information about human subsistence and way of life, is considered not only necessary but crucial, although outside the limits and scope of this paper.

Layer 2: This assemblage consisted of 417 pieces, out of which a total of 168 were classifiable according to de Sonneville-Bordes and Perrot's Upper Paleolithic typology. The most represented types were the following: type 90, Dufour bladelets, with 25 pieces (14.8%); type 77, sidescrapers, with 24 pieces (14.2%); and type 47, atypical Chatelperron points, with 19 pieces (11.2%).

A list of characteristics expected in a Catalan Aurignacian assemblage, according to Soler (1981, 1982), as well as traits observed in other European Aurignacian assemblages by Kozlowski (1990) and Otte (1990), is tabulated next to the traits exhibited by Abric Romaní's layer 2 assemblage in Table 9.

Table 9 A list of characteristics of the Aurignacian (including those expected in Catalan Aurignacian assemblages) and evidence collected from Abric Romaní's layer 2, mapped against them (Camps 2003; Kozlowski 1990; Otte 1990; Soler 1986)

Abundant carinated endscrapers	3 (1.8%)
Ogival endscrapers	None
Nosed endscrapers	None
Aurignacian blades	None
Strangulated blades	None
Dufour bladelets (characteristic)	Most represented type: 25 (14.8%)
Burins *(fossile directeur)* well represented	12 (7.2%)
High number of retouched blades	2 (types 65 and 66)
Absence of backed blades	48 (types 45–59)
Invasive retouch	8
IG high or very high	15.97%
IB very varied (but lower than IG)	7.10%
IBd is higher than IBt	IBd = 4.14%, IBt = 1.77%

The disagreement between expected traits for the assemblage and its real characteristics extends also into the typological indices and makes any comparisons with Aurignacian sites studied by de Sonneville-Bordes (1960) completely impossible (Camps 2006). As a summary of the above, the indices of two characteristic groups are provided: GA (Characteristic Aurignacian Group) = 3.55%, strikingly low for a supposedly Aurignacian assemblage; and clearly different from the GP (Characteristic Perigordian Group) = 37.27%. Comparing this assemblage with data from Perigordian layers from sites such as Laugerie-Haute (PIII level) according to de Sonneville-Bordes' data (1960) is equally difficult after slight similarities among the percentages of the early types in her typological list.

In light of the above, as well as the site disturbance processes mentioned earlier, I feel it is extremely risky to rule out any admixture of layers containing different assemblages, as some authors have done in the past (Carbonell et al. 1996). Laplace proposed in 1962 that layer 2 could be formed by different levels, mixing Aurignacian and Gravettian materials. Adding the materials which that scholar was unable to study broadens the possibility of a mixture of layers and materials to include a Chatelperronian component, which would explain the large numbers of atypical Chatelperron points and sidescrapers. It is also important to highlight that a previously unstudied part of this assemblage includes pieces such as a triangle (see Fig. 3), a type traditionally associated with Magdalenian assemblages (Demars and Laurent 2003). The latter is one more reason to render previous classifications of this layer (e.g., only Aurignacian, early Aurignacian, and so on) as completely unwarranted, if not just wrong.

Other interesting nonlithic materials were also found spread across several collections including materials from layer 2. These included bone implements and perforated shells, as well as fish vertebrae interpreted as personal ornamentation items. This would conform with the generalized tenets marking the transition to the Upper Paleolithic. They are the focus of the aforementioned next level of study, which is the subject of forthcoming papers (e.g., Camps and Higham n.d.).

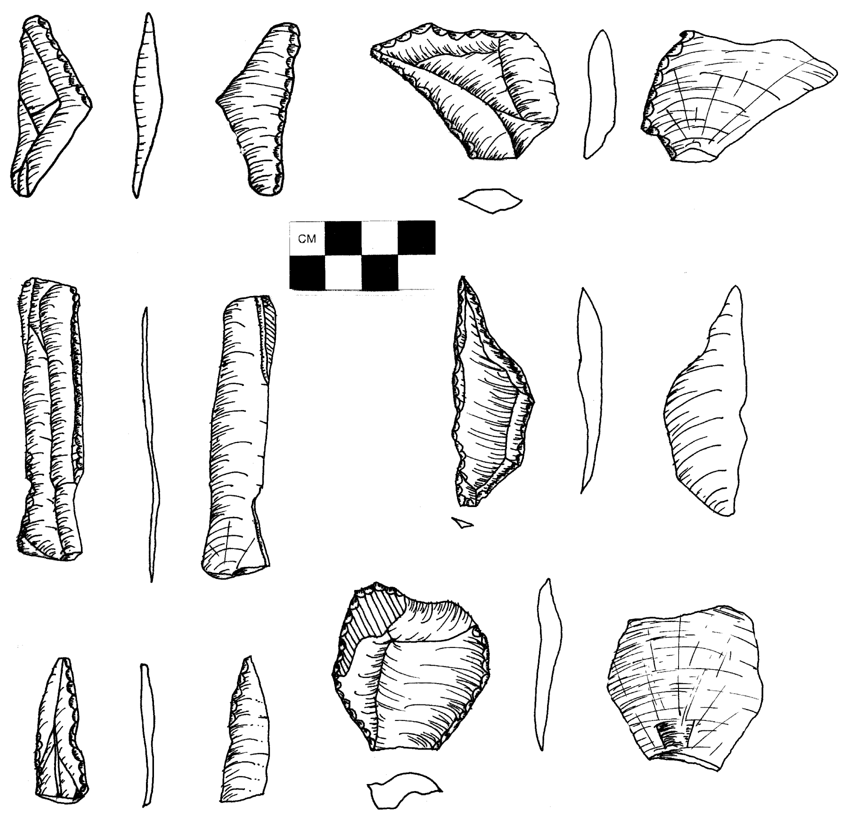

Fig. 3 Examples of pieces found within the assemblage excavated from Abric Romaní's layer 2. Drawings by M. Camps and P.R. Chauhan (Camps 2006)

Layer 4: There seems to have been a rather generalized consensus among previous researchers who studied Abric Romaní's layer 4 as to the fact that this would have been a Mousterian layer (see Table 8), with some seeing a Denticulate Mousterian variant, *sensu* Bordes (1961). This was either because the large number of denticulates present in partial studies that included layer 4 in a large group of layers were analyzed as a single one (Ripoll 1959), or just because it did not seem to fit into the characteristics of any other Mousterian variant (Canal and Carbonell 1989).

Comparisons with previous typological analyses, even those using Bordes' typology, are pointless because, as stated above, those were performed not on layer 4 exclusively, as the system requires, but by grouping this layer with several others (Ripoll and de Lumley 1965). A low number of pieces was put forward to justify the move, something which was clearly solved in this study in a totally different way: including all the pieces which could be securely attributed to layer 4 from all the different collections into which this assemblage is divided.

From a total of 249 pieces, only 144 were able to be classified according to *la méthode* Bordes. Again, just as with layer 2, differences with previous analyses began to emerge rather quickly, something that was expected after correcting the sample of materials analyzed. Although the assemblage contained no handaxes, just as required by a Denticulate Mousterian assemblage, the rest of the traits did not anywhere near match.

Questions of a possible mixing with layers above and below were ruled out right away, as the separation was rather clear in sedimentological and geological terms (Bischoff et al. 1988, 1994); so a study of the characteristics of other types of Mousterian assemblages ensued. Table 10 explains the differences between a Denticulate Mousterian assemblage and Abric Romaní's layer 4, as well as the latter's similarities with a La Ferrassie Mousterian assemblage.

While other layers grouped with layer 4 by Ripoll and de Lumley (1965) could well be Denticulate Mousterian layers, layer 4 comprises a very low number of denticulates, thus making the former attribution erroneous.

The restricted usefulness of plain and simple typological analyses cannot be emphasized strongly enough; however, they do serve as a good organizational aid, when used correctly. This is a crucial point to take into account if we are to work by including old research results among the data we are obtaining at present, whether that comes from new typological analyses or otherwise (Fig. 4).

Conclusions

It is hoped that the previous pages will have illustrated that some authors have been rather too quick in dismissing important sites with remains dating to the transitional phenomenon addressed here, just because they doubted the validity of early studies. Unfortunately, there are cases in which taking action is the only way forward, but in the case of Abric Romaní, that would be like throwing the baby out with the bath water, and let's face it, we would lose quite a large amount of information which is crucial to the debate.

So how can this debate and the research behind it progress? Well, clearly by taking old research into account, revising, reanalyzing if necessary, as well as working—with the highest standards—in new sites, both in well-researched areas as well as in

Table 10 Traits defining a Denticulate Mousterian assemblage and a La Ferrassie Mousterian assemblage mapped against Abric Romaní's layer 4 assemblage (Bordes 1961; Camps 2003)

Denticulate Mousterian	*Abric Romaní's Layer 4*	*La Ferrassie Mousterian*
No handaxes	None	No handaxes
No backed knives	5 (3.5%) 3 types	No backed knives
Few or no points	7 (4.9%) 2 types	
25% max. of sidescrapers	71.7%	50–80% of sidescrapers
Very high % of denticulates	11 (7.6%)	Few denticulates
	10 (7%) 3 types	Levallois technique present
	9 (6.3%)	Some endscrapers (carinated, nosed)
	1	Numerous notches

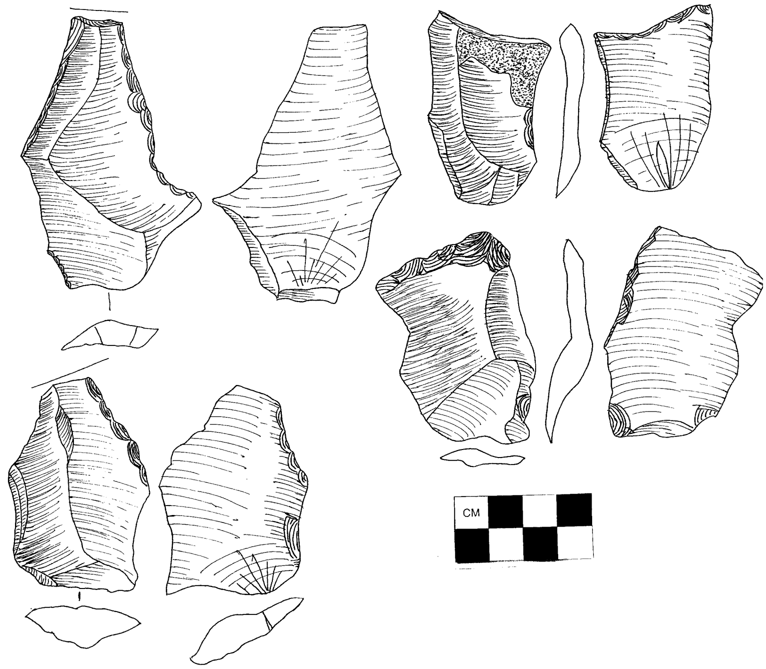

Fig. 4 Examples of pieces found within the assemblage excavated from Abric Romaní's layer 4. Drawings by M. Camps and P.R. Chauhan (Camps 2006)

those where, for a large number of reasons, Paleolithic research is still just in its early days.

Multidisciplinary approaches are crucial to explain parts of the phenomenon; more precisely, human responses and actions in front of events such as climatic variability and change in faunal patterns in the areas the different groups inhabited, to name but two things to consider, for which more environmental studies as well as research on faunal remains are needed. Iberia has some very robust paleoenvironmental studies, but they are largely confined to areas near the coastline, and hence more inland research on this aspect is basic to the progress of the discussion.

No information has been included in this paper regarding radiometric dating methods, the role of these, and more especially radiocarbon dating, in the Mid-Upper Paleolithic transition. Fortunately, several projects that include Iberia are already ongoing to fill this gap. The information they produce will undoubtedly be greatly beneficial for the development of research on this transitional phenomenon in this area.

Since Iberia became a hot spot in which to study the transition, it has been an area prone to be used for a large list of new hypotheses: we have had a bit of everything—hybrids, *refugia*, impossible to cross rivers, etc. More than making a Franco-centric bias right, it is important to see that this is a double-edged sword: since for every hypothesis that is thoroughly tested, many others ideas are not. By thorough tests, I do not mean those that select sites according to how well the data fit in, which is another problem that stalls research.

More generally, it is important to consider in the framework of this volume what a transition really is. Personally speaking, I acknowledge that I believe in the Mid-Upper Paleolithic transition (in the traditional sense) because I received my academic training from scholars and in institutions where the existence of this phenomenon is accepted and promoted. No events in my career so far have showed me that this was not the case, apart from lively discussions with fellow researchers trained in the opposite belief, which have expanded my views on the subject here studied. I do think, however, that while I can see changes in the record, for which I am sure that my academic background is partly to "blame," many that think like me have long forgotten that the "transition" as such was put in place by us only, modern-day Paleolithic researchers, who, overwhelmed by large amounts of data and time scales far larger that we can comprehend, needed a way to organize the field in order to proceed with our research.

Early AMH did not have a “travel westwards” agenda, and Neanderthals had probably no clue that their days were numbered. I have the feeling that the transition as a study aid is following the path of typological analysis, which long ago turned into an end-in-itself gadget that would get one a research degree if the amount of data was large enough. It is probably a case of those types of forests that do not allow us to see the trees, but they are there, plenty of them. It is just a matter of looking for them, but doing so open-mindedly and in the right way.

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What Is a 'Transitional' Industry? The Uluzzian of Southern Italy as a Case Study

Julien Riel-Salvatore

Abstract While the Uluzzian is one of the most widely known 'transitional' industries documented at the beginning of the European Upper Paleolithic, little is known about it beyond its typological characteristics. Despite this, it continues to be cited alongside the Szeletian and Châtelperronian industries as evidence for the behavior of the last Neanderthals resulting from their acculturation by modern humans bearing Aurignacian technology. This paper presents a comprehensive summary of the available data on the suites of behaviors embodied by the Uluzzian as well as some new data gleaned from key Uluzzian assemblages that permit an empirical assessment of these behaviors. It closes with a discussion of whether this evidence agrees with the meaning of the term 'transitional industry' in the context of the debate over Neanderthal acculturation by modern humans. It is concluded that continued use of this term is misleading, as it inappropriately implies the existence of sociocultural processes unlikely to be reflected by the Uluzzian as an industry.

Keywords Uluzzian • Middle-Upper Paleolithic transition • Italy • Neanderthals • Modern humans • Transitional industry • Acculturation

J. Riel-Salvatore (✉)
Department of Anthropology, Leacock Building, Montreal, Quebec, Canada

Along with the Franco-Cantabrian Châtelperronian and the Szeletian of Eastern Europe, the Uluzzian is among the best known industries claimed to document an adaptation intermediate between those of the late Middle and early Upper Paleolithic. In no small part, this has to do with the comparatively long history of the Uluzzian as an analytical unit relative to that of many other comparable technocomplexes (Djindjian et al. 2003; Kozlowski 2004). First recognized in the early 1960s at the site of Grotta del Cavallo in the southern Italian region of Puglia (Palma di Cesnola 1966, 1967, 1993), the Uluzzian quickly became one of the 'big three' transitional industries, mentioned repeatedly alongside the Châtelperronian and Szeletian as evidence for the last behavioral manifestations of a Middle Paleolithic mindset and for increasing cultural regionalism at that moment of the Late Pleistocene (d'Errico et al. 1998).

Given its relevance to the debate surrounding the disappearance of Mousterian technology (usually taken, by extension, to mean the disappearance of Neanderthals), it is worth examining how much we truly know about the Uluzzian. This is because most of our knowledge is derived from site reports—some close to half a century old—that emphasized typological description of lithic assemblages and gave only nominal attention to contextual data such as absolute chronology, paleoecology, and sedimentary environment. Accepted wisdom on the Uluzzian depicts it as a flake-based industry, with few Upper Paleolithic tools, that was made by Neanderthals acculturated by modern humans bearing proto-Aurignacian technology (e.g., Gioia 1988, 1990; Mussi 1990, 2001; Palma di Cesnola

M. Camps, P. Chauhan (eds.), *Sourcebook of Paleolithic Transitions*, DOI 10.1007/978-0-387-76487-0_25,

1989, 1993, 2004). In reality, the situation is considerably more complex and nuanced (Riel-Salvatore 2007).

The label 'transitional' for the multiple lithic industries documented at the onset of the Upper Paleolithic has been argued to be a useful shorthand descriptor for those diverse but roughly contemporaneous industries, one that can be detached from any implicit meaning (Kuhn 2003; Bar-Yosef 2006a, 2006b). However, because industries lumped under the heading 'transitional' continue to be taken by some specifically as evidence for the acculturation of Neanderthals by modern humans (e.g., Mellars 2004, 2005, 2006), it is important to critically examine whether they correspond to what an acculturated Neanderthal industry should look like. While there are other definitions of transitional industries (see e.g., papers in Zilhão and d'Errico [2003] and Brantingham et al. [2004]), this paper focuses explicitly on the notion of a transitional industry as seen from the acculturation perspective (e.g., Mellars 2004, 2005).

From this perspective, transitional industries are seen as amalgams of Mousterian and 'modern human' (usually taken as meaning Aurignacian) technology created by the last European Neanderthals. Their technological innovations are seen as the result of 'contact, interaction, copying, or technology transfer between the two populations' (Mellars 1999, 348). While it nominally acknowledges that culture contact is usually a two-way relationship, however, the acculturation perspective sees information as having flowed one way, from modern humans to Neanderthals—a view allegedly supported by the interactions of Native Americans and Australian Aborigines with European colonists during the Renaissance (Mellars 1989, 1999, 2005).

In sum, the acculturation perspective sees transitional industries as fundamentally Epi-Middle Paleolithic phenomena expressing predominantly Mousterian behavioral poses enhanced slightly by a few select 'modern' behaviors. The implication of their disappearance in face of the supposedly widely cohesive behavior of modern humans—as exemplified by the Aurignacian (Mellars 2006; cf. Clark and Riel-Salvatore 2005, 2005–2006; Straus 2003, 2007)—is that, despite these minor adjustments, in the long term Neanderthal behavior remained suboptimal relative to that of modern humans, who eventually displaced them through a variety of mechanisms (displacement, competition, genetic swamping, etc.).

On a technological level, a relatively straightforward implication from the acculturation perspective on transitional industries is that they should have clear links to that of the regional Mousterian facies that precede them stratigraphically. This has been argued to be the case with the Châtelperronian industry, which has relatively clear antecedents in the Mousterian of Acheulean Tradition (e.g., Mellars 1999, 2005), although it is unclear whether its distinctive features can truly be argued to be the result of copying Aurignacian technology (d'Errico et al. 1998; Pelegrin 1995). Regardless, the presence of technological features akin to those documented in the local Mousterian in various transitional industries has been used to make the case that acculturation of Neanderthals by modern humans was a widespread phenomenon during the interval usually referred to as the Middle-Upper Paleolithic Transition.

The Technotypology of the Uluzzian

Due to the predominance of the typological substrate in Uluzzian assemblages (Palma di Cesnola 1966, 1967, 1989, 1993), it has been claimed that they display striking similarities with the Late Mousterian of the region, thus paralleling the MTA-Châtelperronian link in southwest France (Gioia 1988, 1990; Mussi 1990, 2001). However, the classic Levallois technology that dominates the Late Mousterian of Grotta di Castelcivita is altogether absent in the Uluzzian levels that overlay it (Gambassini 1997a), indicating that blank production strategies may differ greatly between the two industries, a fact that typological analysis alone cannot capture. However, a recent reanalysis of the majority of recovered Uluzzian material (i.e., Riel-Salvatore 2007) permits a better understanding of all facets of Uluzzian technological organization and, in turn, an objective assessment of whether the main postulate of the acculturation model is valid for the Uluzzian.

As concerns its typology, the Uluzzian has traditionally been defined by a prevalence of Mousterian

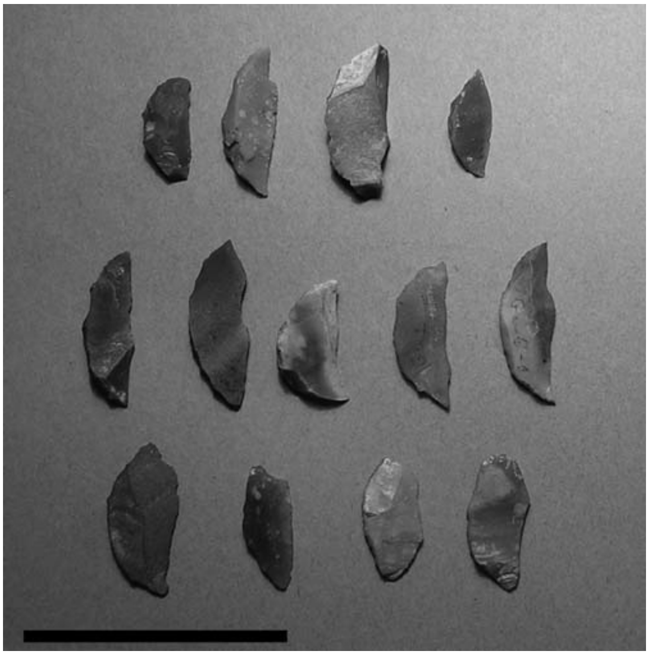

Fig. 1 Lunates (from Grotta del Cavallo, Level E III). Scale-bar = 5 cm

tool types (sidescrapers, denticulates, notches), an abundance of splintered pieces (*pièces esquillées* in French, or *pezzi scagliati* in Italian), and small numbers of Upper Paleolithic tools—mainly endscrapers but almost no burins. The *fossiles directeurs* of the industry are crescent-shaped geometric microliths usually referred to as lunates (*semi-lune* in Italian), although they are proportionally very scarce relative to all other tool types (Fig. 1). Table 1 summarizes the frequencies of the main artifact classes in Uluzzian assemblages, as represented by the main 'typological groups' in the analytical typology of Laplace (1964, 1966), with splintered pieces (i.e., *pièces esquillées*) added as an extra artifact class (following Palma di Cesnola 1989). These data come only from stratified Uluzzian

Table 1 Typological characteristics of stratified Uluzzian assemblages in %

	Castelcivita				*Cavallo*			
	RSI	PIE	RPI	RSA	E III	E II-I	E-D	D
Burins	0.0	1.0	0.0	1.6	0.5	0.1	0.0	1.0
Endscrapers	20.0	3.9	2.9	3.4	16.1	2.8	1.6	4.6
Truncations	0.0	2.9	1.9	0.9	0.7	1.6	0.5	2.0
Piercers	0.0	0.0	0.5	0.2	0.6	0.5	0.0	0.7
Backed points	0.0	2.9	0.5	1.1	0.6	2.6	4.9	1.0
Backed blades	0.0	0.0	1.0	1.1	1.2	3.1	2.2	3.0
Backed truncations	0.0	1.0	0.5	0.0	0.2	0.4	2.2	1.0
Geometrics	0.0	1.0	2.4	0.2	1.0	3.4	8.2	1.6
Retouched blades	5.0	1.9	0.5	1.6	1.0	1.7	7.1	5.9
Sidescrapers	10.0	28.2	14.3	13.6	33.9	8.0	13.7	14.8
Abruptly retouched pieces	0.0	1.0	1.9	2.5	0.6	1.6	2.7	2.3
Denticulates	30.0	21.4	19.0	24.0	8.4	4.7	9.3	31.9
Splintered pieces	35.0	35.0	54.8	49.8	35.1	69.4	47.5	30.3
N	20	103	210	442	986	762	183	304
Cores	6	4	31	35				
Debitage	85	192	926	1160	nd	nd	nd	nd

Table 1 (continued)

	Mario Bernardini			Uluzzo C		Uluzzo	Serra *Cicora A*		La Cala
	A IV	A III	A II-I	D	C	N	D	C	14
Burins	14.9	7.7	14.9	12.5	11.1	0.0	5.0	7.6	3.0
Endscrapers	16.0	0.0	19.1	0.0	0.0	5.9	4.1	8.2	3.7
Truncations	0.0	0.0	6.4	0.0	0.0	0.0	3.2	3.2	0.0
Piercers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Backed points	0.0	0.0	2.1	0.0	0.0	0.0	1.2	1.9	0.0
Backed blades	0.0	7.7	2.1	0.0	11.1	0.0	0.3	0.0	0.7
Backed truncations	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geometrics	0.0	7.7	2.1	6.3	11.1	5.9	0.3	0.0	0.7
Retouched blades	0.0	0.0	12.8	0.0	0.0	47.1	2.3	7.0	3.0
Sidescrapers	11.7	0.0	6.4	12.5	22.2	41.2	28.6	29.7	29.1
Abruptly retouched pcs.	36.2	38.5	6.4	50.0	33.3	0.0	0.0	0.0	0.0
Denticulates	21.3	38.5	19.1	18.8	0.0	0.0	51.6	38.0	26.1
Splintered pieces	0.0	0.0	8.5	0.0	11.1	0.0	3.5	4.4	33.6
N	94	13	47	16	9	17	343	158	134
Cores	13	0	2			4	2	10	21
Debitage	389	28	103	35	21	247	901	602	nd

assemblages whose stratigraphic context is secure (see discussion in Riel-Salvatore 2007).

Technologically, the Uluzzian has been described as a flake-based industry based on ad hoc core preparation (Gambassini 1997a; Palma di Cesnola 1989, 1993). There is also a high incidence of bipolar reduction in Uluzzian assemblages, as demonstrated by the presence of numerous splintered pieces and 'anvil' stones bearing characteristic pitted depressions in the center (Le Brun-Ricalens 1989) (Fig. 2). A recent reanalysis of extant Uluzzian collections suggest that splintered pieces have been systematically underreported in the assemblages from Grotta Mario Bernardini and Grotta di Uluzzo, where they account for 23–61% of retouched pieces of those comparatively small lithic assemblages, despite having published frequencies of 0–11% (Riel-Salvatore 2007, 42, Table 2.4). This reanalysis was undertaken after the assemblages from Grotta del Cavallo had been studied (and where splintered piece frequencies match those from published accounts), ensuring that the same criteria were used to identify splintered pieces across all assemblages. Since the assemblages from Uluzzo and Mario Bernardini were analyzed by the same team that analyzed the collections from Serra Cicora A and Uluzzo C (Borzatti von Löwenstern, 1965, 1966; Spennato 1981), it is likely that splintered piece frequencies are underestimated in those assemblages as well.

In sum, it appears that splintered pieces account for an important fraction of all Uluzzian assemblages, and that denticulates, sidescrapers, and miscellaneous retouched pieces account for the bulk of the rest of the 'tools' associated with the industry (Palma di Cesnola 1989; Riel-Salvatore 2007). This

Fig. 2 Splintered pieces from Grotta del Cavallo. Scale-bar = 5 cm

is an important observation in that it establishes that stratified Uluzzian assemblages are defined by an important dependence on bipolar technology, a feature that clearly distinguishes them from both the Mousterian and the proto-Aurignacian (Palma di Cesnola 1993).

Most discussions of the technological significance of splintered pieces have revolved around whether they were used as wedges to groove/splinter hard tissue (e.g., bone, antler, wood) or as a reduction method to maximize the utility of raw material packages (Hayden 1980; Le Brun-Ricalens 1989; Shott 1999). As concerns the Uluzzian, there have been no experimental studies to determine the way in which these implements were produced, although Mussi (2001, 169–170) hypothesizes that they most likely represent 'the outcome of indirect percussion of bone or wood' (i.e., wedges).

While it is difficult to test the 'wedge' hypothesis without use-wear studies (cf. Villa et al. 2005), the 'exhausted core' hypothesis is more amenable to testing based on splintered piece frequency. If splintered pieces were employed to extract the greatest possible amount of blanks from nodules of prized raw material, the frequency of such lithotypes should be correlated to the incidence of splintered pieces in an assemblage. In such a context, it can further be assumed that fine-grained lithotypes will be the most prized ones. The frequency of splintered pieces and the importance of fine-grained lithotypes in the assemblages from Castelcivita, Cavallo, Mario Bernardini, and Uluzzo are presented in Table 2. There are only weak and statistically insignificant relationships between the frequency of splintered pieces and the incidence of fine-grained raw material used to manufacture retouched pieces ($r = -0.29$, N = 12, p = 0.37) and that of splintered pieces ($r = 0.29$, N = 12, p = 0.35). In contrast, there is a significant relationship between the frequency of splintered pieces and the incidence of fine-grained raw material in Uluzzian assemblage as a whole ($r = 0.74$, N = 8, p = 0.04).

This leads to an apparent paradox: One the one hand, this pattern might be interpreted as showing that, in the Uluzzian, bipolar reduction was used to produce a maximum number of blanks from nodules of fine-grained raw materials. On the other, the fact that the incidence of splintered pieces is not correlated with the frequency of fine-grained raw material in retouched pieces might be taken to imply that curation of that resource did not necessarily follow from the desire to produce as many blanks as possible from it. That is, in some contexts, Uluzzian toolmakers seem to have wanted to produce many blanks of fine-grained raw material without in turn curating them very heavily, if at all.

These apparently contradictory conclusions can be reconciled by an approach to bipolar technology that eschews the 'wedge vs. core' perspective and that is based on the archaeology and early ethnographic record of Australian Aborigines. In some of these contexts, bipolar technology was used to produce small, sharp pieces of stone of unstandardized morphology that were hafted as ad hoc armatures in weapons termed 'death spears' that could be used in both hunting and warfare (Mitchell 1959, 197;

Table 2 Frequencies of splintered pieces within retouched stone tool assemblages relative to the frequency of fine-grained raw material in various categories of chipped stone

Site	Level	% splintered pcs	% FG whole	% FG tools	FG splintered pcs
Casteclcivita	*RSI*	0.35	0.58	0.64	0.58
	PIE	0.35	0.72	0.54	0.72
	RPI	0.55	0.92	0.85	0.92
	RSA	0.50	0.90	0.81	0.90
Cavallo	*E III*	0.35	n/a	0.22	0.36
	E II-I	0.69	n/a	0.72	0.63
	E-D	0.48	n/a	0.85	0.95
	D	0.30	n/a	0.85	0.80
Uluzzo	*N*	0.61	0.84	0.88	0.78
Mario Bernardini	*A IV*	0.38	0.10	0.11	0.88
	A III	0.24	0.05	0.39	0.00
	A II-I	0.23	0.44	1.00	1.00

Mulvaney and Kamminga 1999, 292–293; Noone 1949, 112, Figure 1i; Worsnop 1897, 127–128, Plate 63:4). In these cases, the 'splinters' were the desired end-product of bipolar reduction manifested archaeologically by the presence of splintered pieces; and they were not curated, despite being essential to death spear functionality. It must be emphasized that this strategy was also often a response to peculiar raw material constraints and decreases in overall mobility, that is to say more lengthy occupation of base camps and the adoption of more logistical land-use strategies (see Attenbrow 2004 and references therein). Given that broadly comparable parameters appear to characterize at least the beginning phases of the Uluzzian, however, it is warranted to explore whether this analog might prove useful to resolve at least some of the interpretive ambiguity linked to the role of bipolar reduction in Uluzzian technological organization.

As discussed above, most Uluzzian assemblages show reduction strategies designed to produce blanks of fine-grained stone, despite these blanks not being retouched or curated to any significant degree. This pattern is consistent with the purposeful production of sharp pieces of stone that could have been used as ad hoc insets in composite weapons. While this interpretation is tantalizing, it remains to be tested by future, in-depth examinations of Uluzzian splinters and debitage. However, even if it is only partially correct, this interpretation would also explain why formal insets (i.e., Uluzzian lunates) are so rare in Uluzzian assemblages despite the advantages provided by multicomponent technology in resource acquisition (see Table 1). In this case, lunates would have represented only one comparatively minor way of manufacturing projectile weapons in the broader context of Uluzzian multicomponent weaponry (Riel-Salvatore 2007).

Turning to patterns of blank production, the Uluzzian is usually described as a mainly flake-based industry (Palma di Cesnola 1993), although no quantitative treatment of this dimension of Uluzzian technology has so far been published. The types of blank produced by Uluzzian toolmakers include flakes, laminar flakes (i.e., flakes at least twice as long as they are wide but lacking parallel dorsal ridges), blades, bladelets, splintered pieces, crested blades, and technologically undiagnostic pieces referred to as 'chunks.' Uluzzian assemblages from the Salento also contain a large number of pieces made on siliceous limestone slabs (*liste*), especially in the lower levels of Cavallo and Mario Bernardini. Since these are not bona fide technological elements, however, they mask the true importance of various blank production strategies and they are excluded from consideration here, which deflates the total number of pieces in those assemblages but renders them directly comparable to those from Castelcivita (see Riel-Salvatore [2007] for full discussion).

The frequencies of the various kinds of blanks retouched into formal 'tools' by Uluzzian toolmakers are presented in Table 3. These data are

Table 3 Blank selection among retouched pieces for Uluzzian and Late Mousterian (Bernardini A V-VII) assemblages

Site	Level	Flake	Lam. Flake	Blade	Bldlt.	Crest Blade	Chunk	Splint. pc.	N
Mario Bernardini	*A I-II*	0.68	–	0.16	–	–	0.08	0.08	25
	A III	0.40	–	0.30	–	–	0.30	–	10
	A IV	0.22	–	0.06	–	–	0.61	0.11	18
	A V-VII	0.92	–	–	–	–	0.08	–	24
Castelcivita	*RSI*	0.80	–	0.10	–	–	0.10	–	10
	PIE	0.49	0.02	–	–	–	0.46	0.04	57
	RPI	0.66	0.03	0.03	–	–	0.27	0.03	79
	RSA	0.49	0.05	0.05	–	–	0.32	0.09	108
Uluzzo C	*N*	0.52	–	0.43	–	–	0.04	–	23
Cavallo	*E III*	0.60	0.03	0.05	0.02	0.03	0.25	0.03	180
	E II-I	0.81	0.03	0.07	–	0.01	0.07	0.02	182
	E-D	0.76	0.01	0.12	–	0.09	0.01	–	89
	D	0.63	0.01	0.17	–	0.02	0.17	–	172

Table 4 Blank selection among unretouched debitage for Uluzzian and Late Mousterian (Bernardini A V-VII) assemblages

Site	Level	Flake	Lam. flake	Blade	Crest blade	Chunk	N
Mario Bernardini	*A I-II*	0.68	–	0.16	–	0.08	25
	A III	0.40	–	0.30	–	0.30	10
	A IV	0.22	–	0.06	–	0.61	18
	A V-VII	0.92	–	–	–	0.08	24
Castelcivita	*RSI*	0.80	–	0.10	–	0.10	10
	PIE	0.49	0.02	–	–	0.46	57
	RPI	0.66	0.03	0.03	–	0.27	79
	RSA	0.49	0.05	0.05	–	0.32	108
Uluzzo C	*N*	0.52	–	0.43	–	0.04	23

consistent with Uluzzian tools being made prevalently on flake blanks, but they also highlight the importance of chunks (i.e., pieces with no well-defined striking platform and/or ventral surface) as retouched blanks. The importance of 'chunks' as retouched blanks may reflect the high incidence of bipolar technology in the Uluzzian, since this reduction strategy tends to obliterate striking platforms and results in 'sheared' ventral surfaces (Hayden 1980). A noteworthy pattern is that flake blanks are less important in the Uluzzian than in the reference Late Mousterian assemblage from Mario Bernardini (i.e., Level A V–VII). Although these data are admittedly few, they suggest that Uluzzian toolmakers employed a wider range of blank production strategies than in the Mousterian.

Comparative data on unretouched pieces are only available for Mario Bernardini, Uluzzo, and Castelcivita, since the debitage from Cavallo was unavailable for study (Table 4). In this case, too, flakes dominate, but chunks are proportionally more important than for retouched pieces. This suggests that in the Uluzzian, flakes and complete pieces were preferred for retouch. As well, blades are found as retouched implements more frequently than in unretouched debitage. This is consistent with the pattern highlighted for flakes and chunks, and suggests that Uluzzian toolmakers preferentially selected complete, regular blanks for retouch.

Given their distinct production strategy, splintered pieces were analyzed separately from both retouched tools and unretouched debitage (Table 5). The general pattern of blank selection among retouched tools holds for splintered pieces, with flakes and blades being preferentially reduced bipolarly. *Liste* also appear to have been selected for bipolar reduction, especially in 'archaic' Uluzzian assemblages (Riel-Salvatore 2007, 46, Table 2.8b). The main difference in blank selection between retouched and splintered pieces is that chunks are much more numerous among the latter. This again probably reflects the nature of bipolar reduction, which tends to remove diagnostic landmarks from flakes and blades. In fact, it is to be expected that 'chunks' should be proportionally more important among splintered pieces, given that bipolar technology was, by definition, employed to produce them.

The dominance of flakes in Uluzzian debitage, retouched pieces, and splintered pieces lends support to the general characterization of Uluzzian cores directed at the production of flakes (Benini et al. 1997; Gambassini 1997a; Palma di Cesnola 1989, 1993). Morphological classification of core types in Uluzzian assemblages (and in the Late Mousterian of Mario Bernardini) is presented in Table 6, and also agrees with previous descriptions of Uluzzian core preparation as largely opportunistic (Gambassini 1997a; Palma di Cesnola 1989, 1993). For the purposes of this analysis, cores labeled as 'amorphous' show no clear organization of the striking platforms, while bipolar ones are globular in shape, with a splintered base and splintered removals from the base and the top of the core. Unidirectional cores are those cores whose removals are oriented in a single direction from the striking plane, while bidirectional cores have removals from two opposite planes, and centripetal cores have removals from three or more planes on the core surface. Discoid cores display the features

Table 5 Blank selection among splintered pieces for Uluzzian and Late Mousterian (Bernardini A V-VII) assemblages

Site	Level	Flake	Lam. Flake	Blade	Crest Blade	Chunk	N
Mario Bernardini	*A I-II*	0.23	–	0.54	–	0.23	13
	A III	–	–	–	–	1.00	1
	A IV	0.14	–	–	–	0.86	22
	A V-VII	0.20	–	0.20	–	0.60	5
Castelcivita	*RSI*	0.17	–	–	–	0.83	6
	PIE	0.29	–	–	–	0.71	34
	RPI	0.30	–	–	–	0.70	109
	RSA	0.23	0.02	–	–	0.75	111
Uluzzo C	*N*	0.41	–	–	–	0.59	22
Cavallo	*E III*	0.30	0.03	0.02	–	0.65	60
	E II-I	0.54	–	–	0.01	0.45	133
	E-D	0.75	–	0.10	0.05	0.10	20
	D	0.43	–	0.03	–	0.55	40

Table 6 Core classification for Uluzzian assemblages in southern Italy, and for the Late Mousterian at Mario Bernardini

Site	Level	Amorphous	Bipolar	Unidirectional	Bidirectional	Centripetal	Discoid	N
Mario Bernardini	*A I-II*	–	–	–	0.25	–	0.75	4
	A III	–	–	–	–	–	1.00	1
	A IV	–	–	–	–	–	–	0
	A V-VII	–	–	–	0.33	–	0.67	3
Castelcivita	*RSI*	0.63	0.25	–	–	0.13	–	8
	PIE	0.50	0.25	0.25	–	–	–	4
	RPI	0.48	0.29	0.19	–	0.05	–	21
	RSA	0.43	0.17	0.24	–	0.09	0.07	46
Uluzzo C	*N*	–	1.00	–	–	–	–	1
Cavallo	*E III*	–	0.33	0.33	–	–	0.33	3
	E II-I	0.29	0.21	0.04	0.08	0.21	0.17	24
	E-D	–	1.00	–	–	–	–	1
	D	–	0.40	–	0.20	0.20	0.20	5

of Middle Paleolithic discoid technology, with a lack of hierarchy between the striking surfaces (Boëda 1994, 1995; see also papers in Peresani [2003]).

At Castelcivita, Cavallo, and Uluzzo, amorphous, bipolar, and unidirectional flake cores dominate the assemblage (Table 6). At Mario Bernardini, in contrast, centripetal and discoid forms dominate, perpetuating the Late Mousterian pattern of core organization. It is worth noting that it is only in the Salento that discoid cores account for >10% of Uluzzian cores. At Castelcivita, the dominance of amorphous and bipolar cores marks an especially conspicuous break with the well-developed Levallois technology documented in the underlying Mousterian levels (Gambassini 1997a).

Beyond Uluzzian Typo-Technology

Having established a baseline of what the Uluzzian 'looks like,' it must be stressed that few new data—behavioral, contextual, or chronological—have augmented the initial studies of the Uluzzian (with the notable exception of the rich and detailed information available for Grotta di Castelcivita [Gambassini 1997b]). This is in sharp contrast with recent in-depth work on the Châtelperronian (Harrold 1978, 1989, 2000; Lucas et al. 2003; Pelegrin 1995), the Szeletian (Adams 1998, 2000, 2007; Adams and Ringer 2004; Allsworth-Jones 1986, 1990, 2000), and other transitional industries (see papers in Brantingham et al. [2004]; Riel-Salvatore and Clark [2007]; Straus [2005]; and Zilhão and d'Errico [2003]).

As a result, the Uluzzian is often considered to be an 'Italian Châtelperronian,' with all that entails for its makers' behavioral modernity, its chronology, and its relation to the Aurignacian (Gioia 1988, 1990; see also d'Errico et al. 1998; Mussi 2001). This tends to obscure the fact that we know relatively little about the Uluzzian behavioral package and the adaptations its technology embodies, a fact also reflected in recent publications. For example, a recent volume edited by Zilhão and d'Errico (2003) contains studies on transitional industries from throughout Eurasia, ranging from the well-known Châtelperronian (e.g., Lucas et al. 2003) to others identified only at single sites (e.g., Svendsen and Pavlov 2003). However, no chapter in this otherwise comprehensive volume deals specifically with the Uluzzian, which receives only oblique mention in a continental-scale synthesis of transitional industries (Djindjian et al. 2003). The most recent paper on the Uluzzian is a short synthesis of previous knowledge about the industry's distribution and its tentative chronology (Palma di Cesnola 2004). A review of currently available contextual data nonetheless opens up new, nontypological avenues of research on this industry.

First, in terms of its basic geography, the Uluzzian presents some interesting characteristics that have gone largely unnoticed or unaddressed in previous work (but see Kuhn and Bietti 2000). Stratified Uluzzian assemblages are only found in the southernmost third of the Italian peninsula, since Bietti and Negrino (2007; Bietti 2006) have empirically demonstrated that Grotta della Fabbrica—the only putative stratified Uluzzian assemblage in central Italy (Pitti et al. 1976)—does not actually contain an Uluzzian component. Likewise, in the absence of appropriate technotypological data to permit comparison with meridional assemblages, it is at present difficult to assess objectively whether recent claims about an Uluzzian component at Fumane (i.e., Peresani 2008) are to be taken at face value, or if these assemblages are best attributed to the Late Mousterian with backed knives documented at La Fabbrica by Bietti and Negrino (2007).While there have been recent claims for an Uluzzian assemblage at Klisoura Cave in Greece (e.g., Koumouzelis et al. 2001a, 2001b; d'Errico 2003; Kozlowski 2004, 2005; Zilhão 2006, 2007), a quantitative assessment of the typotechnological characteristics of that assemblage and the Uluzzian in Italy suggests that the two industries may not be as similar as had been claimed (Riel-Salvatore 2007; n.d. a), which restricts the industry's geographic distribution to peninsular Italy.

Italy served as a biological refugium during glacial advances throughout the Pleistocene, with all that entails in terms of ecosystem richness and diversity (Hewitt 1999, 2000; Schmitt et al. 2002; Taberlet et al. 1998; Tzedakis et al. 2002, 2004), and the peninsula was continuously occupied by hominins throughout the Middle and Late Pleistocene, even as wide stretches of Eurasia were depopulated during glacial advances (van Andel et al. 2003; Finlayson 2004, 16, 68). However, Blondel and Aronson (1999; see also Stiner 2005) have shown that during glacial advances, only central and coastal northwestern Italy maintained Mediterranean ecosystems. Thus, only those parts of the peninsula can truly be considered glacial refugia. During Late Pleistocene glacial advances, southern Italy was characterized by a much more open and arid ecological regime, as demonstrated by palynological analyses from lake cores extracted from Lago Grande di Monticchio, in Basilicata (Allen et al. 1999). These studies indicate that much of southern Italy was a cold, arid steppe, including the flat plateau of the Salento peninsula where most stratified Uluzzian sites are located. In sum, southern Italy was a marginal periphery to the central Italian Mediterranean refugium during glacial advances, with implications for the ecological diversity of the region.

In addition to its restricted geographical distribution, the Uluzzian is also defined by some artifacts quite unlike those found in underlying Mousterian assemblages. Like the Châtelperronian, the

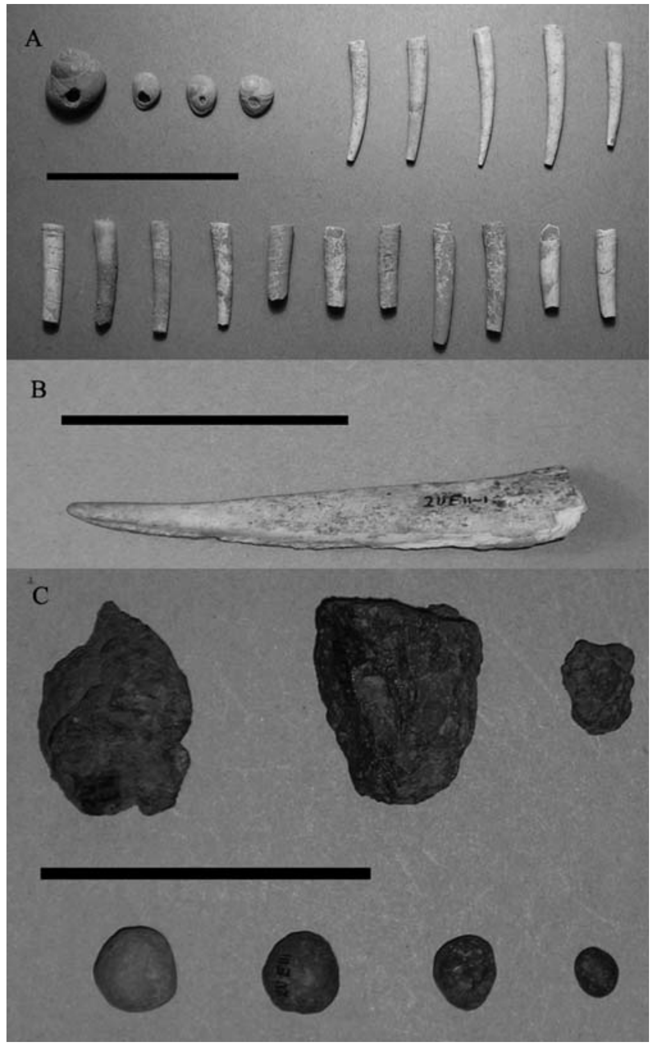

Fig. 3 Shell ornaments (**A**), bone awl (**B**), and ochre and limonite fragments (**C**) from Grotta del Cavallo. Scale-bar = 5 cm

Uluzzian is characterized by the appearance of bone artifacts (mainly points and awls), pierced shells likely used as ornaments, and coloring materials such as ochre and limonite (Fig. 3). For example, undisputed osseous artifacts and coloring materials have been recovered from Uluzzian layers at Cavallo (Palma di Cesnola 1993), Mario Bernardini (Borzatti von Löwenstern 1970), and Uluzzo C (Borzatti von Löwenstern 1965). Bone points also were recovered in the Uluzzian levels at Castelcivita, where they are more abundant than in the overlying proto-Aurignacian levels, and features (i.e., post holes) have only been identified in that site's Uluzzian layers (Gambassini 1997a, 121). In fact, with the exception of two fragmentary bone points and 'numerous pierced shells' from the proto-Aurignacian levels of La Cala (Benini et al. 1997, 51) in southern Italy, it is the *Uluzzian* rather than the proto-Aurignacian that has yielded most of these artifacts: Proto-Aurignacian deposits at Serino and Paglicci contain no evidence of organic technologies or ornaments, while the Serra Cicora A proto-Aurignacian deposits have produced only a single fragment of a bone awl and faint traces of ochre (Spennato 1981). The only fully published Uluzzian assemblages to have been excavated using modern methods (i.e., those from Grotta di Castelcivita) have also yielded suggestive evidence of small game exploitation, notably of several varieties of fish and fowl (Cassoli and Tagliacozzo 1997). Additionally, in southern Italy, long-distance raw material transfers are only associated with Uluzzian assemblages (Riel-Salvatore and Negrino, 2009; see also Bietti 2006; Bietti and Negrino 2007). This is especially relevant in light of the claims of researchers who see such behaviors as hallmarks of the earliest modern humans in Europe (e.g., Bar-Yosef 2003; Kuhn and Stiner 2006; Mellars 2004, 2005). These behaviors not only have few antecedents in the southern Italian Mousterian, but they are more strongly expressed in the Uluzzian than in the proto-Aurignacian record (Riel-Salvatore and Negrino, in press). Such an observation is at odds with the acculturation model, which sees transitional industries as reflecting basically Mousterian behavior onto which have been grafted disparate elements of modern human behavior.

The chronology of the Uluzzian is of paramount importance in helping establish whether 'culture contact' might even have been possible. So far, the Uluzzian has generally been thought to cover a span of time stretching from the end of the Würm II–III interstadial and lasting to the Arcy interstadial in the Salento, and to the first cold phases of the Würm III stadial in Campania (Palma di Cesnola 1993, 2004). Radiometrically, this assessment is based on radiocarbon dates from Grotta della Cala (Benini et al. 1997) and the top of the Uluzzian sequence at Grotta di Castelcivita (Gambassini 1997c), as well as on one infinite radiocarbon determination from level E II-I at Grotta del Cavallo (Palma di Cesnola 1970). Loose biochronological associations have also been derived from the macromammal assemblages of the Salentine assemblages (Palma di Cesnola 1993), and these agree with the available dates that the Uluzzian appears to fall somewhere within the transition interval. In sum, based on the available chronometric dates and on coarse-grained macrofaunal data of variable quality, the industry as a whole lasted about 10,000 years, from c. 40 kyr BP to, at the latest, 30–29 kyr BP. This is broadly supported by the available radiocarbon dates, although it must be stressed that the basal Uluzzian remains undated in Campania and, until recently, in Puglia.

AMS ^{14}C dates were recently obtained for the base of the Uluzzian deposits at Grotta del Cavallo and these push back the date of the earliest Uluzzian by about 3,000–3,500 kyr BP (Riel-Salvatore et al. 2006). Importantly, a comparative analysis of the available dates for the earliest proto-Aurignacian in northwest Italy and the earliest Uluzzian in south-eastern Italy indicate that they appear during a comparable interval of climatic instability, but in opposite parts of the peninsula, all the while being separated by a zone of late-lasting Mousterian assemblages in central Italy (Riel-Salvatore 2007, Chapter 3). These observations militate against the case for acculturation through direct or indirect 'culture contact' and suggest that the development of the Uluzzian was independent of that of the proto-Aurignacian.

Who Made the Uluzzian?

The 'behavioral modernity' implied by some of the artifacts found in Uluzzian assemblages is linked to the thorny issue of the identity of the hominins who made it. Palma di Cesnola (1989, 1993) was the first to argue that the Uluzzian was the handiwork of Neanderthals, and that its novel features were the results of contacts with modern humans. Until recently, the only human remains found in association with Uluzzian artifacts were two deciduous molars found in layers E III (archaic Uluzzian) and E II-I (evolved Uluzzian) of Grotta del Cavallo. Originally, the first one was described as having modern human affinities while the second (and more recent) one was described as being more Neanderthal-like in morphology (Messeri and Palma di Cesnola 1976; Palma di Cesnola and Messeri 1967). While these counterintuitive results warranted caution with regards to the definitive attribution of the Uluzzian to a specific hominin population, inconvenient details have generally been disregarded and the attribution of the Uluzzian to Neanderthals remains the consensus view among prehistorians (see e.g., Palma di Cesnola 1989, 2004). While a recent reassessment of the published measurements of these teeth suggests that both fall within the range of variability of Neanderthals (Churchill and Smith 2000, 77–78), these data remain scant and were published well after the dominant view of the Uluzzian as a

Neanderthal fact had been accepted by the vast majority of researchers interested in the question of the Transition in Italy (Mussi 1990, 2001; Palma di Cesnola 2001, 2004).

In the summer of 2004, a deciduous human incisor was found associated with unpublished material from Layer E III at Grotta del Cavallo being studied by the author. Subsequent study of the tooth identified Neanderthal apomorphies and a wear-pattern similar to that borne by other Neanderthal incisors. Gambassini et al. (2005) have interpreted these data as evidence reinforcing the prevalent view that the Uluzzian was manufactured by Neanderthals. However, recent debates about the reliability of taxonomic attributions based on deciduous teeth found in early Aurignacian deposits at Brassempouy underscores some of the problems associated with basing species identifications on such remains (Gambier-Henry et al. 2004; cf. Bailey and Hublin 2005). In light of this, an argument can be made that there are no unambiguously diagnostic human remains on the basis of which to attribute the Uluzzian to a specific hominin type. While Bar-Yosef (2006a, 2006b) interprets the absence of a conclusive association between the Châtelperronian and diagnostic Neanderthal remains as likely evidence that modern humans were the makers of many transitional industries (including the Uluzzian), it is perhaps more prudent to consider the Uluzzian's authorship unknown and thus to remain agnostic about the taxonomic designation of its makers. By considering Uluzzian toolmakers first and foremost as Pleistocene hunter-gatherers, this view provides an analytical vantage point from which to evaluate claims that have been made about their behavior based on the assumption that they were Neanderthals.

Uluzzian Behavioral Ecology

Importantly, this perspective encourages studying the Uluzzian as a behavioral phenomenon all its own, as opposed to one that needs to be understood in relation to either the Mousterian or the proto-Aurignacian. Rather than focusing on the typological distinctions of various assemblages, such an approach permits researchers to view the Uluzzian adaptive package from an explicitly nontypological perspective grounded in well-established principles of human behavioral ecology and hunter-gatherer ethnoarchaeology (Riel-Salvatore 2007).

Riel-Salvatore and Barton (2004, 2007) were the first to adopt such a perspective to study some aspects of Uluzzian lithic variability, employing a 'whole assemblage analysis' perspective conceptually grounded in the idea that variability in retouched tools is best understood in the wider context of the cores and debitage of their assemblages (cf. Barton 1998). This method enables a quantitative assessment of lithic procurement, technological organization, and assemblage curation patterns that echo the overall mobility and land-use strategies of prehistoric foragers (Riel-Salvatore and Barton 2004). Applied to the Uluzzian, this method suggests that assemblages belonging to that industry pattern according to the model's expectations, provided that due consideration be given to raw material variability (Riel-Salvatore and Barton 2004, 2007). This in turn implies that Uluzzian toolmakers were able to adjust the organization of their lithic technology to different conditions, the exact nature of which conditions remained somewhat unclear in those studies. Importantly, however, it showed that behavioral flexibility characterized the Uluzzian as a whole (Riel-Salvatore and Barton 2004, 2007).

Additionally, the patterns obtained through the use of this method for the Uluzzian of Grotta Mario Bernardini suggest that Palma di Cesnola's 'evolutionary phases' of the Uluzzian might represent different strategies of technological organization (Riel-Salvatore 2007; n.d. b; Riel-Salvatore and Barton 2007). Specifically, the 'archaic Uluzzian' displays characteristics of an expedient lithic technology, while 'evolved' and 'final' Uluzzian assemblages represent more curated forms of technological organization. An analysis of the Uluzzian lithic assemblages from Grotta del Cavallo lent strong empirical support both to observations based on ancillary lines of evidence such as raw material exploitation patterns, and to artifact-based measures of curation intensity (Riel-Salvatore, n.d. b). Lastly, a large-scale study of Uluzzian assemblages from Grotta del Cavallo, Grotta Mario Bernardini, Grotta di Uluzzo, and Grotta di Castelcivita indicates that this conclusion is supported by the lithic assemblages from other sites; and that the earliest phases of the Uluzzian are characterized by expedient technological organization and logistical land-use strategies, which is what human behavioral ecological principles predict for the earliest phase of a new industry (Riel-Salvatore 2007).

This same study shows that Uluzzian mobility, land-use, and technological organization is nonetheless quite distinctive from that of the proto-Aurignacian at the other end of the peninsula and from that of the Mousterian in both southern and northern Italy. That is, hominins seem to have become overall more mobile over the course of the Italian Early Upper Paleolithic than they had been in the Mousterian, although the patterns of mobility in northern and southern Italy clearly differ in how this mobility was organized, likely in response to distinct sets of environmental constraints operating on the hominins living in these two segments of the peninsula (Riel-Salvatore 2007).

This approach thus offers the potential to significantly reorient the way in which the Uluzzian is understood. First, it allows the incorporation of all Uluzzian assemblages into a single interpretive framework, even if they do not display 'evolutionarily diagnostic' typological signatures, as at Grotta di Castelcivita and Grotta della Cala (Benini et al. 1997, Gambassini 1997a). Second, it suggests that the Uluzzian demonstrates a level of flexibility fully comparable to, but nonetheless distinct from that of the 'behaviorally modern' proto-Aurignacian, indicating that the two industries were responses to similar kinds of problems during the transition interval in Italy. Lastly, it constitutes the first model to analyze the Uluzzian as a behavioral (and thus adaptive) system, fully consistent with the tenets of contemporary evolutionary biology and especially human behavioral ecology (Kelly 1995; Winterhalder and Smith 2000). This offers an untapped source of insights and explanatory potential relative to those offered by the culture-historical approach advocated by workers like Palma di Cesnola (1989, 1993) and Gioia (1988, 1990). Critically, it offers a way of understanding the Uluzzian on its own, all the while permitting its comparison to other industries using unified methodological frameworks that do away with the a priori assumptions that assemblages classified using different typologies are necessarily different in evolutionarily meaningful ways.

Discussion

The insights provided by a human behavioral ecological approach to the Uluzzian indicate that it is possible to understand it as the material embodiment of the interface between the ecology of meridional Italy and hominin behavior following the end of the Mousterian in that region (Riel-Salvatore 2007; Riel-Salvatore and Barton 2004, 2007). Moreover, the Uluzzian is characterized by the emergence of behaviors not documented in the southern Italian Mousterian, behaviors fully consistent with recent reviews of what the archaeological correlates of 'behavioral modernity' should look like (Henshilwood and Marean 2003; McBrearty and Brooks 2000; Wadley 2001) and that parallel—though not duplicate—similar developments in the proto-Aurignacian of northern Italy (Bartolomei et al. 1992; Broglio 2005; Broglio et al. 2006; Kuhn 2002; Kuhn and Bietti 2000). Fast-moving small game (i.e., fish and fowl) may also have been exploited by the hominins who made Uluzzian assemblages (Cassoli and Tagliacozzo 1997), although a thorough assessment of the context and importance of this expansion of the diet base has yet to be conducted.

Because of the high proportional representation of Middle Paleolithic tools in Uluzzian assemblages, it has generally been assumed that the Uluzzian is directly and technologically derived from the underlying Mousterian, despite the clear technological and typological differences highlighted in this paper. Up to now, the most popular explanation for the emergence of the Uluzzian postulates that Neanderthals who originally made Mousterian tools in southern Italy were 'acculturated' by contact with proto-Aurignacian-making modern humans who first settled the northern part of the Italian peninsula (Mussi 2001; Palma di Cesnola 1993, 2004). However, it seems clear that the Uluzzian lasted for several thousand years and that, as befits a behavioral system of such duration, it was flexible and responsive to changing conditions. It developed in southern Italy in isolation from the more or less contemporary development of the proto-Aurignacian in the north of the peninsula during the climatically-turbulent interval of late Oxygen Isotope 3 (Riel-Salvatore 2007). During that time, the center of the peninsula appears to have been occupied only by hominins manufacturing Mousterian assemblages, although the scant but suggestive data from the Adriatic coast prevent us from absolutely ruling out a potential diffusion of the Aurignacian along that segment of the peninsula. Nevertheless, there is a good association between the Uluzzian and relatively open and arid conditions that prevailed in meridional Italy during the transition interval, although the precise mechanism behind this conjuncture remains to be investigated more fully. What is undeniable, however, is that the earliest Upper Paleolithic industries of the Italian peninsula are first documented in areas marked by pronounced shifts in ecological conditions, as recorded in proxy records (e.g., the lake core from Lago Grande di Monticchio [Allen et al. 1999, 2000]).

What emerges form this discussion is that the Uluzzian does not display the implied characteristics of transitional industries as conceptualized from the acculturation perspective. This is true on several counts. First, typologically and technologically, it is unique and very distinct not only from the Mousterian, but also from the proto-Aurignacian. Most saliently, neither of these two industries is associated with lunates or lunate-like armatures, nor are they associated with the bipolar technology that defines the blank production strategy of the Uluzzian. Second, temporal and chronological data indicate that the Uluzzian is very unlikely to have been descended from the proto-Aurignacian in any way, shape, or form, because the two industries are first manifest archaeologically in parts of Italy separated by about 1,000 km, by the Apennines and by the Mediterranean refugium of central Italy, where only Mousterian industries are documented at that time. Third, and most importantly, the Uluzzian does not fit the profile of a behavioral system that was either fleeting or internally heterogeneous. In other words, the Uluzzian is marked by its own, distinct technotypological signature as well as by land-use patterns distinctive from those of other broadly contemporaneous industries found in the Italian peninsula. These observations do not 'square' with a view of the Uluzzian as simply 'Mousterian plus' or 'Aurignacian lite,' which most acculturation scenarios implicitly depict it as being. In this author's view it is simply inconceivable to label as 'transitional' a multimillennial behavioral package marked by coherent sets of technological, economic, and foraging strategies. It is even less warranted to claim that the only mechanism that could have given rise to such industries is 'acculturation.'

While these observations greatly refine our understanding of the defining characteristics and internal dynamics of the Uluzzian, their implications are much less clear as concerns the phylogeny, cultural and biological, of the Uluzzian. It has been established that the Uluzzian differs in significant ways from both the Mousterian *and* the proto-Aurignacian. Phylogenetically, this can be interpreted in several ways, one of which is the currently dominant scenario that portrays it as the handiwork of Neanderthals, arguably the scenario best supported by the very limited fossil evidence (Bietti 1997; Gambassini 1997a; Kuhn and Bietti 2000; Palma di Cesnola 1993, 2004). Alternatively, some authors have recently claimed that the Uluzzian—and most other 'transitional' industries—was most likely manufactured by the first wave of modern humans to enter Europe (Bar-Yosef 2006a, 2006b, 2007). This view certainly accounts for the many differences between the Mousterian and Uluzzian, but it then leaves unaddressed the question of the Uluzzian's differences with the Aurignacian. A final hypothesis is that all industries documented in Italy during the transition interval were manufactured by Neanderthals, and the first 'modern human' industry in the peninsula was the Gravettian (cf. Fedele et al. 2003; Giaccio et al. 2006).

In the absence of additional, unambiguous hominin fossil evidence, it is impossible to clearly establish which of these interpretations is most likely to be correct. However, if one goes on the assumption that the Uluzzian was manufactured by Neanderthals, this implies that marked behavioral ('cultural') breaks during the transition interval need not be correlated with the arrival of a new hominin clade. This would open up the possibility that the proto-Aurignacian might also have been manufactured by Neanderthals, thus further showcasing the resilience and behavioral flexibility of those hominins in the face of environmental and social duress (Clark and Riel-Salvatore 2005). And, if both early Upper Paleolithic industries were manufactured by the same biological population, this implies that there was a great deal of regional diversification of its behavior during that interval. Perhaps most importantly, it also implies that *groups of the same population apparently competed against one another at that time* (cf. O'Connell 2006). Even more provocative, this correlate holds true even if we accept the idea that modern humans were the makers of those industries. The point is, then, that *intraspecific* competition is very likely to have characterized the human population dynamics of the transition interval to a much greater degree than has heretofore been generally assumed.

As concerns acculturation and its archaeological correlates, it is worthwhile to note that researchers focusing on more recent periods than the Paleolithic—and especially those informed by some kind of ethnographic record—agree that the term is a very problematic one, and that it encompasses a wide range of social, cultural, economic, and demographic scenarios (e.g., papers in Cusick 1998a). It has in fact cogently been argued that the very notion of 'acculturation' and how it might be visible archaeologically remains fraught with conceptual and epistemological ambiguities (Cusick 1998b). Yet, in paleoanthropology, acculturation continues to be dealt with in broad strokes and glossed over as an intuitively satisfying and self-evident process by its proponents (e.g., Mellars 1989, 1999, 2004, 2005, 2006). And while the 'acculturation' of Neanderthals by modern humans has been argued to parallel that of Native Americans and Australian Aborigines by European colonists (Mellars 2005, 22), it has been pointedly remarked that 'the encounters between Cro-Magnons and Neanderthals were not equivalent to the colonial confrontation between Europeans and indigenous peoples. There was no Upper Paleolithic empire; there was no shocking disparity in firepower. There were no relevant institutions to frame such a contest' (Gamble 1999, 269). Additionally, the time scales involved are completely incompatible with such a process, since European contact in the Renaissance decimated American and Australian populations in one or two centuries, with major demographic impacts at a decadal scale. Put briefly, if 'acculturation' as a concept is to retain heuristic value in paleoanthropological research, archaeologists need to explicitly discuss what they mean by it and how that phenomenon matches these theoretical expectations in the coarse-grained record of the transition interval, in light of the archaeological work on acculturation done in other contexts. Having answered this, it will also be important to address two additional issues: (1) Why should 'culture contacts' during the transition interval have resulted in a flow of ideas apparently exclusively from modern humans to Neanderthals, considering that the latter had occupied the human niche of Eurasia for the past 150–200,000 years? And (2) if acculturation *can* be documented during the transition interval and can thus be argued to be visible archaeologically, why have paleoanthropologists referred to that concept almost exclusively in the context of the Middle-Upper Paleolithic transition?

Conclusion

Descriptive, typological approaches have led many researchers to claim that there was evidence that the Uluzzian was the result of the acculturation of Mousterian-making Neanderthals by proto-Aurignacian-making modern humans in Italy. This paper has shown, however, that when the Uluzzian is adequately contextualized geographically, chronologically, and paleoenvironmentally, the case for strong similarities between the Mousterian and the Uluzzian is rather weak. In fact, the Uluzzian appears to be a beast all its own rather than a derivative of the Mousterian *or* the proto-Aurignacian. Further, considering the Uluzzian as an industry that hominins used for their day-to-day survival, as opposed to an exercise in cultural self-affirmation, shows that a view of this industry as somehow 'below par' compared to the proto-Aurignacian of northern Italy is unwarranted. One likely correlate of this observation is that such is also probably the case for most, if not all, of the other so-called transitional industries documented across Eurasia during the transition interval. In the specific case of the Uluzzian, the record demonstrates that the Uluzzian was a comparatively long-lived and polyvalent behavioral system that was likely developed by hominins in southern Italy as a response to the distinctive ecological conditions of the region during the transition interval. This suite of observations argues strongly against some of the most salient preconceptions implied by the label 'transitional industry' as used in scenarios invoking acculturation as a prime mover behind the florescence of non-Aurignacian industries during the Middle-Upper Paleolithic transition in Eurasia. Besides the fact that the notion of acculturation in the Paleolithic remains to be properly defined and operationalized so that it can be detected archaeologically, continued use of the misnomer 'transitional industry' will only perpetuate the mistaken impression that a single phenomenon can adequately explain the multiplicity of cultural, ecological, and biological contexts in which the transition unfolded across a wide range of biogeographical settings.

Whatever transitional industries may be, from the acculturation perspective, this paper has shown that the Uluzzian is *not* one of them. Here I have sought to highlight the interpretive advantages that come from studying any given industry in its proper context and from using methods that yield mainly behavioral as opposed to largely descriptive information. In this specific case, this study has lead to a dramatically different interpretation of the Uluzzian than that reached by the majority of previous analyses. By focusing on behavioral questions, this paper aims to turn away from debates about the interactions of Neanderthals and modern humans, which have grown increasingly sterile as the diagnostic hominin fossil record of the transition interval has failed to keep pace with the discovery of new lithic industries dating to that period. Such a perspective underscores the critical contribution archaeology has to offer the modern human origins debate, and highlights promising new avenues of research that, when combined with the insight of morphological and genetic analyses, will lead to a truly holistic understanding of the Middle-Upper Paleolithic Transition.

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Middle/Upper Paleolithic Interface in Vindija Cave (Croatia): New Results and Interpretations

Ivor Karavanić and Marylène Patou-Mathis

Abstract Vindija Cave in Croatia is a well-known site because of its association with fossil hominids and Middle and Upper Paleolithic stone industries. Several publications have discussed Neanderthal remains found alongside a Mousterian industry in Level G3 and Upper Paleolithic bone points in Level G1. This paper presents recent results of faunal and lithic analysis from the G1 transitional level of the site, as well as a revision of the bone tools. Taphonomy of large mammals and hominid bones was examined. Although no human remains were found within the faunal assemblage, the results of this analysis are an important addition to understanding site formation processes, as well as Neanderthal behavior during the so-called transitional period. Based on the taphonomy of faunal and human remains from Vindija cave Level G1, we can strongly suggest that the Neanderthals were active predators. Human occupations were short and alternating with carnivore occupations.

Keywords Middle/Upper Paleolithic • Transition • Neanderthals • Vindija • Croatia

Introduction

The sites of the Hrvatsko Zagorje region in northwestern Croatia are well-known in paleoanthropology and prehistoric archaeology because of important finds of fossil hominids associated with faunal and lithic material. While in Krapina the remains of classical Neanderthals and Mousterian industry were recovered, the Vindija cave contains late Neanderthals, probably associated with both Middle and Upper Paleolithic industries. Several publications have discussed Neanderthal remains found with Mousterian industry in Level G3 and Upper Paleolithic bone points in Level G1 (see Ahern et al. [2004] and references therein; Karavanić and Smith [1998, 2000]); while the detailed studies of the Vindija faunal material are relatively rare (Brajković 2005; Miracle 1991). Therefore, we have analysed the entire bone assemblage of large mammals from the Vindija G complex, and we will here report the main results related to the faunal remains of the G1 layer together with results of lithic analysis and taphonomy of human bone material. We will only discuss the finds with clear stratigraphic positions, bearing a G1 label on the bones themselves.

Background

Vindija Cave is situated in northwestern Croatia 2 km west of Donja Voća village, and 20 km west of Varaždin. S. Vuković (1950), who visited the site in 1928 for the first time, excavated there intermittently during more than 30 years, while M. Malez (1975) started systematic excavations at Vindija in 1974, with subsequent yearly field seasons until 1986. It was during this second period that most of the lithic and faunal material—and all the human remains—were discovered.

The cave is more than 50 m deep, up to 28 m wide, and over 10 m high. The stratigraphic profile

I. Karavanić (✉)
Department of Archaeology, Faculty of Humanities and Social Sciences, University of Zagreb, Zagreb, Croatia

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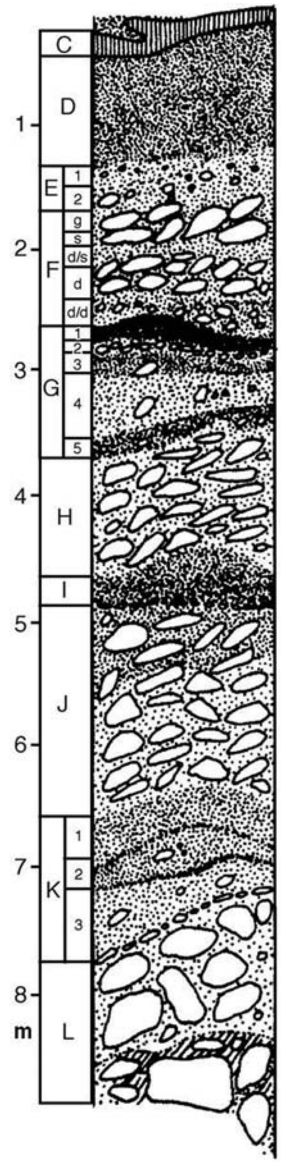

Fig. 1 Stratigraphic profile of Vindija cave (modified after Ahern et al. 2004, Fig. 1)

is about 9 m high and comprises about 20 strata that were deposited over an interval spanning from the onset of Riss glaciation (Oxygen Isotope Stage 6 or perhaps earlier) through the Holocene (Fig. 1).

Chronostratigraphic Position of Level G1

Level G1 of stratigraphic complex G is the oldest level which can be reliably dated to the Upper Paleolithic. It is situated between Level Fd/d and G2, but there are parts of the cave where Levels G1 and G3 are in direct stratigraphic contact (Karavanić and Smith 1998; Malez and Rukavina 1979). Level G1 is a distinctive stratum of clayey red-brown sediment 8–20 cm thick. It is easily distinguished from other levels of the G and the overlying F complexes. Occasionally it contains carbonaceous particles. Chronostratigraphically, G1 correlates to the Würm 2/3 interstadial in the French version of the Alpine terminological scheme (Rukavina 1983). Furthermore, animals determined by the analysis reported in this paper belong to species living in wet climate forests. Therefore, during the formation of the G1 layer, the climate was wet and relatively mild with a low density of coniferous woods and grass prairies dominating the landscape. If the megaloceros appeared during the Emian and disappeared by the end of the Upper Pleistocene, the elk appears in central Europe starting with OIS 3. It has been identified in Hungary, in the Szeletian levels of Transdanubia (at Szelim) and the Mousterian levels at Bükk (in Büdöpest). This, along with the results of palaeoecological studies, suggests that the Vindija G1 layer was formed during the interstadial corresponding to OIS 3.

Several different radiocarbon dates on bone samples from Level G1 have been obtained (see Ahern et al. 2004, Table 1). However, the most important are direct dates from Neanderthal remains. Two Neanderthal skeletal specimens from Level G1 were dated to 28 and 29 ka BP, respectively (Smith et al. 1999), and recently redated to about 33 ka BP (Higham et al. 2006), which corresponds well with one of the previous dates obtained on cavebear bones (Karavanić 1995).

Faunal Remains

Carnivores

Remains of 279 large mammal bones were identified in Vindija Level G1. More than 91% of the bone assemblage belongs to carnivores, most of which are cave bears (over 86%, excluding isolated teeth, metapodial and phalanges, which we have not studied). For the percentages of the number of carnivore remains, see Fig. 2. We have identified the remains of at least 13 cave bears (Fig. 3), 4 of

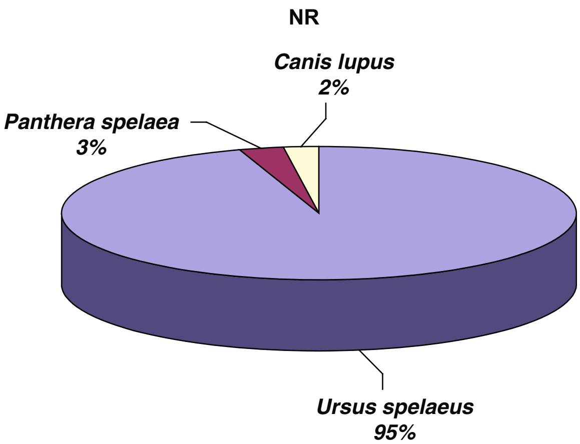

Fig. 2 Percentages of number of carnivore remains

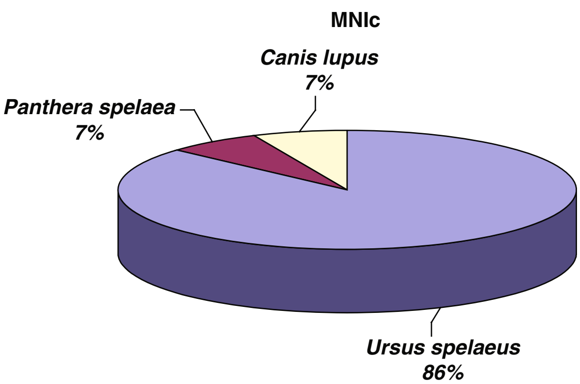

Fig. 3 Percentages of minimum number of individual carnivores

which are adult males (from the presence of the baculum = penis bone). All age groups are represented (5 juveniles, of which 2 are very young; 2 subadults; 5 adults; 1 older) (Fig. 4). Males and females with young successively hibernated in the cave on several occasions. All skeletal parts are represented in the sample, confirming the in situ deaths of those individuals. Most skulls are relatively complete but broken into bigger parts. All the long bones are broken, with the exception of one humerus of a very young animal. Bone breakages are attributable to natural processes, sediment pressure, and trampling. The frequency of bone breakages indicates frequent and recurring visits during the winter season by cave bears. Two other identified carnivores are wolf and cave lion (6 and 7 remains, respectively). Although during the formation of the G1 layer, carnivores were occupying Vindija Cave, carnivore gnawing marks on the bones are quite scarce (only on two bones). Furthermore, carnivores did not have an important role to play in the accumulation of large ungulate remains.

Ungulates

The bones of ungulates are relatively scarce. Most abundant among the ungulate remains are those of cervids (28) (Fig. 5). Four species are represented: elk, megaloceros, red deer, and roe deer. Elk have been identified by 15 remains (mostly belonging to the skull) from 3 different individuals, of which one is younger than 28 months, one is approximately

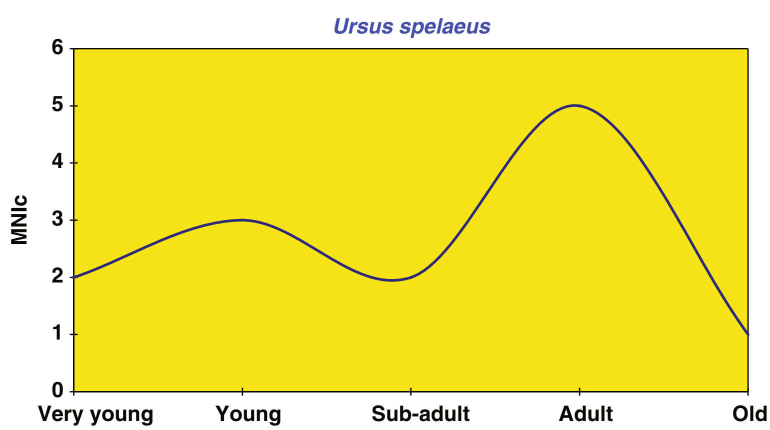

Fig. 4 Mortality profile of *Ursus spelaeus*

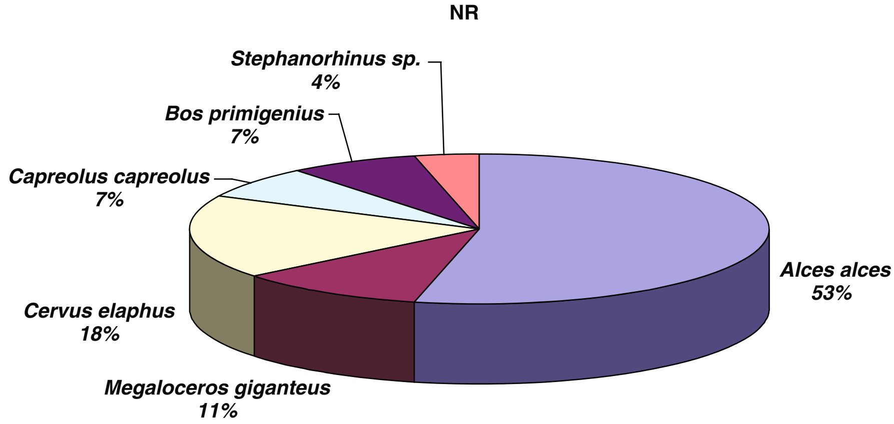

Fig. 5 Percentages of number of ungulate remains

3 years old, and one is an older adult (probably female). Megaloceros is represented by 3 autopodial remains from at least one adult. In addition, one fragment of a metacarpal bone belonging to a large cervid could not be attributed to a specific species. As far as the adults are concerned, the absence of antlers in the case of the two large cervids may indicate either males without antlers or females; the second hypothesis seems more probable. Red deer were identified by 5 remains (among them a fragment of an antler) belonging to at least one adult male (who probably died during summer or autumn). The roe deer are represented only by two fragments of the same femur belonging to an adult (Fig. 6). In addition, two vertebrae belonging to a small ungulate, maybe a roe deer, have also been found.

Two other species have been identified: the aurochs (two left metacarpals from an adult and a juvenile) and the prairie or forest rhinoceros (one fragment of an upper milk tooth).

Discussion

The presence of traces resulting from percussion on fresh bones proves the intervention of humans on the carcasses of Vindija G1 ungulates, with the exception, perhaps, of the rhinoceros remains. The three elk, probably belonging to a small family group (one female, one young, and one male, which were together from March until June) had been hunted and eaten during the summer season (bone marrow had been removed). It is hard to infer the precise way the megaloceros had been acquired, but it had certainly been eaten by humans (bone marrow had been removed). The male red deer was

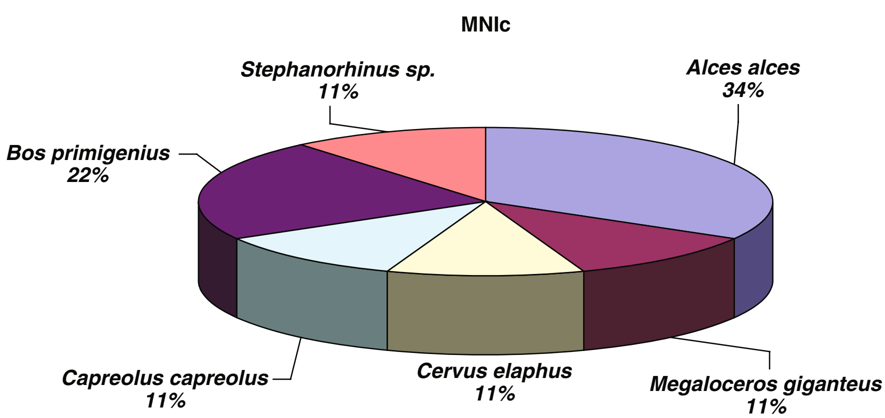

Fig. 6 Percentages of minimum number of individual ungulates

most probably hunted and eaten during the summer season (bone marrow had been removed), just like the roe deer. The biogeochemical analyses conducted by Richards et al. (2000) on Neanderthal remains from the G1 level prove that their diet consisted mostly of meat. We agree with their conclusions: that Neanderthals, at least in this region, were active predators and not exclusively scavengers.

Results of our analysis are only partial, since the exact provenance of many bone remains from the Vindija G complex is not known. It is quite probable that some of them do belong to the G1 layer. According to the global analysis of the material, it would seem that human occupation of the cave during the G1 layer was short. This hypothesis is confirmed by the scarcity of lithic artifacts.

Lithics

Artifact Assemblage

There are only 60 lithic specimens from Level G1. The stone tools combine Middle and Upper Paleolithic typological characteristics (Fig. 7, nos. 1–5). Some of them contain edge damage, part of which may have resulted from post-depositional displacement (Zilhao and d'Errico 1999; but see Karavanić and Smith 2000). Together with side-scrapers and denticulates (some of which may be 'pseudo-tools'), Upper Paleolithic tool types, like burin (Fig. 7, no. 2) and blade fragments with two continuously retouched edges, are also present in this level. Only one tool (i.e., an end-scraper on an Aurignacian blade) may be linked to the Aurignacian type (Karavanić 1995). A leaf-shaped bifacial piece (Fig. 7, no. 4) made on nonlocal red radiolarite has also been recovered from this level, and it appears that this piece was imported from elsewhere, probably from nearby Hungary.

About half of the artifacts from layer G1 were made on quartz and related materials, while the other half were made on chert and tuff (Ahern et al. 2004; Blaser et al. 2002). When compared to the Middle Paleolithic layers of Vindija, a significant reduction in the use of quartz as a raw material is seen; while there is an increase in the use of chert, which also dominates in the Upper Paleolithic layers.

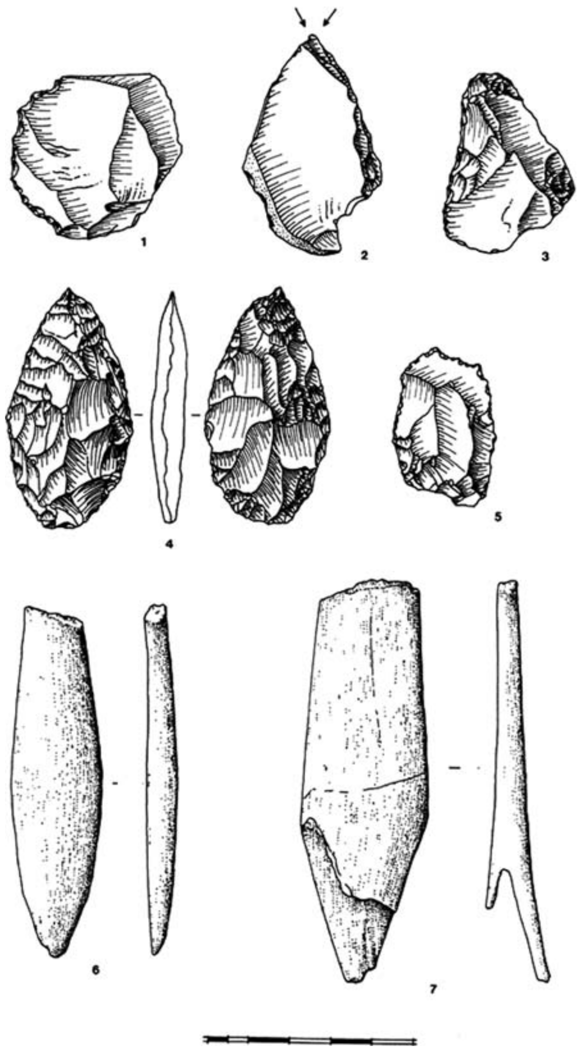

Fig. 7 Selected stone and bone artifacts from Vindija Level G1: 1. pseudotool, 2. burin, 3. sidescraper, 4. leaf-shaped bifacial point, 5. marginal retouched flake, 6. massive base point, 7. split base point (modified after Karavanić 2005, Figure 3; drawing: Marta Perkić)

Discussion

Overall, the lithic industry of this level strongly suggests affinities to a non-Levallois Mousterian technological and typological tradition, while the selection of raw material could suggest a continuous behavioral change from the Middle to the Upper Paleolithic. Furthermore, early Upper Paleolithic bone points were found in the same context.

A number of interpretations have been given for the Vindija G1 associations (Karavanić 2000; Karavanić and Smith 1998; Kozlowski 1996; Miracle 1998; Montet-White 1996; Straus 1999; Svoboda 1999). Svoboda (1999) has suggested affinities to the Szeletian. Straus (1999) and Montet-White (1996) see it in the context of a complex pattern that characterizes the Middle/Upper Paleolithic transition. The Vindija G1 assemblage might represent an aspect of such complexity, as suggested by Karavanić and Smith (1998).

Bone Artifacts

Points and Retouchers

Our study of the bone pieces from the G complex, believed to have been modified by humans, was primarily based on taphonomic processes and the nature of the material, and secondarily on the technological aspect. Our analysis showed that several of the pieces were in fact not the result of human activity. This refers to some pieces that were supposed to be 'retouchers' (Ahern et al. 2004; Karavanić and Šokec 2003) or fragments of bone artifacts (Karavanić 1994; Malez 1988). Pieces G1-3441 (bone fragments), G1-3442 (bone fragments), G1-3443, and Fd/d + G1-3446 (two bear penis bones) possess no traces of human processing. On bone fragments 3442 and 3446 striations have been observed, but those are not the result of human intervention (specimen 3443 has previously been described as an engraved bone). Pieces 3449, 3445, and 2506 are fragments of a metacarpal shaft of an elk. On these, striations are also visible. One piece (G1-3444) is identical to the one from the G4 layer, in which no human activity was noted on bone material (no. 3464, as well as several faunal pieces with no labels). This element, previously believed to be a button, is in fact a bone fragment of, most likely, bear fibula which has all the characteristics of bear trampling damage.

In contrast, nine pieces (3438, 2510, 3437, 3439, 2509, 2512, 3456 + 3440, 3445, and 3436) undoubtedly represent tools. One is a split-base point (Fig. 7, no. 7), three are massive base points (Fig. 7, no. 6), and one is an awl. Eight of these pieces are from the G1 layer, while one piece (3436) bears only label G. This awl was made most likely on elk vestigial metacarpal. The technique used for its production seems to have been more complex than in the case of the other pieces. Two pieces (3439 and 2512) have been crafted from either the baculum or fibula of a cave bear, while one piece (3437) was made on a rib of an undetermined species. The species determination of the other 5 bone pieces could not be conducted.

To these nine bone pieces, three retouchers should be added, but only one of them is marked by a 'G' without precise level designation, and it could be from layer G1. This piece is similar to a shaft fragment of a large cervid metatarsal.

The bone retoucher from the G3 layer is similar to the shaft fragment of a red deer metacarpal, the one labeled G is similar to a shaft fragment of a large cervid metatarsal, and the one found in F/D is similar to a radius or tibia shaft fragment either of a bovine or a large cervid.

These bone pieces are similar in dimensions (maximum length between 7.2 and 7.5 cm, maximum width between 2.8 and 2.9 cm). On these three pieces, traces are in the form of incisions perpendicular to the bone axis and parallel to each other. All these incisions are grouped on a single surface with dimensions varying from 1.3 to 1 cm for the maximum length, and 1.5 to 0.8 cm for the maximum width.

Discussion

The presence of the bone pieces produced in an Aurignacian manner found in the same level as Neanderthal remains brings up several possibilities. One of these might be a result of mixed sediments. From a taphonomic point of view, the preservation of bone tools is similar to other bone remains of large mammals and humans. Therefore, we cannot completely exclude them from the G1 layer. Furthermore, a human mandibular fragment and a split-based bone point were found close to each other. Therefore, we cannot exclude the possibility of exchanges with early modern humans or technological emulation (acculturation). *In situ* technological evolution also cannot be excluded (in case of the lithics, the Middle Paleolithic types are found alongside typical Upper Paleolithic types).

Human Remains

Taphonomic Analysis of Human Remains

Human remains from Level G1 have been studied on many occasions and it was concluded that these remains represent Neanderthals (see Ahern et al. 2004; Smith and Ahern 1994; Wolpoff et al. 1981). We analysed these remains from taphonomic perspectives.

A right mandibular part, a skull fragment, a left parietal, an upper right incisor, and an upper right canine most likely belong to a single individual (probably a young adult female). These 5 remains are well preserved and heavily mineralized with various traces of MnO_2. These traces are more abundant on the mandible fragment, which therefore comes from a place where percolation was more pronounced (close to a cave wall). Three skull fragments could belong to a human cranium. The preservation is similar to one of the previously mentioned pieces. The remaining three human remains (left zygomatic bone, left frontal fragment, and the shaft part of a left radius of a young individual) have been identified, but their exact stratigraphic position is uncertain. The left frontal is in a similar state of preservation and therefore could belong to the same individual from layer G1. In contrast, the state of preservation of the other two pieces is more similar to human remains found in layer G3.

No traces of human activity have been noted on the aforementioned pieces. From a taphonomic point of view, the conservation of human bones is similar to that of other bone remains of large mammals and bone tools. The breaks on them are postmortem and due to natural causes (e.g., sediment compaction). These fragments do not show trampling stigmata, indicating no cave bear perturbations.

It is possible that the skull was deliberately deposited in the cave by other Neanderthals.

In layer G3, a different situation seems likely. The number of human bones is more abundant, as well as the number of individuals. Cranial remains are most numerous and belong to eight different individuals. The crania of six individuals were most likely deliberately deposited in the cave. Only nine postcranial remains have been found, and they belong to three different individuals. Two right humeri of young individuals bear traces of percussion made on fresh bone. A left humerus bears striations made by a sharp stone tool. Neanderthals from the G3 layer probably broke these bones in order to obtain the marrow. Besides that, the left arm (humerus and radius) of an individual aged 12–13 years has been disarticulated. Based on these results, we propose cannibalistic practices by Neanderthals represented by layer G3.

Discussion

Some observations allow us to propose a hypothesis of successive occupational episodes during the formation of layer G1.

Initially bears occupied the cave during winters. Afterwards, human occupation was documented by the deliberately broken left metatarsal of a male red deer that also bears polishing and trampling traces. Once the bone was broken by humans to obtain the bone marrow, this bone was trampled by bears. It confirms that carnivores again visited the cave, after the humans abandoned it. Furthermore, one of the Upper Paleolithic bone tools (2510), brought to the site or produced by Neanderthals, shows trampling traces, thus confirming that bears visited the cave after the Neanderthals left. Finally, no trampling was observed on the human remains, confirming that the skull was either deposited long before the carnivores arrived, or alternatively, that the skull was buried deliberately (possibly in a context of funerary rites).

Conclusions

Based on the taphonomy of the faunal remains from Vindija cave Level G1, we can strongly suggest that the Neanderthals were active predators and not exclusively scavengers. Humans and carnivores alternatively occupied Level G1, and the human occupations were short. The lithic industry represents Mousterian non-Levallois technology, including some Upper Paleolithic tool types and one leaf-shaped bifacial point. Early Upper Paleolithic bone points are found in the same assemblage together with Neanderthal human remains. Although this is unusual, the conservation of bone tools is similar to that of the other bone remains of large mammals and humans, and therefore we cannot exclude them from the G1 layer.

In comparison to previous interpretations of Vindija Neanderthal behaviour (Levels G3 and G1) concerning a skull cult (Malez 1985) and cannibalism (White 2001), according to the results of our taphonomic analysis we proposed several successive alternating occupations (humans/carnivores), with possible deliberate deposition of human skulls by Neanderthals represented by Level G1 and cannibalistic practices by Neanderthals represented by Level G3.

Vindija Cave is one of the rare European sites that has remains of fossil hominids associated with lithic industries during the time span of the Middle/Upper Paleolithic transition. Therefore, it is very important to continue analyses of material from this site. Dating the large cervid bones with traces of human activity and dating or redating bone points with radiocarbon (AMS), especially the ones with trampling traces, would be of great importance indeed.

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Szeletian, Not Aurignacian: A Review of the Chronology and Cultural Associations of the Vindija G1 Neandertals

João Zilhão

Abstract Analysis of the lithic assemblages from provenience units Fd/d + G1, G/F, and G1 of Vindija confirms that a significant proportion correspond to items bearing edge damage and/or abraded dorsal scar ridges. Diagnostic Aurignacian items exist in the stratigraphically mixed G/F assemblage, and they may well have been discarded in the context of the same occupation as the split-based bone point recovered in G1. This level, however, also contains fragments of bone points of the Mladeč type, as well as a typically Szeletian bifacial foliate point. Thus, G1 is best explained as a post-depositionally disturbed palimpsest, one where the co-occurrence of finds is no sufficient indicator of true contemporaneity. This hypothesis is corroborated by the >10,000 years age difference between the two cave bear bones from that level that have been AMS radiocarbon dated. Given the regional archeological and human paleontological context, and the evidence suggesting that the direct dates obtained for the Neandertal remains from G1 are minimum ages only, it is concluded that such remains are likely to be Szeletian- rather than Aurignacian-related. The fact that Mladeč bone points are the only diagnostic tools throughout the F and E units further indicates that these deposits belong to the later Aurignacian, not the Gravettian. This pattern implies a major stratigraphic discontinuity at Vindija during the Last Glacial Maximum, thus providing an analog for the site formation processes inferred for G1 times on the basis of the level's mixed content.

J. Zilhão (✉)
Department of Archaeology and Anthropology, University of Bristol, Bristol, UK

Keywords Vindija • Neandertals • Aurignacian • Szeletian

Introduction

The cave site of Vindija, Croatia (Fig. 1), is one of the key sequences for the study of the late Middle and the early Upper Paleolithic of Europe. Unfortunately, the data set has several shortcomings (Karavanić and Smith 2000): modern excavation standards were not used, cryoturbation affected the site at least in part, and the exact stratigraphic provenience of some key finds is uncertain. However, AMS dating of cave bear and human bone samples (Smith et al. 1999; Wild et al. 2001; Higham et al. 2006a), analysis of the artifact assemblages (Malez 1988; Karavanić 1994, 1995, 2000; Karavanić and Smith 1998; Blaser et al. 2002; Ahern et al. 2004), and paleonutrition and ancient DNA studies of the human remains themselves (Krings et al. 2000; Richards et al. 2000; Serre et al. 2004) have made it possible to overcome some of these problems and to obtain information of major relevance for the Middle-to-Upper Paleolithic transition (henceforth, the Transition) in this part of the world.

Of the 22 stratigraphic levels recognized at the site, the c. 3.2 m of deposits comprised between the top of layer D and the base of complex G, with subdivisions (*g* for *gore,* top; *s* for *sredina,* middle; *d* for *dolje,* infra), contain Upper and late Middle Paleolithic occupations (Fig. 2). According to Karavanić (1994, 1995), the succession is as follows: level D, Epigravettian; level E, Late Gravettian or

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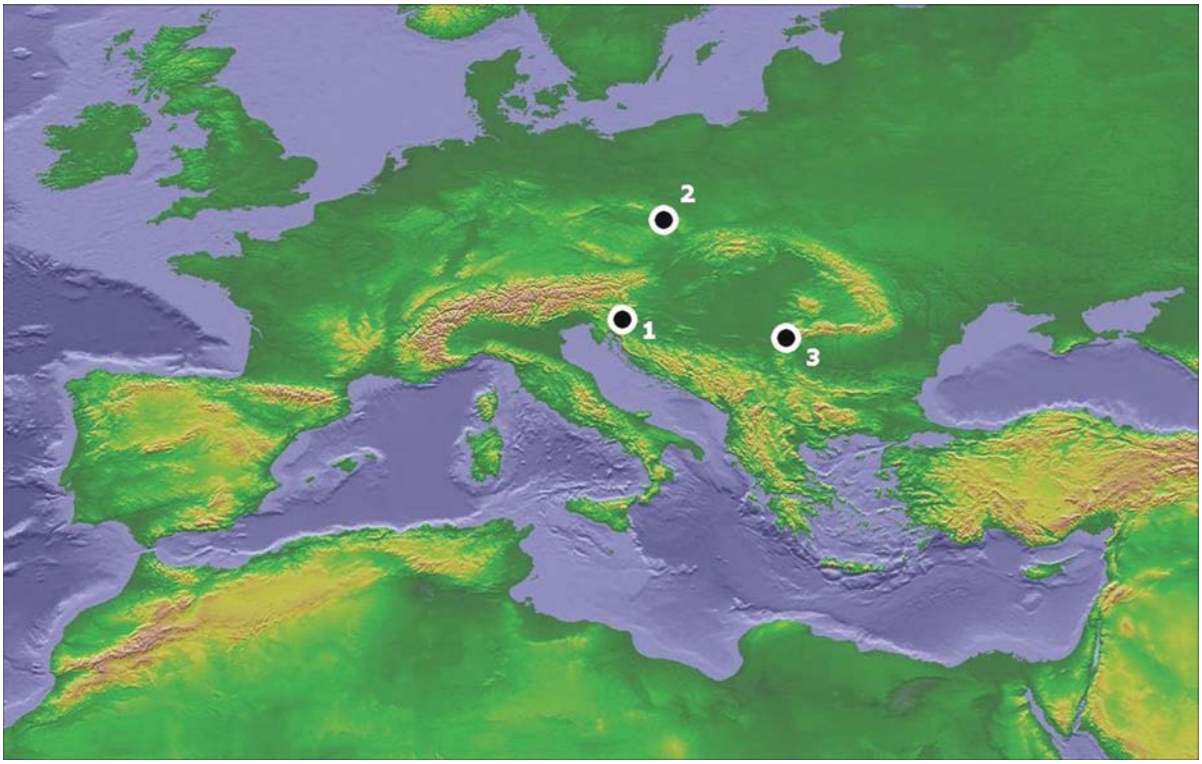

Fig. 1 The location of Vindija cave (1) on a physiographic map of Europe. The site is located at the western boundary of the Pannonian basin, at the northern and eastern boundaries of which are located two sites that yielded diagnostic modern human remains in the time range indicated by the direct dating of the Neandertals in Vindija level G1: Mladeč (2), and Oase (3)

Epigravettian; levels Fg, Fs and Fd/s, possibly Gravettian (given their position in the succession, but lacking diagnostic stone tools); level Fd, undefined; levels Fd/d and G1, Aurignacian; and levels G2–G5, Mousterian. Karavanić (2000) since has suggested that the assemblage in G1 better might be referred to the Olschewian, an entity that, following Montet-White (1996), he defined as a regional variant of the Aurignacian embodied in the assemblages rich in bone points recovered at several central European cave sites in levels dated to around the time of the Transition.

Besides bone points, level G1 also contained a bifacial foliate, as well as human remains that are clearly Neandertal (Malez et al. 1980; Smith 1984; Ahern et al. 2004). Such an association has been variously interpreted as evidence that Neandertals made split-based bone points and were at least in part the authors of the Aurignacian (Wolpoff 1996); or as evidence that Neandertals still inhabited northern Croatia long after Aurignacian bone and stone tool technology first spread across central Europe (Karavanić 2000), thus providing a temporal and spatial framework for considerable biological and cultural interaction with modern humans in the region (Karavanić and Smith 2000).

All of these interpretations are contingent upon the acceptance, most recently reasserted by Janković et al. (2006), of (1) the integrity of level G1, (2) the true contemporaneity of the different find categories recovered therein, and (3) the accuracy of the direct radiocarbon dating results obtained for the Neandertal remains. Such an acceptance, however, carries implications that are at odds with patterns well established by decades of research. For instance, now that the situation at the Hungarian cave site of Istállós-kõ finally has been clarified (Adams 2002; Ringer 2002; Adams and Ringer 2004), Vindija remains as the only find locality where split-based bone points would co-occur with bifacial foliates in the same occupation horizon. The anomalies have not gone unnoticed and,

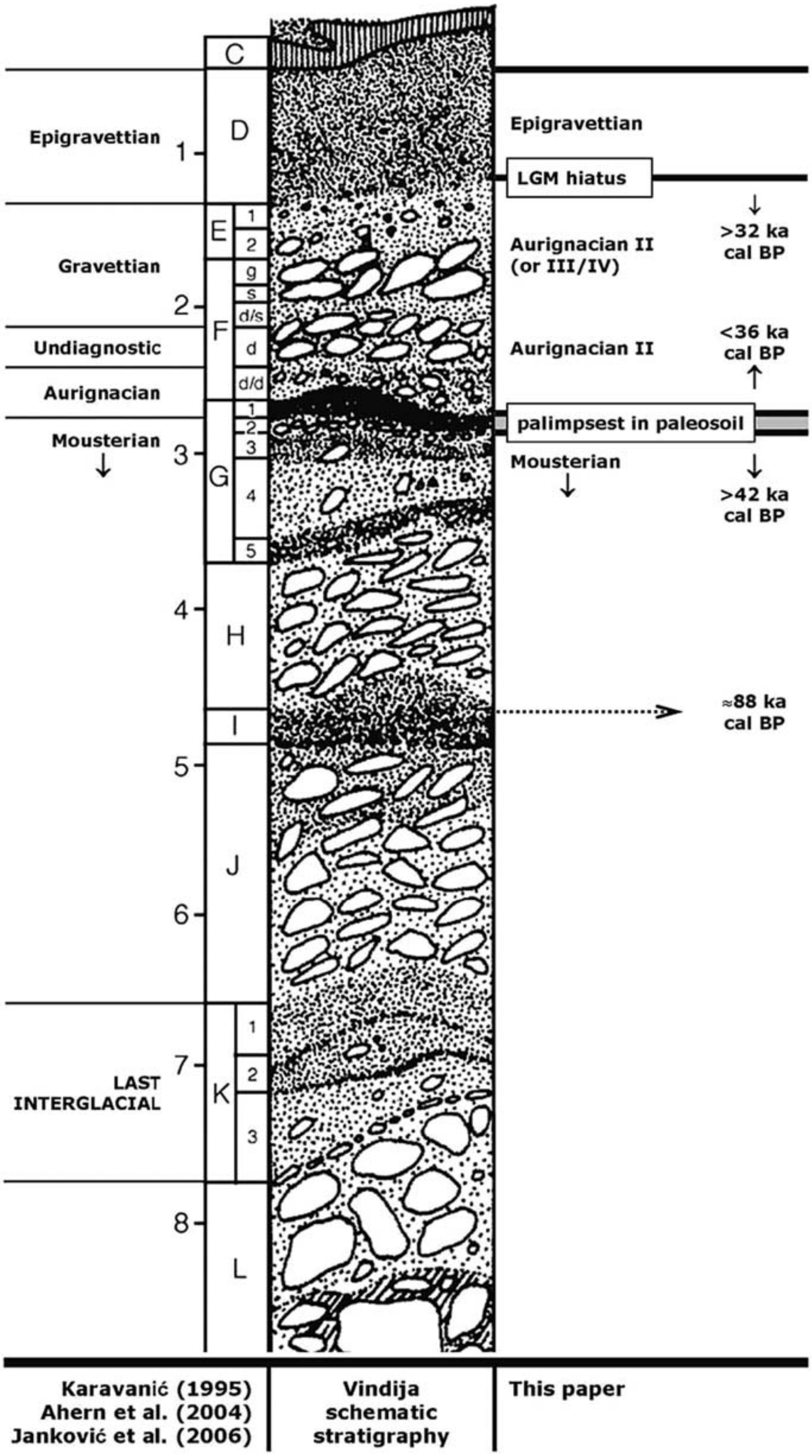

Fig. 2 The Vindija succession and its chronostratigraphic interpretation. Note that Ahern et al. (2004) interpret the presence of a few Upper Paleolithic elements in G3 as a reflection of cultural process (local Mousterian innovations), while they may simply constitute further examples of the post-depositional displacement of artifacts across recognized level boundaries. Where G1 is concerned, the mix therein of Szeletian, Aurignacian I, and Aurignacian II items is consistent with its being either a palimpsest, a byproduct of erosion and redeposition, or a combination of both (see text for discussion)

following previous reservations, notably by Kozłowski (1996), have led to suggestions that the G1 association is spurious and, as indicated by the edge damage of stone tools, an artifact of geological processes, cryoturbation in particular (d'Errico et al. 1998; Zilhão and d'Errico 1999a).

Typology, Distribution, and Condition of the Diagnostic Tools

Results from personal examination, in April 2004, of the Vindija artifact collection housed in the Croatian Academy of Sciences, Zagreb, support previous objections to the integrity of G1 (Table 1; Fig. 3). Of the fifteen retouched stone tools mentioned by Karavanić (1994, 1995), ten were present, of which three are typologically unambiguous: the bifacial foliate, a Szeletian point made on a reddish, exogenous raw material, biconvex in cross-section, and bearing a clear impact fracture on the distal end; a straight dihedral burin; and a small proximal blade fragment with regular, continuous retouch on both sides. The other seven, however, are no more than unretouched blanks bearing post-depositional damage to different degrees: the "endscraper on a flake" Vi-174, for instance, is a small patinated flake with abraded, rounded dorsal edges and featuring marginal, peripheral, irregular, and alternate "retouch," a rather typical combination of attributes indicative of water transport or turbation; and the "sidescraper" Vi-3383 is simply a small 2.5 cm flake where the "retouch" is crushing of the cutting edges and the dorsal edges are clearly abraded.

Edge damage, but no dorsal abrasion, is also apparent in the four "retouched tools" (out of five

Table 1 Classification, compared with Karavanić's (1994, 1995), of the lithic items from G1 and from other provenience units conceivably sampling material from G1 kept at the Croatian Academy of Sciences, Zagreb, with the indication "retouched tools" (as of April 2004)

		G1 (1977–1979 and 1984)		Fd/d + G1 (1984)		G/F (1975–77)	
Type-list #	Description	Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)
1	Endscraper, simple on blade	–	–	1	–	–	–
1	Endscraper, simple on flake	–	–	–	1	–	–
2	Endscraper, simple on blade, atypical	–	–	–	–	1	–
3	Endscraper, double, on flake	–	–	1	1	–	–
5	Endscraper, on retouched blade	1	–	–	–	–	1
6	Endscraper, on Aurignacian blade	–	–	–	–	1	–
8	Endscraper on flake	2	–	–	–	–	–
12	Endscraper, keeled, atypical	–	–	–	–	1	–
13	Endscraper, thick-nosed	–	–	–	–	1	–
16	*Rabot*	–	–	1	–	–	–
29	Burin, dihedral, straight	1	1	–	–	1	–
30		–	–	–	–	1	–

Table 1 (continued)

		G1 (1977–1979 and 1984)		Fd/d + G1 (1984)		G/F (1975–77)	
Type-list #	Description	Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)
	Burin, dihedral, on angle						
35	Burin, on oblique truncation	–	–	–	–	1	–
65	Blade with one continuously retouched edge	–	–	1	–	2	–
66	Blade with two continuously retouched edges	1	1	–	–	5	1
67	Blade with Aurignacian or Aurignacian-like retouch	–	–	–	–	1	3
70	Bifacial foliate point	1	1	–	–	–	–
75	Denticulate	4	–	1	–	–	–
77	Sidescraper	4	–	–	–	–	1
92	Blade with partial retouch	–	–	–	–	–	1
92	Hammerstone	1	–	–	–	–	–
92	Chopper	–	–	–	–	1	–
92	Other	–	–	–	–	4	–
	Prismatic bladelet core	–	–	–	–	–	1
	Unretouched blade	–	–	–	–	–	1
	Flake or blade with edge damage or irregular, marginal, alternate "retouch"	–	7	–	2	–	6
	Heavily patinated, *concassé* piece	–	–	–	–	–	3
	TOTAL	15	10	5	4	20	18

mentioned by Karavanić) that bear the label "Fd/d + G1"—two are indeed retouched (a simple endscraper and a double endscraper on a thick flake); the other two are edge-damaged blade fragments, and all bear adhering remnants of a brownish sediment identical to that seen in the pieces labelled G1. The best preservation was observed among the eighteen "retouched tools" labeled "G/F" (two of the twenty mentioned by Karavanić were not found) (Fig. 4). Although five were broken, edge-damaged blanks, and three were severely *concassé* and heavily patinated pieces, the remaining ten were in good condition. The latter include a prismatic bladelet core, one endscraper on a bilaterally retouched blade, four blades with continuous, Aurignacian-like retouch, one partially retouched blade, two unretouched blades, and one sidescraper.

These observations are consistent with the notion that an Aurignacian component exists among the site's lithics, and it is quite possible that

Fig. 3 The ensemble of G1 lithic artifacts kept at the Croatian Academy of Sciences, Zagreb, with the indication "retouched tools" (as of April 2004): **a**–**g** edge-damaged, patinated, and/or abraded items; **h-i** items in good surface condition (**h**. bifacial foliate point; **i**. straight dihedral burin; **j**. blade with two continuously retouched edges)

such a component represents stone tools discarded at the site in the framework of the human occupation defined by the G1 split-based bone point. But the data also indicate that the stratigraphic position of these Aurignacian lithics is ambiguous, the most diagnostic items having been found in the G/F unit, i.e., in mixed deposits of, or the at the interface between, G and F. Such an ambiguity, plus the significant edge damage apparent on many artifacts—indicating that they were either washed or in situ turbated—suggests considerable disturbance of the deposits found at that interface, in at least some areas of the cave. Given the evidence, it is in any case clear that the level of uncertainty surrounding the provenience of the most diagnostic lithic elements recovered in the basal F and upper G levels is a byproduct of true stratigraphic problems rather than of excavation error.

The typology and provenience of the bone tools corroborate a diagnosis of inhomogeneity for the G1 assemblage (Table 2; Fig. 5). In fact, alongside the well-known split-based point fragment, the level also yielded a few fragments (Vi-2610, Vi-3438, Vi-3439, Vi-3440, Vi-3441) of the same Mladeč point types more abundantly found in overlying levels Fd/d and F/d. The evidence from western Europe is that split-based and Mladeč points belong in different, successive culture-stratigraphic units (Early Aurignacian or Aurignacian I and Evolved Aurignacian or Aurignacian II, respectively), and the same applies to Vindija's immediate regional context.

In adjacent Slovenia, for instance, no other putative "Olschewian" occupation associates split-based and Mladeč points in the same find horizon. The site of Potočka Zijalka (Brodar and Brodar 1983;

Fig. 4 The ensemble of G/F lithic artifacts kept at the Croatian Academy of Sciences, Zagreb, with the indication "retouched tools" (as of April 2004) and that presenting a good surface condition: **a**. prismatic bladelet core; **b**. unretouched blade (with a bit of edge damage); **c**. unretouched blade (partial retouch near the broken base); **d**. unretouched blade; **e**. sidescraper on laminar flake; **f**. proximal fragment of blade with lipped platform with Aurignacian retouch on the left side; **g**. mesial fragment of blade with bilateral Aurignacian retouch; **h**. blade with bilateral Aurignacian retouch; **i**. endscraper on blade with continuous bilateral retouch; **j**. mesial fragment of blade with bilateral retouch

Pacher et al. 2004) produced a rich assemblage of Mladeč points (128 from the 1920s to 1930s extensive excavation work, plus two from the restricted areas investigated in 1997–2000), but not a single example of a split-based point (occasionally—e.g., Karavanić 2000—one particular bone tool from this cave has been referred to the split-based type, but that find is in fact a naturally fissured object where, as Brodar and Brodar point out, no osseous material is missing on the inner side of both lips, as would have to be the case if the split resulted from intentional manufacture). Conversely, at the cave site of Mokriška Jama (Brodar 1985), not one of the nine bone points recovered was of the Mladeč variety: one preserved a proximal portion sufficiently large for a split base to be observed, while at least two other medial and distal fragments (and possibly three smaller ones too) could well have been of the same type. The evidence from the cave of Divje Babe I (Turk 1997), where one split-based point, but none of the Mladeč type, was recovered in level 2, is consistent with this pattern.

Site Formation Process

It seems fair to conclude, therefore, that, even though the Vindija succession may well feature a significant level of stratigraphic integrity above and below the F/G interface, major problems exist at exactly that interface, causing the apparent association in the uppermost G unit (i.e., level G1) of a mix of items that normally would have been stratigraphically differentiated. One possibility is that only the Szeletian bifacial foliate lithic point is in situ, and that the split-based bone point is a later intrusion, since it is most certainly related to an

Table 2 Upper Paleolithic sagaie bone points from Vindija kept at the Croatian Academy of Sciences, Zagreb (as of April 2004)

Inventory #	Year of excavation	Level	Cultural horizon (Karavanić 1995)	Cultural horizon (Zilhão, this paper)	Fragmentation	Base	Cross-section	Mladečtype
Vi-3471	–	D/g	Epigravettian	Epigravettian	Mesial	–	Circular	
Vi-3465	–	D			Proximal	double-bevelled	Circular	
Vi-3466	–	D			Mesial	–	Circular	
Vi-3467	–	D			Mesial	–	Circular	
Vi-3468	1979	D			Mesial	–	Circular	
Vi-3469	1977	D			Mesial	–	Circular	
Vi-3470	–	D			Proximal	Double-bevelled	Circular	
Vi-2508	1983	E + F	Gravettian	Aurignacian II or III/IV	Proximal and mesial	Massive	Oval	*
Vi-3460	1975	E/F			Proximal and mesial	Massive	Oval	*
Vi-3461	–	E/F			Mesial	–	Circular	
Vi-3456	1979	F/s	Gravettian	Aurignacian II or III/IV	Proximal	Massive	Flat	*
Vi-3457	1978	F/s			Mesial	–	Flat	*
Vi-3458	1978	F/s			Distal, with apical fracture	–	Flat	*
Vi-3459	1978	F/s			Mesial	–	Flat	*
Vi-3465	1979	Fd/s			Mesial and distal with apical fracture	–	Flat	*
Vi-3451	–	F/d	Unknown	Aurignacian II or III/IV	Mesial	–	Flat	*
Vi-3452	1979	F/d			Distal with apical fracture	–	Flat	*
Vi-3453	1978	F/d			Distal with apical fracture	–	Flat	*
Vi-3454	1978	F/d			Mesial	–	Flat	*
Vi-3449	–	Fd/d	Aurignacian	Aurignacian II or III/IV	Proximal and mesial	Massive	Flat	*
Vi-3450	–	Fd/d			Proximal and mesial	Massive	Oval	*
Vi-3445	1984	Fd/d + G1	Mixed	Mixed	Proximal to distal with apical fracture	Massive	Flat	*
Vi-3446	1984	Fd/d + G1			Proximal to distal with apical fracture	Massive	Flat	*
Vi-2512	1983	Fd/d + G1? G1?			Mesial	–	Flat	*
Vi-2509	1983	G1	Olschewian	Mix of	Mesial	–	Flat	*
Vi-2510	1983	G1		Szeletian +	Proximal	Massive	Flat	*

Table 2 (continued)

Inventory #	Year of excavation	Level	Cultural horizon (Karavanić 1995)	Cultural horizon (Zilhão, this paper)	Fragmentation	Base	Cross-section	Mladečtype
Vi-3437	–	G1		Aurignacian I + Aurignacian II	Proximal and mesial	Split	Wide, very flat	
Vi-3438	–	G1			Proximal and mesial	Massive	Flat	*
Vi-3439	–	G1			Proximal to distal with apical and lateral fractures	Massive	Flat	*
Vi-3440	1983	G1			Mesial	–	Flat	*
Vi-3442	1979	G1			Mesial, split longitudinally	–	Flat	*

The following items included in Karavanić's (1994) bone tool inventory were excluded because they are either intrusive or not sagaie points: in levels D and D/g, Vi-1977, a pendant, Vi-3474 and Vi-3475, awls, all of which feature a lack of fossilization indicating provenience from the overlying Neolithic; in level E, Vi-3462, an awl; in level G, Vi-3436, an awl; in level G1, a (penian?) bone with marks associated with a note saying "green layer," i.e., G3. Also excluded were Vi-2111 and Vi-3463, which are not artifacts, as well as the Vi-3464, Vi-3447, Vi-3449 and Vi-3464 "buttons," which are in fact carnivore-broken bones.

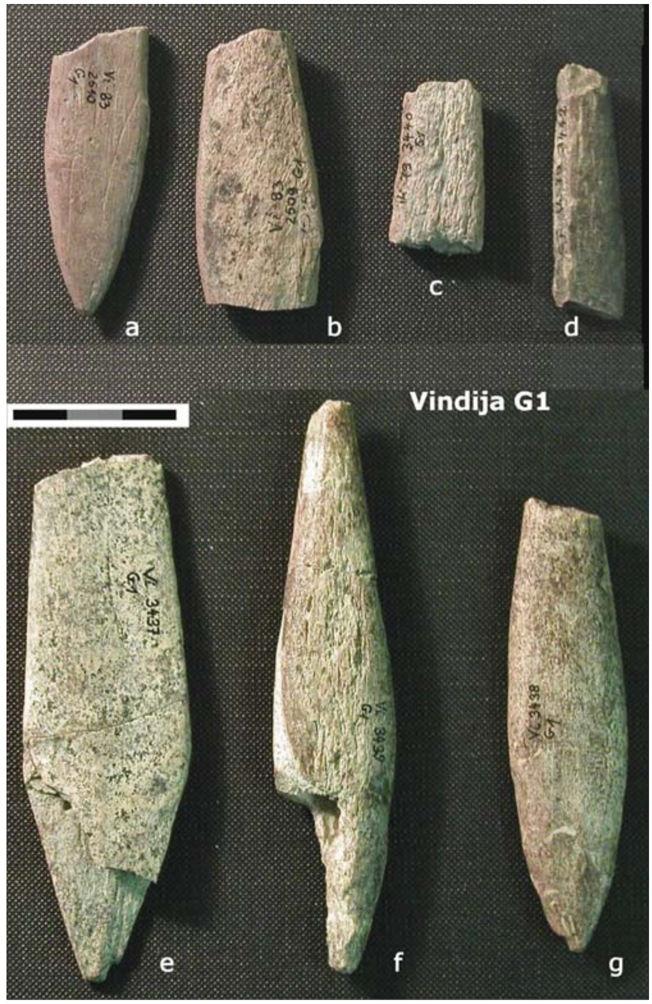

Fig. 5 Split-based (**e**) and Mladeč (**a-f**, **f-g**) points from the G1 unit (cf. Table 2): **a**. Vi-3440; **b**. Vi-3441; **c**. Vi-3437; **d**. Vi-3439; **e**. Vi-3438; **f**. Vi-2610; **g**. Vi-3442

Aurignacian I occupation of the site, also reflected in the retouched blades found in the mixed G/F unit. In such a scenario, the G1 Mladeč point fragments, a type that is represented in the overlying levels by a significant number of finds (Table 2), would likewise be intrusive too.

This view is consistent with the sedimentological nature of G1 as described, for instance, by Karavanić (1995): a red-brown clay sandwiched between two series of sandy sediments with abundant limestone rubble, G3 below (G2 only occurs in restricted portions of the site), and F and E above. The pattern suggests pedogenesis, i.e., that, as the excavators thought, the formation of G1 occurred during a period of warming climatic conditions (Malez et al. 1980). In the regional geological and paleoenvironmental setting, one would expect such conditions to translate into a marked slowdown in the rate of sedimentation, favoring the creation of archeological palimpsests via the intrusion into previously accumulated deposits of material from occupations taking place on long-standing, stabilized surfaces. Coupled with subsequent post-depositional disturbance (e.g., cryoturbation), such well-known and purely geological processes parsimoniously explain the utterly exceptional association in G1 of tool-types that elsewhere always occur separately, effectively dispensing with the need to christen a new cultural-stratigraphic category (the "Olschewian") to account for it.

If we consider the evidence from G1 in light of the site's wider geographical context, both regional and continental (Teyssandier 2003; Teyssandier et al. 2006; Liolios 2006; Zilhão 2007), it is also clear that the association in that level of find categories that, elsewhere, are of Aurignacian II, Aurignacian I, or Szeletian affinities, would represent (if taken as meaning strict contemporaneity) the survival, reappearance, or first appearance of those items several millennia beyond their documented chronological range. For the sake of the argument, let us assume, for instance, that the Mladeč bone points are good indicators of the level's formation age. In that case, the deposition of its contents would have taken place c. 30–32 ka ^{14}C BP (c. 34–35 ka cal BP), i.e., within the interval defined by the dates for six such points from the Potočka Zijalka (Rabeder and Pohar 2004), and in agreement with the fact that, elsewhere in Europe, no other specimen of unambiguous assignment to this type has ever yielded a direct date older than c. 32 ka ^{14}C BP (Jacobi and Pettitt 2000; Charles et al. 2003; Bolus and Conard 2006; Higham et al. 2006b). However, if G1 is homogenous and formed c. 30–32 ka ^{14}C BP, then the split-based bone point would be two to three thousand years later than the most recent occurrences of the type elsewhere in Eurasia, where it is found from Asturias (northern Spain) in the west to the northern Levant in the east, only during the time interval of c. 32–35 ka ^{14}C BP (c. 37–40 ka cal BP); and, in the case of the Szeletian- or Altmühlian-type bifacial foliates from central Europe, whose distribution, spatially, covers Moravia, Germany, Hungary, and southern Poland and, temporally, the interval of c. 37–40 ka ^{14}C BP (c. 41–44 ka cal BP), the difference in the expected age would be some ten thousand years.

Obviously, the contradictions above are reversed in their terms, but not eliminated, if we consider that the true age of deposition of G1 is that given by the temporal distribution of Szeletian foliates or of Aurignacian I split-based bone points. In contrast, in the framework of a palimpsest model, the co-occurrence of "index-fossils" of such distinct chronology is easy to understand, since it implies that the contents of G1 mix remains from different, chronologically widely separated and very episodic human visits to the cave.

Chronology of the Succession

The palimpsest *cum* disturbance model is also the only interpretation of G1 that can accommodate without any form of special pleading the actual dating results available for the Vindija sequence itself (Wild et al. 2001) (Table 3). Where G1 is concerned, the earliest date is that of 46,800/ +2300/–1800 ^{14}C BP (VERA-1428) (c. 50.4 ka cal BP), obtained for a cave bear bone. A second cave bear bone yielded a date of 33,000±400 ^{14}C BP (c. 37.3 ka cal BP), and the U-Th ages obtained for two other samples were c. 27.9 and 33.1 ka cal BP. Even if the latter are rejected due to the issues of uncertainty concerning uptake assumptions discussed by Wild et al., the two radiocarbon results confirm that the contents of G1 do sample an extended period of time—in fact, broadly the same ten millennia obtained when, as in the preceding section, the level's formation process is assessed on the basis of chronological estimates derived from cultural-stratigraphic patterns of regional and continental validity.

Moreover, since the G1 deposits are 8–20 cm thick only, both the relative and the absolute chronological timescales further imply a sedimentation rate in the range of 5–15 mm per thousand years. This is five to fifteen times less than can be estimated for the site's Upper Pleistocene succession as a whole (levels D–K): being c. 7.25 m thick, it accumulated at an overall rate of some 72.5 mm per thousand years. Such a slowdown of sedimentation rates at the F/G interface perfectly fits the expectations of the palimpsest *cum* disturbance model.

Immediately underlying G1, level G3 is 10–20 cm thick and is dated by two AMS results on samples of Neandertal bones (Krings et al. 2000; Serre et al. 2004). One is a minimum age only: >42 ka ^{14}C BP (Ua-13873) (>45 ka cal BP). The other is a finite result of 38,310±2130 ^{14}C BP (Ua-19009) (c. 42.3 ka cal BP); given its large standard deviation, this date probably is simply a minimum age too. Combined, the results indicate a chronology securely in excess of 42 ka cal BP for the deposition of G3, in good agreement with the U-Th result of c. 41 ka cal BP obtained for a cave bear bone from that level.

While fully consistent with the palimpsest interpretation for G1, the chronology of the G3 deposit further leaves open the possibility that a marked hiatus existed at the interface between G1 and G3, implying significant erosion and, possibly, redeposition. Such a hiatus would provide yet another conceivable explanation, via the presence in G1 of

Table 3 Radiometric dates for the Transition in Croatia and Slovenia, after Karavanić (1995, 2003), Turk et al. (1997), Smith et al. (1999), Krings et al. (2000), Wild et al. (2001), Rabeder and Pohar (2004), Serre et al. (2004) and Higham et al. (2006a). Calibration uses the 2007 Hulu version of the CalPal software (Weninger and Jöris 2004). Following Zilhão and d'Errico (1999) and Wild et al. (2001), conventional dates on bone were excluded

Country	Site	Level	Culture	Material	Method	Lab no.	Age ^{14}C BP	Age cal BP	cal BP 2σ range
Croatia	Sandalja II	G	Aurignacian II	Charcoal	^{14}C	Z-536	27,800±800	32,500±690	31,120–33,880
	Velika Pećina	G	Aurignacian II	Charcoal	^{14}C	Z-189	27,300±1200	31,940±1120	29,700–34,180
		I	Aurignacian I	Charcoal	^{14}C	GrN-4979	33,850±520	38,930±1480	35,970–41,890
		J	Intrusive	Modern human frontal	AMS ^{14}C	OxA-8294	5045±40	–	–
	Vindija	F	Aurignacian II and/or III/IV	Charcoal	^{14}C	Z-612	24,000±3300	28,050±3470	21,110–34,990
		F		Charcoal	^{14}C	Z-613	29,700±2000	34,360±1990	30,380–38,340
		F/d, or F/d-F/d/d		Charcoal	^{14}C	Z-551	27,000±600	31,630±540	30,550–32,710
		G1	Mixed	Cave bear bone	U-Th	–	–	27,900±1000	25,900–29,900
				Cave bear bone	U-Th	–	–	33,100±800	31,500–34,700
				Cave bear bone	AMS ^{14}C	ETH-12714	33,000±400	37,300±820	35,660–38,940
				Cave bear bone	AMS ^{14}C	VERA-1428	46,800/+2300/–1800	50,390±2700	44,990–55,790
				Neandertal parietal (Vi-208)	AMS ^{14}C	OxA-8295	28020±360	32,540±370	31,800–33,280
					AMS ^{14}C	OxA-X-2089-07	32,400±1800	37,360±2240	32,880–41,840
				Neandertal mandible (Vi-207)	AMS ^{14}C	OxA-8296	29,080±400	33,500±430	32,640–34,360
					AMS ^{14}C	OxA-X-2089-06	32,400±800	36,860±1150	34,560–39,160
		G3	Mousterian	Cave bear bone	U-Th	–	–	41,000/+1000/–900	39,100–42,900

Table 3 (continued)

Country	Site	Level	Culture	Material	Method	Lab no.	Age ^{14}C BP	Age cal BP	cal BP 2σ range
				Neandertal bone (Vi-80/33.16) (a)	AMS ^{14}C	Ua-19009	38,310±2130	42,340±1770	38,800–45,880
				Neandertal bone (Vi-75-G3/h-203)	AMS ^{14}C	Ua-13873	>42,000	>45,000	–
		H/I	Mousterian	Cave bear bone	U-Th	–	–	88,200±2300	83,600–92,800
		I	Mousterian	Cave bear bone	AMS ^{14}C	VERA-0109	37,000±600	–	–
		J	Mousterian	Cave bear bone	AMS ^{14}C	VERA-0105	34,700±500	–	–
Slovenia	Divje Babe I	2	Aurignacian I	Bone	AMS ^{14}C	RIDDL-734	35,300±700	40,210±1020	38,170–42,250
	Potočka Zijalka	Layer 5, NW sector, Brodar excavations	Aurignacian II	Bone point PZ59, #806	AMS ^{14}C	VERA-2522	30,140/+330/–310	34,370±250	33,870–34,870
				Bone point PZ54, #802	AMS ^{14}C	VERA-2521	31,080/+370/–360	35,090±370	34,350–35,830
		Layer 7, W sector, Brodar excavations	Aurignacian II	Bone point PZ128, #831a	AMS ^{14}C	VERA-2526	29,560±270	33,910±300	33,310–34,510
				Bone point PZ126, #830a	AMS ^{14}C	VERA-2525	29,740/+330/–310	34,040±300	33,440–34,640
				Bone point PZ121	AMS ^{14}C	VERA-2524	29,760/+330/–310	34,060±290	33,480–34,640
				Bone point PZ112, #847	AMS ^{14}C	VERA-2523	31,490/+350/–340	35,370±390	34,590–36,150

(a) The bone is a piece of human tibia originally put in the fauna. The label Vi-80 was written on the bone to identify the level and area from which it came, and it still bears this label. When the bone was recognized as human, it was given the hominid catalog number Vi-33.16 (Hawks, personal communication) material derived from G3, for the mix of items with very different chronology that characterizes the G1 bone and stone tool assemblage. In a hiatus scenario, one might think, for instance, that the split-based bone point was in situ, while the Szeletian foliate (plus the cave bear bone dated to c. 50.4 ka cal BP) derived from G3, and, as in the palimpsest scenario, the fragments of Mladeč points intruded from Fd or Fd/d.

The chronometric evidence, therefore, concurs with the typological indications in favoring "palimpsest *cum* post-depositional disturbance" and "hiatus with erosion and redeposition" views of level G1, or any combination of the two. Whichever model is preferred, it is in any case clear that such ordinary site formation processes need to be rejected before cultural factors (such as the putative Olschewian) can be accepted for consideration as a viable explanation for the anomalous find association that characterizes the level.

Where the chronology of the E and F complexes is concerned, Karavanić (1994, 1995) and Janković et al. (2006) propose a Gravettian to Late Gravettian age on the basis of their stratigraphic position (between Aurignacian and Epigravettian) and of a date for level E of 18,500±300 ^{14}C BP (Z-2447). However, the latter is a conventional result on bone that must be a minimum age only, as are all the other conventional bone results for the Pleistocene succession of the site, which appear systematically rejuvenated by comparison with those obtained for the same levels by AMS ^{14}C or U-series methods. On the other hand, all the bone points from the different E-F levels (Fd/d, F/d, Fd/s, Fs, Fg and E) feature shapes and cross-sections that fall fully within the range documented in the large, chronologically homogeneous collection from the Potočka Zijalka, indicating that they all belong to the Mladeč type (Fig. 6). Such an exclusive representation, combined with the lack of any stone tools that can be considered either as exclusive of the Gravettian or as incompatible with the Aurignacian, suggests that these E-F deposits in fact date to Aurignacian times in their entirety.

The relative abundance of burins reported by Karavanić (1994, 1995) for the retouched pieces found in E and F replicates the pattern observed in the few well-described post-Aurignacian II lithic assemblages of western Europe, better examplified by level 6 of the Abri Pataud (Chiotti 1999), assigned to the Aurignacian III/IV. At Vindija, attribution of the E-F assemblages to such latest manifestations of the technocomplex is fully consistent with the conventional charcoal dates obtained for associated samples (Table 3). The large standard deviations indicate that the results may simply represent minimum ages; but even so, at the 95% confidence level, there is significant overlap with the chronological range of that latest Aurignacian (c. 28–30 ka ^{14}C BP, i.e., c. 32.5–34.2 ka cal BP).

The chronostratigraphic reassignment of the E-F units implies that the succession features a significant hiatus at the Aurignacian/Epigravettian interface, with no preservation at the site of deposits dating to the Last Glacial Maximum (LGM). Whether this pattern denotes that sediments ceased to accumulate at Vindija as the LGM approached, or that pre-Epigravettian erosive processes removed any deposits accumulated during the Gravettian, is something that remains to be clarified. The significant cryoturbation features reported by Karavanić (1995) for level E, however, are in all likelihood of LGM age, suggesting that we are dealing with a sedimentation hiatus indeed.

A rapid accumulation of sediments during Aurignacian II and later Aurignacian times, leading to the formation of rather thick deposits, rich in cave bear bones and containing traces of human incursions, followed by a hiatus and by erosion and redeposition at the time of the LGM, is exactly what we have at the Potočka Zijalka (Rabeder and Pohar 2004, 243), and one would expect to see the same pattern replicated at nearby sites in a similar setting. The regional evidence thus corroborates that the Vindija succession should not be seen as a continuous record, and that the formation processes proposed here for level G1 are in no way exceptional.

Age of the G1 Neandertals

A separate but related issue is that raised by the presence of Neandertal remains in G1. Their direct dating initially suggested a surprisingly recent chronology, in the range of c. 28–29 ka ^{14}C BP (c. 32.5–33.5 ka cal BP; Smith et al. 1999). Such an age could conceivably support the reality of the Olschewian

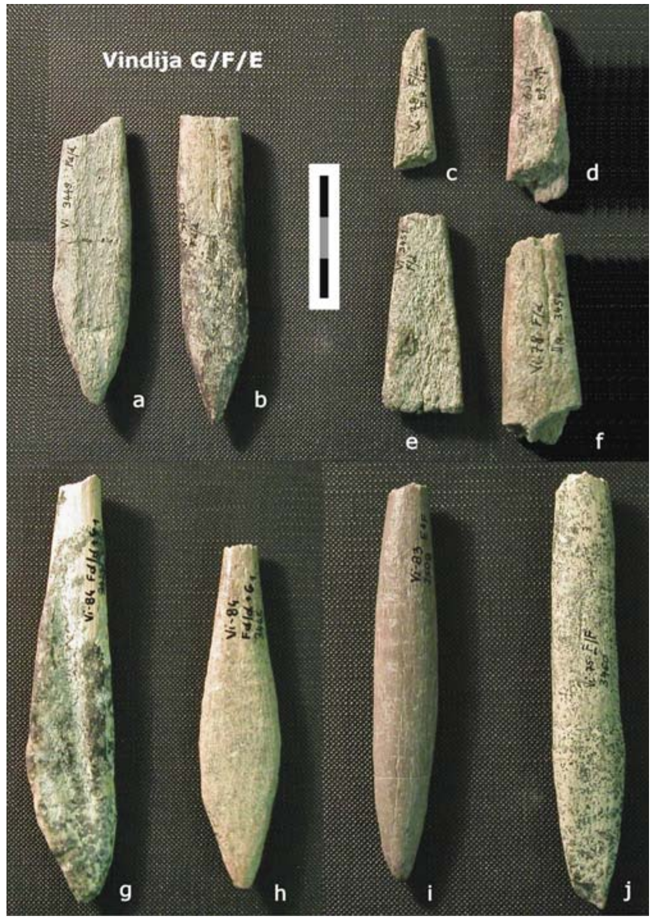

Fig. 6 Mladeč points from the E, F, and G units, as well as from contact or mixed levels at the E/F and F/G interfaces (cf. Table 2): **a**. Vi-3449; **b**. 3450; **c**. Vi-3453; **d**. Vi-3452; **e**. Vi-3451; **f**. Vi-3454; **g**. Vi-3446; **h**. Vi-3445; **i**. Vi-2508; **j**.Vi-3460.

and of its specific combination of split-based bone and bifacial foliate lithic points. For instance, assigning a Neandertal authorship to the technocomplex, one might speculate, following Svoboda's (2001, 2005) line of reasoning, that the Olschewian represented the incorporation into a long-standing Neandertal stone-tool tradition (e.g., the Szeletian) of innovations (the different types of bone points) acquired via independent development or via diffusion from, or exchange with, neighboring modern human populations. Alternatively, if the Olschewian model is rejected, palimpsest views of G1 are accepted, and the fact is duly considered that the very recent results for the G1 Neandertals postdate by one or two millennia the most recent direct date for the Mladeč points of the Potočka Zijalka, then such results might be taken instead to indicate a Neandertal (Late Szeletian?) reoccupation of the site (and the region?) during a brief time period between the Aurignacian II and the Gravettian.

The recent revision of the age of the two G1 Neandertal samples to c. 32.4 ka ^{14}C BP (c. 37.1 ka cal BP) (Higham et al. 2006a) means that such speculations can no longer be entertained, while at the same time opening up a new possibility: since the revised age falls within the time range of the Aurignacian I, the level legitimately can be viewed, even in the framework of a palimpsest interpretation, as sufficient evidence that the split-based bone point found therein (and, conceivably, the regional Aurignacian I as a whole) was manufactured by anatomically Neandertal populations. Where issues of formation process are concerned, however, the new age estimates do not change the fact that the G1 Neandertals would still be of a very different chronology from that of the associated Mladeč bone and Szeletian lithic points. Put another way: if correct, they simply provide additional corroboration of the notion that the level features a mix of finds of rather disparate age and therefore that, where Vindija G1 is concerned, co-occurrence is no sufficient proof of contemporaneity.

In all probability, however, these revised dates are still underestimated, as Higham et al. (2006a, 555) also explicitly caution: "the results should not be used to infer more than that the level G1 human remains and associated archeological debris date in the vicinity of 32,000–34,000 B.P. *and perhaps somewhat earlier*" [present author's emphasis]. Personal observation of the dated specimens (the mandible Vi-207 and the parietal Vi-208) indicates that there is good reason to be cautious indeed: the dates were obtained on very small samples—229 and 233 mg, respectively, according to Smith et al. (1999)—of cancellous bone extracted from inside the mandibular ramus and from the inner wall of the cranial fragment. The nature of the material, and the fact that the specimens were coated with consolidants, make it only reasonable to suspect that even the older results reported by Higham et al. (2006a) may well be no more than minimum ages. This inference is supported by Wild et al.'s (2005) report of rejuvenated results for human long bones from Mladeč that had been consolidated, yielding dates that are several thousands of years younger than those obtained on noncontaminated collagen extracted from the dentine of human teeth from the same collection.

The fact that the radiocarbon dating of bone samples from Vindija is a technically challenging issue is further corroborated by the fact that Smith et al. (1999) report only two successful determinations out of the seven Vindija samples that they took. The failed ones include two other Neandertal specimens, and all three bone points sampled, including the split-based piece from G1. Wild et al. (2001) encountered the same problem with attempts at dating cave bear bones from this level. Based on the determination of their nitrogen content, only one out of eleven, that which yielded the c. 50.4 ka cal BP result, was found suitable for analysis. That even bones so judged may in fact yield minimum ages only is further proven by the fact that, given the overall site stratigraphic patterns, the 37,000±600 ^{14}C BP (VERA-0109) and 34,700±500 ^{14}C BP (VERA-0105) results obtained, respectively, for cave bear bones from levels I and J, much deeper in the sequence, are vast underestimations of their true age, as cautioned by Wild et al. (2001) and confirmed by their U-Th dating of a cave bear bone sample at the H/I interface to c. 88.2 ka cal BP. These I and J results illustrate well the potentially problematic nature of the radiocarbon dating of bone in this time range (Zilhão and d'Errico 1999b; Jöris et al. 2003), particularly prior to the recent development of the ultrafiltration technique (Higham et al. 2006b).

Discussion

In this context, one is thus forced to ask the key question concerning the samples from levels G1 and G3 of Vindija that supporters of the validity of the direct dates obtained on the site's Neandertals have so far failed to address: how can one explain a success rate of 67% for the dated human bones (four out of six: two out of the four submitted to Oxford, plus two out of the two submitted to Uppsala), compared to 9% (one out of eleven) for the cave bear bone dated at Vienna, and 0% (zero out of three) for the bone tools whose dating Oxford also attempted? Taken at face value, such success rates would lead us to believe that small samples of cancellous bone from human remains treated with consolidants are a better dating material than larger samples of compact, cortical bone from cave bear remains, when, obviously, the opposite must be true. Thus, the null hypothesis in this case can only be that the finite results reported for the Vindija Neandertals reflect a residual presence of contaminants in the dated samples, not their true radiocarbon age.

Direct dating problems such as those encountered at Vindija are in no way exceptional for human remains from the Transition, and affect as well, for instance, the chronology of the Neandertal infant skeleton from the cave of Mezmaiskaya, in the northern Caucasus. Directly dated to c. 29 ka ^{14}C BP (Ovchinnikov et al. 2000), this skeleton was found below intact Mousterian deposits with an age clearly in excess of c. 36 ka ^{14}C BP, as established by several reliable radiocarbon results (Golovanova et al. 1999), and as independently corroborated by ESR dating of animal teeth from the same levels (Skinner et al. 2005). A further and perhaps more pertinent example from a geographically closer region is the failure, after three attempts, in obtaining a finite date from samples collected, as with Vi-208, from the inner side of a human parietal—in this case, the Romanian cranium Oase 2, otherwise contextually dated to c. 35 ka ^{14}C BP (c. 39.9 ka cal BP) (Rougier et al. 2007).

Although completely sorting out the situation at Vindija is clearly a difficult task, and the real age of the Neandertal material in G1 remains an open issue, it can at least be concluded that the evidence does not support the notion of "Olschewian" Neandertals living in Croatia until c. 33–28 ka ^{14}C BP (c. 37.3–32.5 ka cal BP). The arguments presented above show that the data in fact easily fit the normal central European patterns of (1) Mousterian and Szeletian Neandertals inhabiting the site prior to c. 43 ka cal BP, and (2) the split-based bone points characteristic of the Early Aurignacian being stratigraphically and chronometrically earlier than the Mladeč bone points characteristic of the Evolved Aurignacian.

The interpretation of the Vindija sequence presented here is also in complete agreement with the stratigraphic patterns displayed by the three other cave sequences with Aurignacian I material known in Croatia and Slovenia, all of which neatly fit into the overall regional and continental chronostratigraphy of the Transition. At the Šandalja II cave, on the Adriatic coast, basal layer H yielded a split-based bone point associated with undiagnostic lithic elements; and the overlying layer G, featuring a small lithic assemblage with atypical carinated scrapers and a pierced tooth pendant, yielded a conventional charcoal date of 27,800±800 ^{14}C BP (Z-536) (Karavanić 2003). At c. 32.5 ka cal BP, this charcoal date is fully consistent with the *terminus ante quem* provided by the results obtained on similar samples for the Vindija F complex. At Velika Pećina (where the modern human partial frontal bone in Aurignacian level J was shown to be intrusive through direct radiocarbon dating to the mid-Holocene; Smith et al. [1999]), split-based bone points were recovered in levels H and I, the latter conventionally dated on charcoal to 33,850±520 ^{14}C BP (GrN-4979), i.e., c. 38.9 ka cal BP. Conversely, no such items were present in overlying levels F and G, which feature other types of bone points and for which a conventional date on charcoal—27,300±1200 ^{14}C BP (Z-189), i.e., c. 31.9 ka cal BP—is available for level G (Karavanić 1995). And finally, at the Slovenian site of Divje Babe I, the split-based bone point comes from level 2, AMS dated on bone to 35,300±700 ^{14}C BP (RIDDL-734), i.e., c. 40.2 ka cal BP.

The lack of diagnostic human remains in association with Protoaurignacian and Aurignacian I assemblages makes it impossible completely to reject the notion that the Aurignacian I occupation of Vindija signaled by the split-based point from G1 is related to Neandertals. However, despite their purely paleontological context, the human fossils from the cave of Oase, in the Romanian Banat, prove that modern humans were present in the region during the time range of concern here. In fact, as the crow flies, the distance between Oase and Vindija is less than 500 km, with the two sites being found at broadly the same latitude in the eastern and western boundaries, respectively, of a vast expanse of unimpeded plains where the Danube and its tributaries provide easy communication routes between the foothills of the Alps (where Vindija is located) and the foothills of the southwestern Carpathians (where Oase is located; Fig. 1).

Given this geographical setting, it is difficult to support the notion that some sort of long-lasting, stable biocultural frontier—such as, for instance, the "Ebro frontier" of Iberia (Zilhão 1993, 2006)—existed between western Romania and eastern Croatia at the time of the Transition, making for separate demographical and human biological regional trajectories throughout the interval of the putative frontier's duration. Moreover, there is no indication in the paleonvironmental records that such a frontier ever existed at the purely biogeographical, noncultural level. Finally, for supporters of the Olschewian concept, a further obstacle to any frontier hypotheses is the fact that Oase falls squarely within the postulated geographic range of the entity—"around the Alps and Carpathians" (Karavanić 2000, 159).

Conclusion

Under the assumptions of the Assimilation model (Smith et al. 2005; Trinkaus 2005, 2007), the few Neandertal features apparent in the Oase individuals (Trinkaus et al. 2003; Rougier et al. 2007) carry the implication that, in eastern and central Europe, the absorption of European Neandertals into the larger modern human gene pool was already far advanced in Aurignacian I times, thus making it unlikely that diagnostically Neandertal populations, such as those represented by the Vindija G1 fossils, survived at that time anywhere in this part of the world. Put another way, if you accept the premises of that model, then you cannot have, in the same space (the Pannonian basin) and at the same time (34 ka ^{14}C BP; 39 ka cal BP), "moderns with Neandertal traits" at Oase and "pure Neandertals" at Vindija. If the model is right, the Vindija fossils must be of an earlier age; if the Oase and Vindija fossils are of the same age, the model is falsified, and the rival view of replacement after long-term contemporaneity is strengthened. One cannot have both the model and the dates.

Given the regional archeological context and the site formation and dating arguments reviewed here, the parsimonious reading of the Vindija situation is that the artifact assemblage from level G1 corresponds to a mix of items discarded at the site in the framework of (1) Neandertal-related Szeletian occupation(s) taking place during the 40–50 ka cal BP interval, and (2) modern human-related Aurignacian I and Aurignacian II occupations taking place during the 30–40 ka cal BP interval. Bearing in mind the uncertainties concerning the direct dating of the Vindija Neandertals, a corollary of these conclusions is that the fossils in question represent the makers of the site's Szeletian, not those of the site's Aurignacian. These conclusions are fully consistent with the paleontological arguments suggesting admixture at the time of Neandertal/modern human contact in eastern Europe, arguments derived from the analysis of the c. 40,000-calendar-year-old Oase fossils. The Vindija evidence is thus effectively reconciled with the Assimilation model.

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The Bükk Mountain Szeletian: Old and New Views on “Transitional” Material from the Eponymous Site of the Szeletian

Brian Adams

Abstract The Szeletian refers to Central and Eastern European artifact assemblages that have been interpreted as “transitional” phenomena between the Middle and Upper Palaeolithic. The term Szeletian derives from material found at Szeleta Cave in the Bükk Mountains of northern Hungary. A reconsideration of the criteria employed to justify the classification of this material as “transitional” is presented together with the impact of recent research on the transitional argument. The impact of these investigations on the meaning of the term “Szeletian” is discussed, as is the legitimacy of the term with regard to hypothesized “transitional” industries in the region.

Keywords Szeleta Cave • Szeletian • Aurignacian • Bükk Mountains

Introduction

The Central and Eastern European archaeological literature is rich with intricate models of the evolution of various Middle Palaeolithic cultures into Upper Palaeolithic cultures (e.g., Adams 2000; Anikovich 1992; Allsworth-Jones 1986, 1990; Dobosi 1989; Cohen and Stepanchuk 1999; Gladilin 1989; Gladilin and Demidenko 1989; Kozowski 1988, 1992, 2003; Mellars 1992; Oliva 1991; Orschiedt and Weniger 2000; Ringer 1983, 1988, 1990; Simán 1996; Svoboda and Simán 1989; Vértes 1956; Zilhão and d’Errico 2003). These works commonly present detailed lists of sites and cultures which are compared and contrasted, primarily on the basis of detailed lithic tool inventories. Elaborate scenarios of cultural evolution consisting of hypothesized “transitional” cultures are often accepted uncritically by western scholars with no evaluation of the data used to create such models (Klein 2001; Stringer 2002). Critical evaluation of material presented as “transitional” is necessary to assess models of cultural evolution.

In this paper, one such “transitional” culture, the Szeletian, will be examined in detail in order to understand why this material has been interpreted as “transitional” between the Middle and Upper Palaeolithic in Central and Eastern Europe. In addition, data derived from recent excavations at the type site of Szeleta Cave are presented, and its impact on the interpretation of the Szeletian is discussed.

Szeleta Cave and the Szeletian

Since its discovery, various hypotheses have been advanced to explain the material from Szeleta Cave, and space permits only a very brief summary and critique of the various interpretations of this material. Hungarian and western archaeologists have proposed that the material supports models of both in situ evolution from local Middle Palaeolithic roots and abrupt discontinuity between the Middle and early Upper Palaeolithic (Dobosi

B. Adams (✉)
Department of Anthropology, University of Illinois, Urbana, IL, USA

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1989; Ringer 1989, 1990; Svoboda and Simán 1989; Vértes 1959, 1968). Allsworth-Jones (1986) has presented the acculturation model, arguing that the Szeletian is the result of contact between indigenous Neanderthals and immigrating "Aurignacian" populations of modern humans, and this model has been widely accepted (Kozowski 1988, 1992; Mellars 1992). Based on typological comparison between Szeleta Cave and surface collections from nearby open-air sites, Ringer (1988, 1989, 1990) has argued for the in situ evolution of the Szeletian from a local variant of the Middle Palaeolithic Micoquian, commencing during the last interglacial at the earliest. Major shortcomings of these models include overreliance on the presence/absence of certain lithic tool types, particularly bifaces, with inferred chronological significance; poorly defined and dated Middle Palaeolithic industries; and extremely low population densities that would have made contact unlikely between populations of Neanderthals and immigrating groups (Ambrose 1989; Bar Yosef 1988, 1992, 1995; Butzer 1982; Gamble 1983; Hassan 1978; Klein 1989; Mellars 1996, 1998; Rolland 1990; Stringer and Gamble 1992). Of all these shortcomings, it is the primacy of a "normative" approach to culture heavily reliant on "type fossils" which accounts for the poor or limited explanatory value of the models (Dunnell 1978; Gamble 1986; Sackett 1968, 1981). At the same time, potentially significant factors, such as the impact of various site formation processes, are rarely if ever included in discussions of the material from Szeleta Cave.

It is suggested here that both the acculturation and in situ models of the Szeletian are based on weak, tenuous, and unreliable data. As will be discussed below, a set of radiocarbon dates secured in the 1960s seemed to indicate that the material from Szeleta Cave spanned a period between about 43,000 and 32,000 years ago, potentially placing the site in the period spanning the late Middle Palaeolithic and early Upper Palaeolithic, contemporaneous with the presence of both Neanderthals and modern humans in the region. A set of new dates suggests that this early age is likely incorrect and requires a reevaluation of the concept of the Szeletian as a transitional phenomenon.

The Szeletian industry is named after Szeleta Cave in the Bükk Mountains of northeast Hungary, where extensive excavations were conducted by Kadić and Hillebrand between 1906 and 1913, with more limited and sporadic excavations conducted between 1928 and 1967 (Hillebrand 1910; Kadić 1916, 1934; Mottl 1945; Sáad and Nemeskéri 1955; Vértes 1959a, 1968). Kadić (1916) recognized a sequence of seven stratigraphic layers at this site, and Palaeolithic artifacts were recovered from layers 2–6, while the lowest layer (1) was archaeologically sterile (Fig. 1). The uppermost layer (7) is a black humus dating to the Holocene and associated with Neolithic, Bronze Age, and Iron Age artifacts. Layers 3–6 produced artifacts now classified as "Szeletian," while Layer 2 produced a nondiagnostic assemblage of 27 artifacts that might be Middle Paleolithic (Allsworth-Jones 1986; Ringer 1989).

Kadić divided the cave into seven parts: an "entrance," "entrance hall," "main hall" (front), "main hall" (rear), "side corridor" (front), "side corridor" (rear), and a "dripstone cave." Layers were differentiated and excavated according to geological, palaeontological, and archaeological criteria, and in 50 cm spits (niveaux). A serious obstacle to understanding the Szeleta Cave assemblage stems from the subsequent combing of material from Kadić's stratigraphic levels/niveaux into larger units. Currently artifacts are classified as "Protosolutreen" (Early Szeletian), "Hochsolutreen" (Developed Szeletian), or simply "Solutreen." This situation has serious implications for the use of such combined or "collapsed" assemblages to define archaeological cultures or industries with implied temporal and regional significance (Simán 1990; Svoboda and Simán 1989).

Palaeolithic material from Szeleta Cave was derived primarily from Kadić's Layers 6 and 3. In a summary table, Kadić (1916, 241) correlates Layer 6 with niveaux I, II and III, and Layer 3 with niveaux III through VIII in the cave entrance and main corridor, suggesting a degree of overlap in niveau III. However, in the description of strata presented in the text, Kadić (1916, 216) associates niveau III with Layer 4, a 50 cm thick layer of "dark gray cave loam." Based on the presence of both weathered and cryoclastic *eboulis* and bone fragments, Kadić argues that niveau III represents a climatological transition from moister to drier conditions. He also suggested that Layer 4 represents a cultural transition, as this layer produced 143 lithic

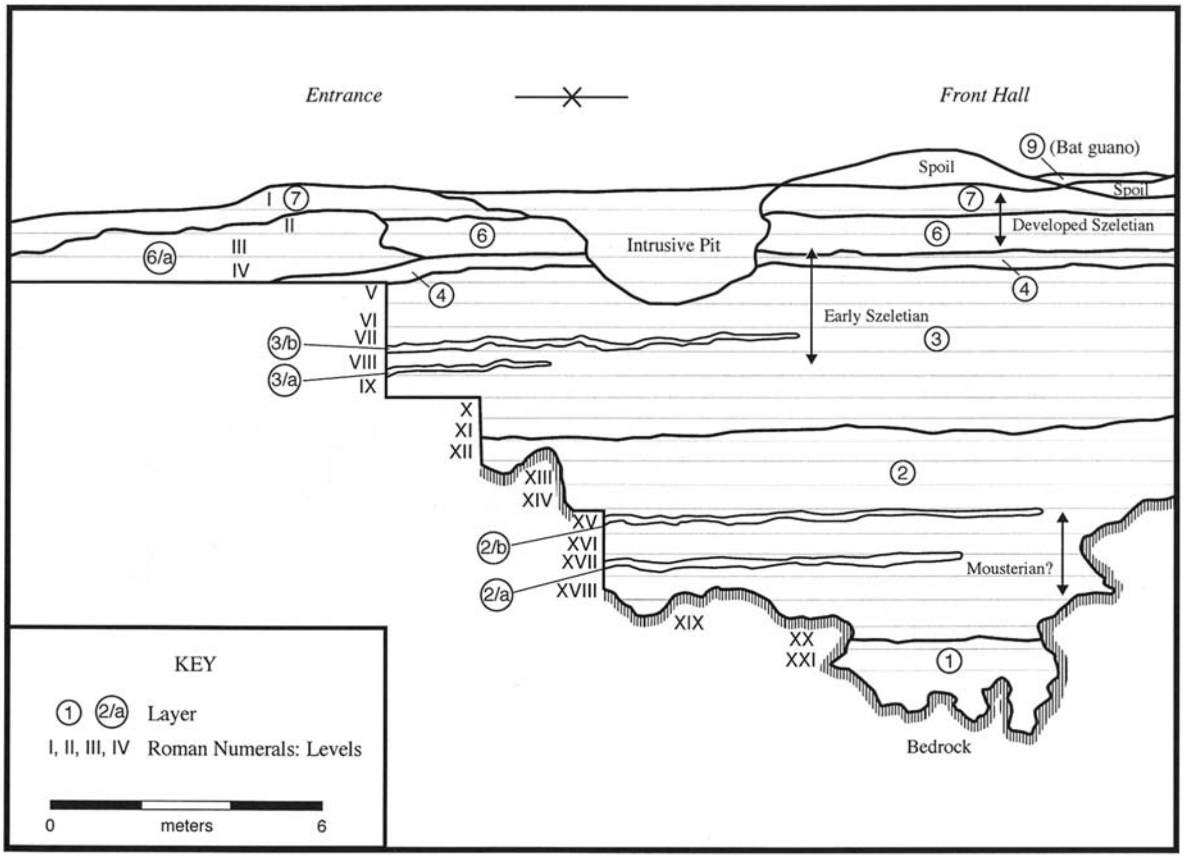

Fig. 1 Detail of Szeleta Cave stratigraphy from the entrance and front hall, showing niveaux and layers (after Kadić 1916)

artifacts, of which two are classified as "crude" leaf points, and two as "fine" leaf points (Kadić 1916, 251). Layer 5, described as a "red-brown cave loam," was documented deeper within the main hall and in the side chamber. In these areas Layer 5 is correlated with niveaux I and II. This layer, which is characterized by finely worked leaf points, was not observed in the entrance or entrance hall. In the cave entrance and entrance hall, Layer 2 is associated with niveaux IX through XIII. In this area, bedrock was reached immediately below niveau XIII.

Kadić (1916) identified two developmental phases at Szeleta as "Solutréen" based on an abundance of bifacially worked pieces. The earlier "Frühsolutréen" phase (hereafter "Early Szeletian") was primarily associated with Layer 3 and characterized by crudely flaked, asymmetrical foliates. This was considered a precursor of the "Hochsolutréen" phase (hereafter "Developed Szeletian"), which was associated primarily with Layer 6 and exhibited more finely worked, thin, symmetrical foliates. The entire assemblage reported by Kadić consists of 1,603 artifacts and is dominated by material he classified as Early Szeletian (n = 853; 53 percent). The bulk of the artifacts (n = 1,237; 77 percent) are from the cave entrance and entrance hall. Of this material, approximately 31 percent is classified as Developed Szeletian and 69 percent is Early Szeletian. The Developed Szeletian material is confined to niveaux I through III, to a depth of 1.5 m below the preexcavation cave surface. Approximately 71 percent of the Early Szeletian material from this area is derived from niveaux IV, V, and VI, from depths of 1.5–3.0 m below the preexcavation cave floor, with most artifacts from niveau VI. The base of the Early Szeletian assemblage was situated within niveau VIII, at a depth of 4.0 m below the original cave floor. Niveau VIII produced 39 lithic artifacts. Approximately 36 percent (n = 60) of the trademark Szeletian leaf points (n = 168) were recovered from the cave entrance and entrance hall. Of these, nine (15 percent) are from the Developed Szeletian niveaux and 51 (85 percent) are associated with the Early Szeletian. Kadić classified four of the Developed Szeletian leaf points as "fine" and five as "crude," while all of the points from the Early Szeletian were classified as crude. Of all the leaf points recovered from the site, Kadić classified 58 (40 percent) as "fine." The bulk of these (60 percent) were found in niveau I of the main chamber. In summary, most of the finely worked Szeletian leaf points were recovered from niveau I in the main chamber, while most of the cruder points were found in the cave entrance and entrance hall in association with the Early Szeletian. Subsequent work at the site resulted in the discovery of three Aurignacian split-based bone points (Allsworth-Jones 1978; Sáad and Nemeskéri 1955). One of these points was found in the entrance hall between 2.2 and 3.5 m below the cave floor (niveaux IV–VII), well within Kadić's Layer 3 (Early Szeletian).

This review of the palaeolithic record from Szeleta Cave emphasizes an important aspect of the collection that is neglected or ignored by many prehistorians: the "Szeletian" in fact consists of three distinct assemblages. This point was made in a brief but illuminating article by Simán, who sees no "genetical" link between the lower and upper complexes and poses the questions "What is Szeletian?" and "Which Szeletian is the real Szeletian?" (1990). The summary presented above indicates that palaeolithic material classified as Early, "transitional" (Layer 4/niveaux III), and Developed Szeletian is derived from three to four meters of cave deposits (niveaux I–VIII). Despite this, models of general cultural evolution from the Middle to Upper Palaeolithic commonly lump all this material together as "Szeletian," without any discussion or consideration of the variability between the differing stratigraphic units (e.g., Klein 2001; Kozowski 1988, 1992; Mellars 1992; Stringer 2002). A notable exception is Simán (1990) who considers the upper and lower complexes different and attributes the shared attribute of bifacial leaf points to "... formal and functional similarities and not cultural ones" (Simán 1990, 192). Indeed, the repeated appearance of bifacial technology around the world at different times need not imply evolutionary connections or direct contact between human groups; such technological similarity is undoubtedly the result of convergence (Otte 2003).

A Reexamination of the Szeleta Cave Material

Reanalysis of the Szeleta Cave material in the Hungarian National Museum (Budapest) and the Herman Ottó Museum (Miskolc) permits a brief summary of the Szeleta Cave assemblages as they currently exist (Adams 1998). The analyzed material consists of 702 retouched tools, debitage, and lithic chunks/blocks from the lower assemblage, and 385 artifacts from the upper assemblage. Approximately 200 artifacts could not be assigned to either the upper or lower assemblage and are not discussed here. Debitage from the Early Szeletian assemblage is dominated by flakes followed by blades (Table 1). Of the 22 cores identified in this

Table 1 Assemblage from Szeleta Cave, lower levels

Type	Count
Flake debitage	480
Blade debitage	67
Leaf points	65
Retouched blade	5
Retouched flake	4
End scraper	5
Burin on truncation	1
Double burin	1
Single burin	1
Ordinary denticulate	2
Unifaces	1
Retouched bladelet	1
Single side scraper	1
Truncation	1
Pyramidal blade core	6
Flake cores	6
Disk core	3
Bladelet core	1
Core fragments	6
Amorphous chunks	33
Blocks, pebbles	6
Bipolar pieces	6
Total	702

unit, flake and pyramidal blade types predominate. Of 93 preserved platforms, 82 percent are plain, unfaceted types. Platform faceting was only observed on nine artifacts, and no evidence of the Levallois reduction technique was observed. Retouched tools from the lower assemblage are dominated by foliates, followed by retouched blades/bladelets, end scrapers, retouched flakes, burins, and denticulates. In addition, the three split-based bone points cited above are associated with the lower assemblage.

Material now classified as "Developed Szeletian" consists of 310 pieces of debitage, of which approximately 67 percent are flakes/flake fragments and 33 percent blades/blade fragments (Table 2). Pyramidal blade cores are the most common core type in the upper assemblage, followed by flake cores. Out of 85 intact platforms, 68 percent are plain types, with faceting on 14 percent, and as with the lower unit, no evidence of the Levallois technique was observed. Two core tablets and three crest blades from this unit indicate that blade core reduction and rejuvenation occurred in the upper layers. Retouched tools are again dominated by bifacial foliate artifacts. The nonbifacial assemblage is dominated by retouched blades and bladelets, followed by burins, end scrapers, and convergent scrapers. Foliates represent about 47 percent of the retouched tool assemblage, although this figure represents only 42 percent of the total number of foliates found by Kadić, who records 66 such artifacts from the upper layers (Kadić 1916, 241).

Table 2 Assemblage from Szeleta Cave, upper levels

Type	Count
Flake debitage	207
Blade debitage	103
Leaf points	24
Retouched blade	4
Convergent side scraper (blade)	3
End scraper	3
Double burin (blade)	2
Single burin (blade)	2
Ordinary denticulate	1
Multiple burin (blade)	1
Aurignacian blade	1
Combined tool (scraper/piercer)	1
Side scraper (flake)	2
Backed blade	1
Pyramidal blade core	4
Exhausted core	3
Blade core fragment	1
Flake core fragment	2
Bladelet core	2
Miscellaneous core fragments	2
"Precore"	1
Core tablett	2
Crest blades	3
Amorphous chunks	9
Bipolar pieces	1
Total	385

Based on these data, the Szeletian material as a whole can be defined as a non-Levallois industry dominated by the production of bifacial tools and retouched blades/bladelets. Other common tools types are end scrapers and burins. The primary difference between the Early and Developed Szeletian material is the dominance of "crude" foliates in the former and more "refined" foliates in the latter.

The question of whether the biface-bearing assemblages from Szeleta Cave should be viewed as a single, unified phenomenon or evidence of stone tool technology actually in the process of evolving from Middle to Upper Palaeolithic entities requires a firm control of chronology at the site. A brief discussion of initial dates secured from Szeleta Cave, followed by a discussion of other sites classified as "Szeletian," is presented, followed in turn by a discussion of new radiocarbon dates from Szeleta Cave.

In the 1960s, Vértes (1968) presented dates of >41,000 bp (GXO-197) and 43,000±1,100 bp (GrN-6058) for the lower assemblage with "crude" leaf points, and 32,620±400 bp (GrN-5130) for the upper assemblage with more "refined" leaf points, and it is on the basis of these three dates alone that the material from Szeleta Cave has been dated to the Middle to Upper Palaeolithic transition in Europe. These dates are discussed in more detail below. Subsequent dates from other sites in the region classified as "Szeletian" also suggested that the material was more than c. 40,000 years old (Table 3). In addition to Szeleta Cave, there are at least three other cave sites and one open-air site in the Bükk Mountains classified as Szeletian, and since its initial recognition in Hungary, the presence of "Szeletian" sites has been claimed in Moravia and Slovakia. Although approximately 100 sites are

Table 3 Radiometric dates from Szeletian sites

Site	Culture	Date
Szeleta Cave	"Pre-Early Szeletian"	42,960±860 bp (ISGS-4464)
Szeleta Cave	Early Szeletian	>41,000 bp (GXO-197)
Szeleta Cave	Early Szeletian	43,000±1100 bp (GrN-6058)
Szeleta Cave	Early Szeletian	>25,200 bp (ISGS-4460)
Szeleta Cave	Early Szeletian	26,002±182 bp (ISGS-A-0189)
Szeleta Cave	Developed Szeletian	32,620±400 bp (GrN-5130)
Szeleta Cave	Developed Szeletian	22,107±130 bp (ISGS- AO131)
Vedrovice V	Szeletian	30,170±300 bp (GrN-17261)
Vedrovice V	Szeletian	37,650±550 bp (GrN-12374)
Vedrovice V	Szeletian	39,500±1100 bp (GrN-12375)
Vedrovice V	Szeletian	47,250 + 3,700/–2,500 bp (GrN-19106)
Čertova pec	Szeletian	38,400 + 2800/–2100 bp (GrN-2438)

attributed to the "Szeletian" in Moravia, only the open-air site of Vedrovice V has produced material in a buried context (Valoch 1993). While it is assumed that Vedrovice V supports an early date for the "Szeletian" (i.e., >37,000 kyr bp), this single component site in fact produced radiocarbon dates ranging from 30,170±300 bp (GrN-17261) to 47,250 + 3,700/–2,500 (GrN19106), a time span of approximately 17,000 years (Valoch 1993). Based on this temporal span, Vedrovice V is conceivably contemporary with the Central European Middle Palaeolithic Micoquian, the Upper Palaeolithic Gravettian, or the "Epiaurignacian." Ambiguity surrounding the available chronometric dates from Vedrovice V emphasizes the poor temporal control over the assemblage from this open-air site. In Slovakia, the cave site Čertova pec has also been cited as evidence of an early occurrence of the "Szeletian." However, it has been argued (Allsworth-Jones 1986, 127), that the undiagnostic assemblage from this site cannot be confidently classified as "Szeletian" and a purported "Szeletian leafpoint" is actually a triangular worked flake. The single radiocarbon date of 38,400 + 2,800/–2,100 bp (GrN-2438) published in 1964 (Vogel and Waterbolk 1964) has a very large standard deviation and may be unreliable, as it was derived from a very small sample. While a cursory examination of the Moravian and Slovakian data suggest an early date for the "Szeletian" in this part of Central Europe, and support similar claims for an early date (i.e., 43,000±1,100 bp [GrN-6058]) from the type site Szeleta Cave, cultural and temporal ambiguities cast serious doubt on such claims.

Results of Recent Investigations at Szeleta Cave

New radiocarbon dates derived from recent excavations at Szeleta Cave suggest that the assemblages with leaf points from this site are not as old as previously reported and span a more restricted time period (Adams and Ringer 2004). As the original, preexcavation cave floor has been marked by a "tar" line, materials derived from recent excavations can be correlated with profiles documented by Kadić. In addition, as was discussed above, Kadić (1916) prepared a detailed table summarizing the depth (niveau) of cultural materials from each section of the cave, allowing the correlation of new finds with zones now identified as Developed and Early Szeletian. The recent excavations produced much faunal material, but little in the way of cultural remains. Aside from an obsidian bladelet core, to be discussed below, the only other artifacts found consist of a few pieces of lithic debitage. This is not surprising given the low density of cultural material found in the cave by previous excavations (Adams 1998). Faunal material consists almost exclusively of cave bear remains.

A date of 22,107±130 years bp (ISGS AO131) was derived from a level correlated with Kadić's Layer 6/a and associated with the Developed Szeletian assemblage. Dates of >25,200 years bp (ISGS-4460) and 26,002 ±182 (ISGS-A-0189) were derived from layers equivalent to the upper part of Kadić's Layer 3 and his "niveau VI," well within the Early Szeletian component, and close to the location from which Vértes secured a radiocarbon date of 32,620

±400 bp in the late 1960s (Vogel and Waterbolk 1972, 62). At a depth of 2.5 m below the original cave floor an obsidian bladelet core was recovered, which in this area is a typical Upper Palaeolithic type. Kadić (1916, 295) describes and illustrates a similar obsidian core from the Developed Szeletian horizons (cave entrance 1.5 m in depth). A new date of 42,960±860 bp (ISGS-4464) was secured from the contact between the base of Kadić's Layer 3 and the top of Layer 2 (niveaus X and XI; approximately 5.0 m below the cave floor and 1.0 m *below* the Early Szeletian component). While Vértes secured a radiocarbon date of 43,000±1,100 bp from this area, the precise provenance of his sample is uncertain: Vértes claimed the sample was from within Layer 3, above the Early Szeletian material, while based on the provenience data reported in the journal *Radiocarbon* (Vogel and Waterbolk 1972), this sample falls within the underlying Layer 2, predating the Szeletian material (Allsworth-Jones 1986). If the sample was derived from within the Early Szeletian layers, it should have come from approximately 1.5 to 4.0 m below the cave floor. A second date of >41,700 bp was also secured by Vértes from Layer 3, but its precise location was not recorded. Based on the new chronometric dates secured thus far from Szeleta Cave, it is concluded that the earlier Szeletian material from this site is no older than approximately 43,000 years bp, and may not be older than ca 30,000 years bp All material classified as "Szeletian" from this site may date to between approximately 30,000 and 20,000 years bp

A New Interpretation of the Szeletian Material

Based on these new data, it is argued that the assemblages from Szeleta Cave can be viewed as a unified phenomenon, the likely product of a single population that inhabited the region during a specific time period. However, the new dates also suggest that the assemblages span a much briefer time period (i.e., approximately 10,000 years) and most likely postdate the disappearance of Neanderthals in the region. It is thus unlikely that the Szeletian is the product of interactions between indigenous Neanderthal populations and modern humans. The new dates suggest that the period of overlap between the Neanderthal and modern human presence in Central Europe was more restricted than previously believed, further suggesting a narrower window of opportunity for potential interactions between the two groups (cf. Conard and Bolus 2003). Current chronometric, ecological, and stratigraphic data indicate that Neanderthal fossils in the northern Carpathian Basin region date to about 40,000 years bp at the latest, while fossils classified as *Homo sapiens sapiens* date to around 35,000 to 30,000 years bp at the earliest (Gábori-Csánk 1992; Ringer 1990; Svoboda and Simán 1989; Svoboda et al. 1996; Valoch 1988). Based on these data, there was minimally a 5,000–10,000 year gap between the disappearance of the Neanderthals and the appearance of modern humans in this region, and the new dates presented here suggest that the assemblages from Szeleta Cave are the product of *Homo sapiens sapiens* and not Neanderthals. However, two dates of approximately 28,000 and 29,000 years bp from Croatia indicate that isolated Neanderthal populations may have continued to survive south of the Carpathian Basin, approximately 500 km south of the Hungarian Bükk Mountains (Karavanić and Smith 2000; Smith et al. 1999). In Hungary, Neanderthal fossils have been found only at Subalyuk Cave, approximately 20 km south of Szeleta Cave, associated with Mousterian lithic assemblages (Adams 1998; Bartucz et al. 1940; Pap et al. 1996; Thoma 1963). The fossils were associated with levels dated to the late last interglacial/Early Würm (Isotope Stages 5 and 4; c. 120,000–60,000 years bp).

If new chronological data and a reassessment of the typological characteristics of the Szeleta Cave lithic material suggest a "unified" Szeletian, how can the "cruder" aspect of the tools in the lower layers be accounted for? It is suggested here that variable foliate and tool morphology is the result of a combination of noncultural postdepositional processes such as cryoturbation and/or bioturbation (e.g., trampling by cave bears), as well as raw material characteristics (Allsworth-Jones 1986; Gargett 1996; McBrearty et al. 1998). A full understanding of the assemblages as they currently exist requires consideration of lithic raw materials utilized at the site. Sources of lithic raw materials utilized throughout prehistory in Hungary have been well-documented (Allsworth-Jones 1986; Adams 1998; Biró and Dobosi 1991; Dobosi 1986, 1991; Markó et al. 2003; Simán 1986, 1987; Takács-Biró 1986a, 1986b; Vértes and Tóth 1963). The Early and Developed Szeletian assemblages consist of nearly 80 and 60 percent respectively of poor- to medium-quality local raw materials (Figs. 2 and 3) (Adams 1998). Both assemblages are dominated by felsitic quartz porphyry, which tends to be of medium-quality, followed by various poor- to medium-quality hydro- and limnoquartzites. As Figs. 4 and 5 indicate, approximately 54 percent of the Early Szeletian leaf points are made from felsitic quartz porphyry, while approximately 67 percent of the Developed Szeletian points are made from this material (Kadić 1916). The mechanical properties of these local lithic raw materials are highly variable, especially with regard to homogeneity and isotropy due to imperfections such as fissures, cavities, impurities along bedding planes, fossil and crystal inclusions, etc. While felsitic quartz porphyry was used to produce many of the leaf points at Szeleta Cave, this material contains inclusions which interfere with the otherwise laminar structure that is conducive to the production of thin bifaces, causing seemingly homogenous pieces to shatter unpredictably (Simán 1986). The same is true for the hydro- and limnoquartzites, where quality of a single nodule can vary from very fine- to coarse-texture due to the presence of fossils, voids, and internal fissures. In short, the Szeleta Cave assemblages are made almost exclusively of medium- to poor-quality lithic materials that can influence the production of standardized, typical tool forms. The influence of lithic raw material on artifact form is well documented (e.g., Amick and Mauldin 1997; Andrefsky 1994; Barham 1987; Blades 2001; Dibble 1985, 1991; Hayden 1980; Kuhn 1995; Lischka 1969; Gábori-Csánk 1968; Kretzoi and Dobosi 1990; Reher and Frison 1991; Simek 1991; Straus 1978; Tieu 1991; Vértes 1964). Poor quality raw material has been suggested as a partial explanation for the rarity of Lower Palaeolithic hand axe cultures in eastern Asia and the general "simple" appearance of lithic industries in this area (Klein 1989; Schick and Toth 1993). Similarly, the use of more intractable raw material has been cited as a partial explanation for the production of crude Developed Oldowan bifaces and the contemporary, more refined early Acheulean axes in east Africa

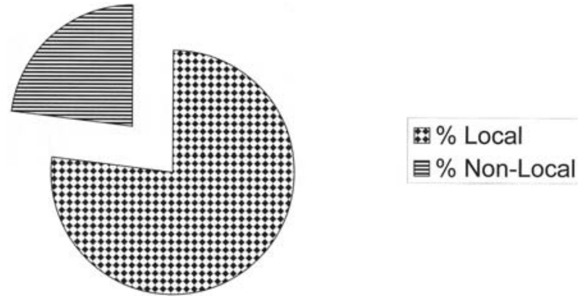

Fig. 2 Early Szeletian lithic raw material utilization

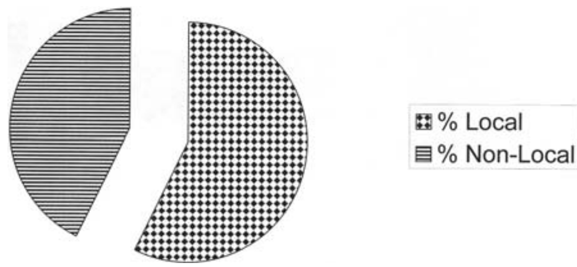

Fig. 3 Developed Szeletian lithic raw material utilization

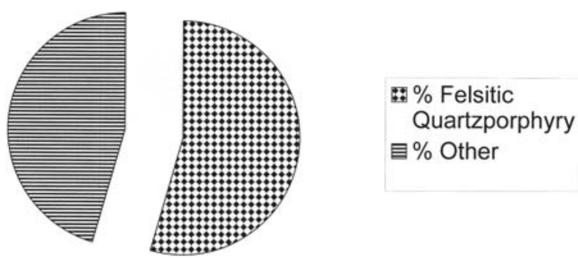

Fig. 4 Raw materials used for Early Szeletian bifaces

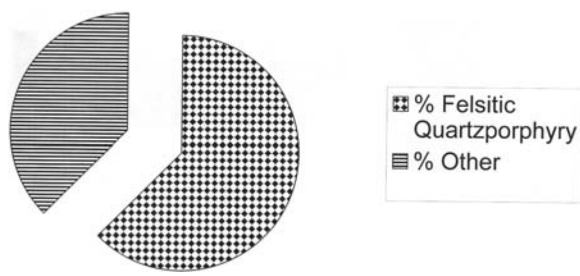

Fig. 5 Raw materials used for Developed Szeletian bifaces

(Jones 1981; Schick and Toth 1993; Stiles 1979). Others working in northern Hungary have come to similar conclusions. For example, the assemblage from Püspökhatvan in northern Hungary consists of both "archaic" and "Upper Paleolithic" elements (Csongrádi-Balogh and Dobosi 1995). "Archaic" characteristics consist of crudely fashioned bifaces and large scrapers and burins, while "Upper Paleolithic" traits consist of smaller, more refined burins, scrapers, cores, tanged fragments, and blade production. Significantly, the bifaces are described as analogous to the rough types from Szeleta Cave. The Püspökhatvan assemblage is made primarily from local hydroquartzites that exhibit "faults," plant remains, and other inclusions. While typologically this assemblage could be classified as yet another "transitional" industry like the material from Szeleta Cave, the excavators attribute the "archaic" attributes to poor raw material quality; and a C-14 date of 27,700±300 (Deb-1901) years ago puts the material within the range of the Upper Palaeolithic, close to the newly obtained dates from Szeleta Cave. It is suggested here that, like the assemblage from Püspökhatvan, the "archaic" appearance of the Szeleta Cave assemblages can be explained by poor raw material quality.

While raw material quality can help explain the occurrence of "archaic" types, the potential impact of postdepositional modification on lithic material must also be considered. Like most Central European late Pleistocene cave sites, the faunal assemblage from Szeleta consists almost exclusively of cave bear remains, followed by other large species such as brown bear and cave hyena (Kadić 1916). Unfortunately, a detailed analysis of the cave bear remains does not exist for Szeleta Cave. An approximation of the density of the cave bear occupation at Szeleta can be derived from Kadić's (1916) site report. Of the nearly 4,000 faunal remains recovered from Level 3, 99 percent consisted of cave bear. Similarly, at the nearby Early Upper Palaeolithic site of Istállóskõ Cave, cave bear remains represent 74 percent (n = 573) of the calculated minimum number of individuals represented in the faunal sample (Vörös 1984). These data indicate that Bükk Mountain cave sites were commonly occupied by cave bears as well as hominids. The weight of an adult cave bear is estimated at close to 500 kg (Kurtén 1968, 1976); and continued trampling by such animals would have undoubtedly altered the appearance and distribution of lithic artifacts on the cave floor, just as they crushed and dispersed their own remains in preparation for hibernation, as Gargett (1996) has demonstrated at Pod Hradem Cave in the Czech Republic. Recent experimental work demonstrates that human trampling can produce edge damage that is easily mistaken for deliberately retouched Middle Palaeolithic types such as notched and denticulated pieces (McBrearty et al. 1998). In two of the experimental assemblages, various notches and denticulates described in the *systèm* Bordes were produced by human trampling, and represented between 57 and 88 percent of the "tools" produced (McBrearty et al. 1998, 116). The experiments indicate that edge modification can be severe on artifacts trampled on fine-grained sediments, and suggest similar, if not more pronounced, modifications due to repeated trampling by cave bears (and other cave occupants) on artifacts deposited on cave floors with coarse, gravelly substrates, such as those at Szeleta Cave.

A Proposed Relationship Between Szeletian and Aurignacian in the Bükk Mountains

The new radiocarbon dates from Szeleta Cave, together with new dates from nearby Istállóskõ Cave, suggest that both sites are contemporary (Adams and Ringer 2004). Further, the presence of leaf points at Istállóskõ Cave and bone points at Szeleta Cave suggest that both sites were occupied by the same human groups possessing Aurignacian material culture. An important aspect of the Szeleta Cave inventory that is often overlooked is the presence of material classified as Aurignacian, including bone points (Allsworth-Jones 1978, 1986; Sáad and Nemeskéri 1955; Simán 1990; Svoboda and Simán 1989; Vértes 1961). According to Simán (1990, 192), Aurignacian material was recovered primarily from niveaux IV. This places Aurignacian and "Early Szeletian" material in the same stratigraphic levels. However, due to the "tyranny of the leaf points," Aurignacian material has always been viewed as a separate entity, and the material was never considered the product of a single human group or groups. Vértes (1957, 1961) even postulated that Aurignacian groups hunted with bone-tipped weapons alongside contemporaneous Szeletian groups using stone-tipped projectiles.

Bifacial leaf points are relatively common in Central and Eastern European Aurignacian assemblages (Hahn 1977), and two leaf points were recovered from the Aurignacian II levels at Istállóskõ Cave and one from the lower Aurignacian I levels. Leaf points derived from the Aurignacian II levels are made from felsitic quartz porphyry, the same raw material used to produce 70 percent of the foliates the author has examined from Szeleta Cave. Recent work conducted at Istállóskõ Cave produced a broken leaf point made from felsitic quartz porphyry between the Aurignacian I and II layers, dating to between 28,000 and 33,000 years bp, making it contemporary with the earlier Szeletian material in the area. Leaf points also occur at nearby east Slovakian Aurignacian sites, some of which are made from Hungarian felsitic quartz porphyry (Adams 1998). In addition to these examples, leaf points have also been documented in Aurignacian contexts in Moravia, Slovakia, Romania, and the former Soviet Union (Hahn 1977).

Artifacts made from bone, antler, and ivory represent a common component of Aurignacian assemblages, and split-base types are especially typical. In the Bükk Mountains, split-based bone points were found in the lower levels of Szeleta Cave and at the Aurignacian sites of Peskõ and Istállóskõ caves (Sáad 1929; Sáad and Nemeskéri 1955; Svoboda and Simán 1989; Vértes 1956). Such points have also been found in Szeletian contexts in west Slovakia at Pállfy Cave/Dzerava skala (Hillebrand 1913). At Istállóskõ Cave, a total of 30 bone points were recovered from the upper Aurignacian deposits while 114 were found in the lower culture level, 31 of which are split-based (Vértes 1955).

The geographical distribution of early Upper Palaeolithic sites in north Central Europe reveals a tendency for Aurignacian sites to cluster at lower elevations, while Szeletian sites are generally found at higher elevations, and it is suggested here that this pattern is the result of functional differences between the two site types. Occupation of the north Carpathian region by Aurignacian groups would have necessitated adaptations to highly varied and closely juxtaposed environments, resulting in the creation of varied archaeological signatures by a particular hunter-gatherer group. In the Bükk Mountains, Szeletian sites occur between elevations of 300 and 350 m above sea level, while in east Slovakia Aurignacian open-air sites occur between approximately 235 and 120 m above sea level (Adams 1998). Exceptions in this area are Istállóskö and Peskö caves. However, both of these sites produced rich bone, ivory, and antler point assemblages, artifacts that may have been functionally equivalent to bifacial leaf points. A similar pattern is observed in the Váh River valley of west Slovakia, and in Moravia (Ambroz et al. 1952; Svoboda 1994). Based on this evidence, it is proposed here that in the north Carpathian region of Central Europe, material classified as "Szeletian" is most parsimoniously interpreted as belonging to special purpose Aurignacian activity sites (cf. Ashton 1983). The data suggest that there is a correlation between Aurignacian and Szeletian assemblages and elevation, a pattern which might reflect seasonal movement of early Upper Paleolithic hunter-gatherers between lowlands and uplands.

What Does the Term "Szeletian" Mean, and Is It Necessary?

Based on the data presented above, the following questions arise. Is the Szeletian, as defined on the basis of material from the eponymous site of Szeleta Cave, a transitional phenomenon representing the product of cultural evolution "in action" between the Middle and Upper Palaeolithic? Or, is it the product of Upper Palaeolithic populations postdating the disappearance of Middle Palaeolithic cultures and Neanderthals? It is suggested here that the latter scenario is better supported by the new data, and it is further suggested that the Szeleta Cave material is likely the product of Aurignacian groups in the region. Central Europe is rich in Aurignacian sites, some of which represent the earliest appearance of the Upper Palaeolithic in Europe between approximately 40,000 and 30,000 years ago (Conard and Bolus 2003). In Lower Austria and Moravia, Aurignacian material has been correlated with interpleniglacial soils (Denekamp and Maisières) and is reliably dated to between 33,000 and 29,000 years bp (Svoboda et al. 1996). While some data suggest the Aurignacian is followed by the Gravettian at approximately 30,000 years bp throughout Europe, data from Moravia indicate that the two technocomplexes temporally overlapped. Here there is evidence that the Aurignacian persisted as the "Upper Aurignacian" or "Epiaurignacian," until approximately 20,000–25,000 years bp (Kozlowski 1986; Svoboda and Simán 1989; Svoboda et al. 1996). Evidence for a late manifestation of the Gravettian in the region is supported by data from Hungary, where it has been consistently dated to between approximately to 20,000 to 12,000 years bp, except at Bodrogkeresztúr, which dates to 28,700 ±3000 bp (Dobosi 1996; Gábori-Csánk 1970). More typical of Hungarian Gravettian or "Epigravettian" occupations are the sites of Ságvár, dated to between approximately 18,000 and 19,000 years bp, and Arka, dated to between about 13,000 and 17,000 years bp (Gábori-Csánk 1970; Gábori 1964; Kozlowski 1986). In east Slovakia, Aurignacian open-air sites in the Hernád River valley and the East Slovakian Lowlands have produced pit features interpreted as structures (Bánesz 1958a, 1958b, 1960, 1968; Sklenár 1975, 1976). One of these sites, Barca I, has recently produced a radiocarbon date of approximately 29,700 years bp (Verpoorte 2002). In the Bükk Mountains of Hungary, material classified as Aurignacian has been documented at Istállóskõ, Peskö, and Szeleta Caves (Vértes 1955, 1956, 1965; Svoboda and Simán 1989). At Istállóskõ Cave two complexes are recognized: Aurignacian II from the upper cultural levels and dated by Vértes to about 31,000 bp, and Aurignacian I from the lower levels with controversial dates of approximately 40,000 bp, but also a date of 31,540 ±600 bp (GrN-1501) (Vogel and Waterbolk 1963). More recent dates suggest the Aurignacian I material may date to about 33,000 years bp, while the Aurignacian II may date to approximately 28,000–32,000 years bp (Adams and Ringer 2004). Peskõ Cave, located approximately 2.5 km south of Istállóskõ Cave, produced a small assemblage of lithic and bone artifacts classified as Aurignacian and radiometrically dated to 35,200 ±670 bp (GrN-4950) (Gábori 1969, 160; Svoboda and Simán 1989, 290; Vértes 1956, 17). In summary, chronometric data from Central European early Upper Palaeolithic sites indicate that Aurignacian material, in its various forms, spans a period extending back as far as approximately 40,000 years bp until approximately 20,000 years bp.

It is suggested here that the term "Szeletian," as defined on the basis of material from the eponymous site in Hungary, in fact refers to cultural material contemporaneous with Aurignacian material in the same area. The most parsimonious interpretation of this material is that it was produced by the same Aurignacian groups responsible for the material at nearby sites such as Istállóskõ and Peskõ Caves. The information presented here indicates that the quality of regional theories of cultural evolution depends upon the quality of the data derived from the individual components (sites) from which they are constructed. In the case of the Szeletian, new radiocarbon dates and a reassessment of the assemblages from Szeleta Cave suggest that the material is younger than the hypothesized period of cultural transition from the Middle to Upper Palaeolithic, and that the so-called "archaic" (i.e., Middle Palaeolithic) traits can be explained in terms of a combination of postdepositional processes and lithic raw material factors. In short, robust models of cultural evolution during the Palaeolithic must incorporate a wide range of variables pertaining to material remains. Reliance on isolated variables, such as stone tool morphology, ignores a wide of range of potentially significant attributes that can assist in the interpretation of a particular assemblage.

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The Subsistence Behaviours of the Last Crimean Neanderthals

Marylène Patou-Mathis

Abstract Some sites that show Neanderthal persistence until 29,000 years bp were discovered in Crimea, as is the case in the south of the Iberian peninsula. This paper presents the subsistence behaviours of the last Neanderthal populations through the example of two recently excavated sites, Kabazi II and Buran Kaya III. The industries of these sites are different: a Western Crimean Mousterian industry for Kabazi II, and an industry with leaf-shaped bifacial points, called a transitional industry, for Buran Kaya III. Moreover, in Buran Kaya III, a level (dated at about 28,000 years bp) with a Crimean Micoquian industry was found just above the leaf-shaped bifacial points level. The craftsmen who elaborated the Mousterian and Micoquian industries were undoubtedly Neanderthals, but those who made the transitional industry remain unknown. From a subsistence point of view, there is a similarity in game acquisition and processing between the Mousterian level of Kabazi and the Micoquian level (level B) of Buran Kaya, but a difference with the leaf-shaped bifacial points level (level C) of Buran Kaya and the Early Aurignacian levels (Unit G) of Siuren I.

Keywords Transition Middle-Upper Palaeolithic • Subsistence • Crimea

M. Patou-Mathis (✉)
Institut de Paléontologie Humaine, Paris, France

Introduction

The Crimean peninsula, situated at the southeastern edge of Europe, is extremely rich in Middle Palaeolithic sites. Thirty-five localities along the second ridge of the Crimean Mountains are documented in this area (Fig.1). On the other hand, Upper Palaeolithic sites were found at no more than ten localities. Three sites, Kabazi II, Buran Kaya III, and Siuren I, provide chronological evidence of late Middle Palaeolithic occupations, as well as the coexistence of Middle Palaeolithic and Early Upper Palaeolithic industries, between 36,000 and 28,000 years bp (Chabaï 2001). During the Last Glacial, the Crimea was a part of a large area of the East European dry land plain, not a peninsula as today. According to Victor Chabaï (2001), the Crimean Mountains were an open, continuous area permitting population movements, not a cul-de-sac for the last Neanderthals.

This paper will present the main results of archaeozoological studies of these three sites.

Kabazi II

The open-air site of Kabazi II is situated on the right bank of the Alma River on the slope of the Kabazi Mount. The site has been excavated by Victor Chabai since 1986. The stratigraphy sequence is formed by 13 m of colluviums and contains five archaeological units subdivided into 21 cultural levels (Table 1). This paper will present the main archaeozoological results of the upper levels: II/7AB to II/7E. The

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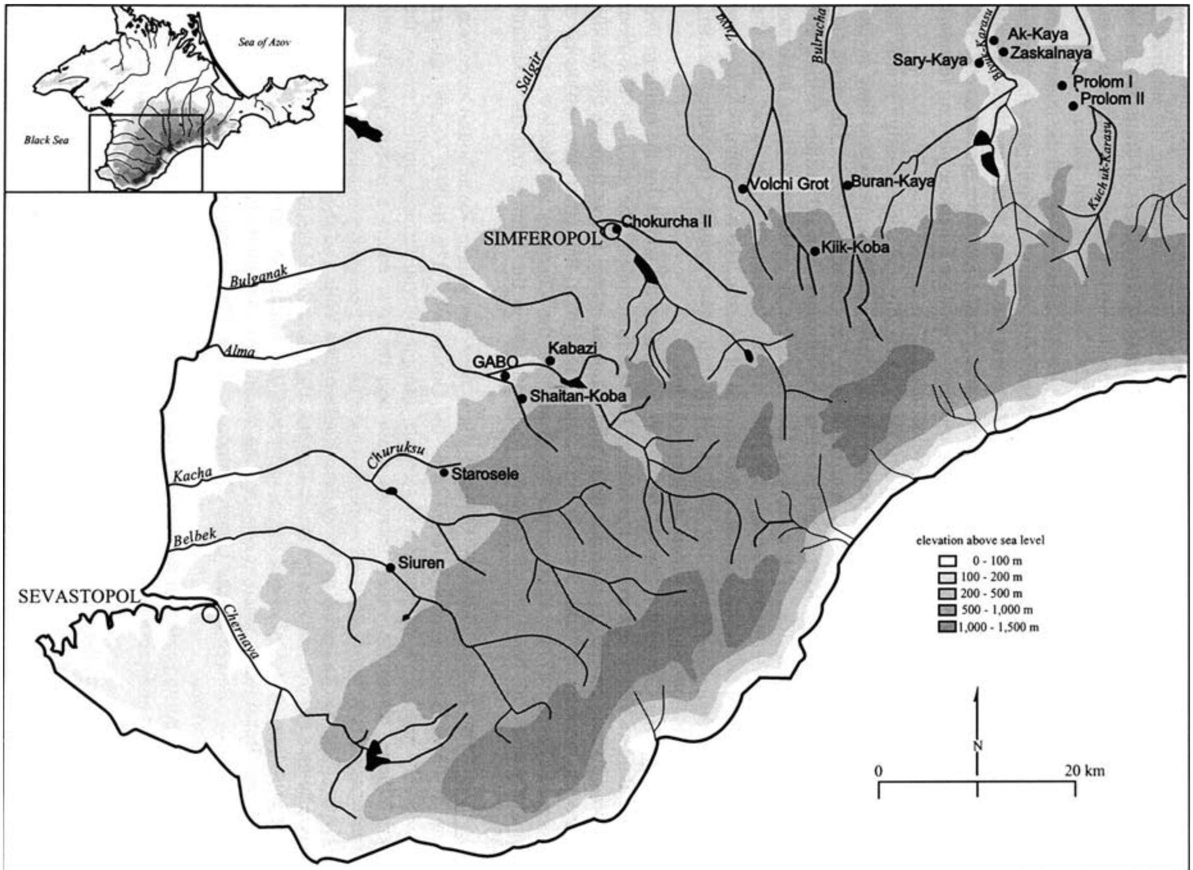

Fig. 1 Crimea: localisation of Kabazi II, Buran Kaya and Siuren I (Marks and Chabaï 1998)

ESR dates determined from teeth coming from the level II/7AB give an age of 36,000 ±3,000 years bp (Marks and Chabaï 1998).

The density of lithic materials is relatively low. Lithic industries of all levels were described by Victor Chabaï as belonging to the Western Crimean Mousterian (WCM). In all levels, the lithic material is relatively sparce but rich in tools (dominated by scrapers). The raw material, mainly flint, is of good quality and local. The debitage, not very intensive, took place in the site according to necessity.

Analysis of the Large Mammal Remains of Kabazi II

The number of studied bones from level II/7AB to level II/7E of Kabazi II varies between 2202 (level II/7AB) and 4466 (level II/7E) (Fig. 2). In all levels, *Equus hydruntinus* is predominant (Table 2). Saiga antelope is present in all levels but with few remains (Table 2). Carnivores are very scarce and even absent in the level II/7AB (Table 2). In all levels, the composition of large mammal fauna points to the predominance of steppe with trees more or less abundant from level to level, in the vicinity of the river (Fig. 3). This environment corresponds to the "Mammoth steppe." The climate was relatively dry and cold but not extreme.

The ratio of the total number of remains to the minimal number of individuals and the percentage of cranial remains allow estimating the bone deficit. It is very high in each level. This is probably because the bone material is very fragmentary. The undetermined fragments represent more than 70% of the total bone remains. According to the bones examined, the majority of those fragments belong to *Equus hydruntinus*. Fragments of 2–5 cm in length dominate.

The alterations observed on the bones' surfaces are mainly the result of weathering and etching by

Table 1 Kabazi II, stratigraphical, archeological, chronological and environmental data (ChabaÏ, 2005)

Strata	Levels	Dates, kyr AMS	U-series	ESR	Pollen zones, #	Marine isotopic scale
2–3	I/1, I/2, I/2A, I/3					
4–5	A, A1, A2, A3,				#XIV, Bug bg_1	Stage 2
5	A3A, A3B, A3C, A4				#XIII, Vytachiv vt_{3b}, Denekamp interstadial	
6	II/1A		32.1±6.5	30±2.0		
	II/1	OxA-4770, 31.55±0.6	40.1±5.0			
	II/2	OxA-4771, 35.1±0.85			#XII, Vytachiv vt_2, Huneborg stadial	
	II/3					
	II/4	OxA-4858, 32.2±0.9			Sterile	
	II/5	OxA-4859, 33.4±1.0				
7	II/6					
	II/7		46.5±8.0			
	II/7AB			36±3.0	#XI, Vytachiv vt_{1c}, Huneborg interstadial	
				38±4.0		Stage 3
	II/7C, II/7D, II/7E					
	II/8			44±5.0		
	II/8C				#X, Vytachiv vt_{1b2}, Hengelo interstadial	
	IIA/1					
					Sterile	
9	IIA/2				#IX, Vytachiv $vt_{1b2\text{-}b1}$, Hosselo stadial	
	IIA/2-3					
	IIA/3, IIA/3A, IIA/3B				#VIII, Vytachiv vt_{1b1}, Moershoofd interstadial	
10	IIA/4					
	IIA/4B				#VII, Uday ud	Stage 4
11, upper	III/1A, III/1				#VII, Pryluky pl_3, Ognon interstadial	Stage 4-5 transition
	III/2		54±3.0	74–85	#VI, Pryluky pl_{1b2} (pl_{1b2+3}), Odderade (Brörup-Odderade) interstadial	Sub-stage 5a

Table 1 (continued)

Strata	Levels	Dates, kyr AMS	U-series	ESR	Pollen zones, #	Marine isotopic scale
	III/2A					
	III/3			82±10	#V, Pryluki $pl_{1b2\text{-}b1}$ (pl_2?), Rederstall stadial	Sub-stage 5b
11, lower	III/4, III/5, III/6, III/7					
	III/8					
	III/8A, III/8B, III/8C					
	III/8D, III/8E				#IVC, IVB-D2, IVA-D1, Pryluki pl_{1b1}, Brörup interstadial	Sub-stage 5c
13	IV/1, IV/2, IV/3, IV/4, IV/5					
13A	V/1, V/2, V/2A				???, Tyasmin, Herning stadial	
14A	V/3, V/4, V/5, V/6				#C, Kaydaky kd_{3b2+c}, Eemian (E6b) interglacial	
14B	VI/1, VI/2, VI/3, VI/4, VI/5, VI/6, VI/7, VI/8, VI/9, VI/9A, VI/10, VI/11-14, VI/15				#III-B4, III-B3, III-B2, II-B1, A, Kaydaky kd_{3b2+c}, Eemian (E6a) interglacial	Sub-stage 5d
					#A, Kaydaky $kd_{3b2\text{-}b1}$, Eemian (E6a) interglacial	
14D					#II, Kaydaky $kd_{3b2\text{-}b1}$, Eemian (E6a) interglacial	Sub-stage 5d
14E					#I, Kaydaky kd_{3b1}, Eemian (E5) interglacial	Sub-stage 5e

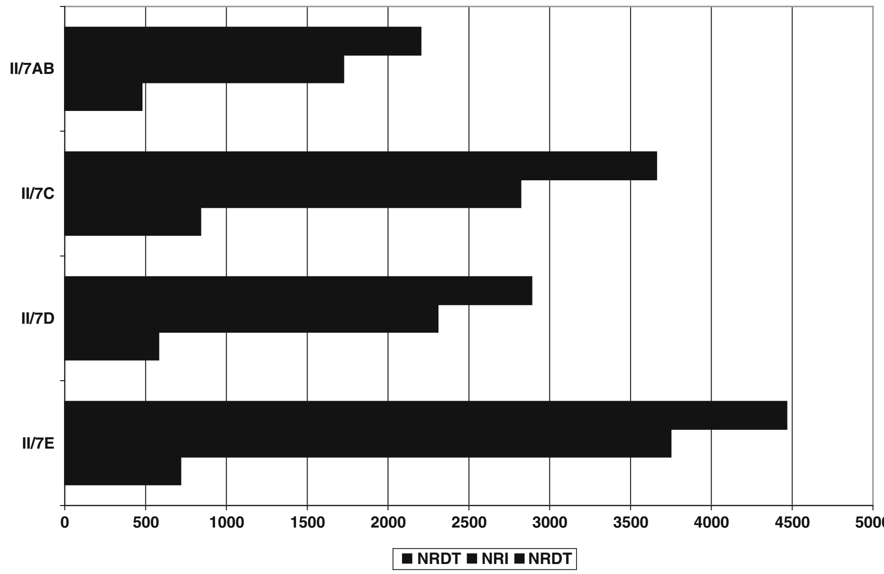

Fig. 2 Number of large mammal bones from Kabazi II, levels II/7AB to II/7 E; NRDt = Number of Determinate Remains, NRI = Number of Indeterminate Remains, NRT = Total Number of Remains

Table 2 Large mammal from Kabazi II, levels II/7AB to II/7 E (NR and MNIc); ind. = individual

Especes/Levels	II/7AB	II/7C	II/7D	II/7E
Equus hydruntinus	468/11 ind	818/24 ind	541/16 ind	679/23 ind
Equus (caballus) sp.	0	0	3/1 ind	0
Bison cf priscus	0	1/1 ind	7/1 ind	1/1 ind
Equus/Bison	0	0	0	1
Cervus cf elaphus	4/1 ind	0	1/1 ind	0
Saiga tatarica	5/1 ind	17/2 ind	27/2 ind	32/3 ind
Small *Cervidae*	0	3/1 ind	0	0
Artiopdactyla	0	0	0	2
HERBIVORES	477/13 ind	839/28 ind	579/21 ind	715/27 ind
Vulpes corsac/Alopex lagopus	0	0	1/1 ind	0
Panthera (Leo) spelaea	0	0	0	2/1 ind
CARNIVORES	0	0	1	2
Fox or *Lepus Sp.*	0	1/1 ind	0	0
NRT/MNIcT	477/13 ind	840/29 ind	580/22 ind	717/28 ind
Dénombrement	II/7E	II/7D	II/7C	II/7AB
NRDt	717	580	840	477
NRI	3749	2308	2820	1725
NRT	4466	2888	3660	2202

plant roots. It seems that these bone materials were on the surface a relatively long time and then covered by a thin depth of sediments. Moreover, the number of carnivore remains in the faunal spectra and the marks on the bones made by these animals are very few. Only 3 bones show small canid or mustellid gnawing marks. These results attest that carnivores have not disturbed these assemblages. Men, and in a smaller proportion, climatic agents are responsible for the fragmentation and the relatively bad preservation of the bone materials.

Our study focused on the analysis of *Equus hydruntinus* bones, the predominant species. The estimated number of *Equus hydruntinus* is more important in levels II/7C and II/7 E and less important in level II/7AB (Fig. 4). Except for level II/7 E, the bell-like aspect of the mortality profiles attests to hunting practices (Fig. 5). Animals between 7 and 10 years old are predominant. These curves are

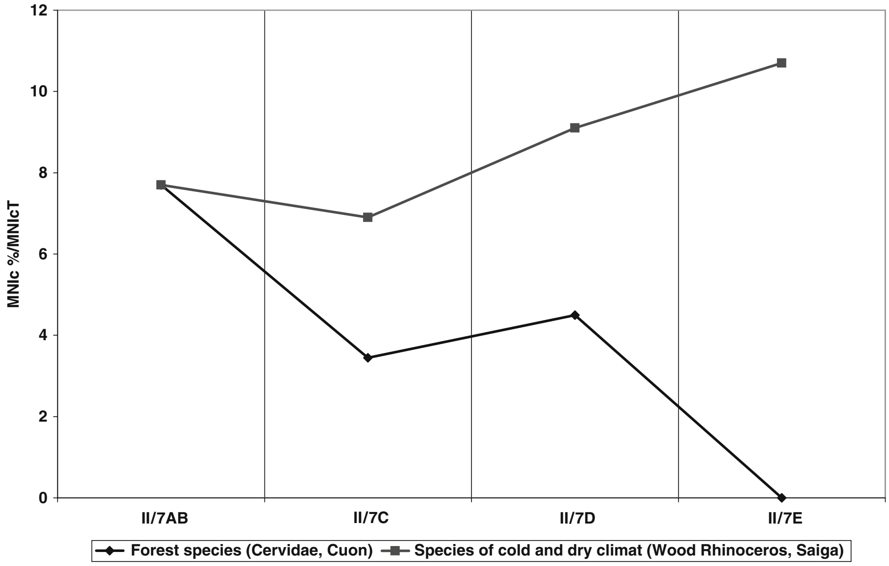

Fig. 3 Palaeoecology of fauna to Kabazi II, levels II/7AB to II/7 E

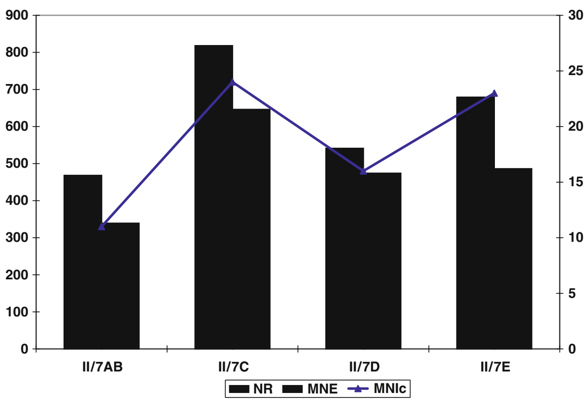

Fig. 4 *Equus hydruntinus* of Kabazi II, levels II/7AB to II/7 E; NR = Number of Remains, MNE = Minimum Number of Elements, MNIc = Minimum Number of Individuals by combination

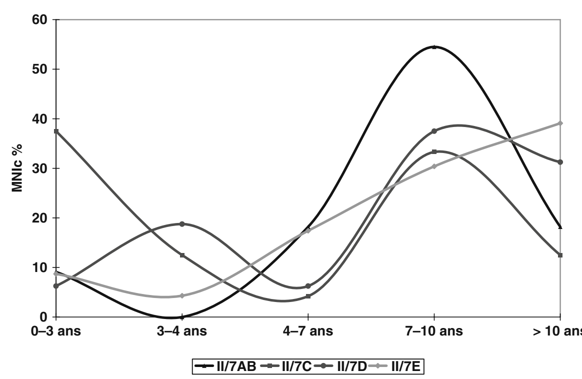

Fig. 5 *Equus hydruntinus* of Kabazi II, levels II/7AB to II/7 E : mortality profile

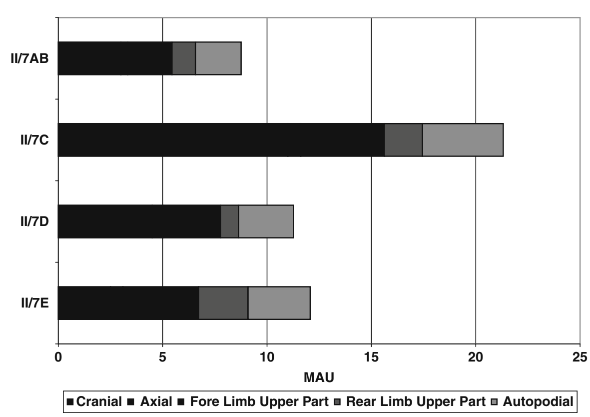

Fig. 6 *Equus hydruntinus* of Kabazi II, levels II/7AB to II/7 E : units preservation (MAU = Minimum Animal Unit)

similar to the Stalking Model defined by M. Levine (1983). The long bones' morphometry and the determination of canines show the presence of males, except in level II/7AB. The hunting of some individuals within family groups is established. Seasonality is established on the basis of juvenile teeth. In all levels, many equids died in spring, some at the beginning of summer (level II/7AB), and others at the beginning of autumn (level II/7D).

Level II/7C is the richest in *Equus hydruntinus* remains, level II/7AB the poorest (Fig. 4). All the main skeletal units are present (Fig. 6) but in all levels except for II/7 E we observe the same variations with the predominance of cranial units and the great rarity of axial skeletal bones. In all levels, the bones corresponding to parts rich in meat are less represented than others. It seems that after killing, equids were dismembered at the spot, and parts of the carcass were transported out of the site. Cut marks are very rare but, with the exception of 3 metapodials, all the long bones were broken for marrow extraction.

An analysis of the relationship between the MAU (Minimum Animal Unit) percent and the FUI (Food Utility Indices) percent (using values calculated by Outram and Rowley-Conwy [1998] for equids), gives good information about the nutritional strategy. The MAU are relatively low for the nutritive elements and higher for the poor ones (Fig. 7). This agrees with the "Reserve Strategy" model defined by Binford (1978), which characterises the butchery sites. However, in level II/7AB, the MAU of poor elements are not relatively high, in comparison to the other levels. The carcass processing has not been very intensive, corresponding to the "Reserve Gourmet Strategy" model (quality over quantity). When we analyse the relationship between MAU percent and meat indices, we observe that the deficit of bones rich in meat is high (Fig. 8). It confirms that parts of carcass were transported out of the site. The representation of the bones rich in marrow (Fig. 9) is difficult enough to explain, but it appears that some bones were taken away and others broken on the spot for marrow extraction. These results show that partial secondary carcass butchery took place in the site and that some part of the meat and marrow were eaten there.

To conclude, the lithic and faunal materials of all levels of Kabazi II do not fundamentally differ. At several times and during a long period of time, the Neanderthals hunted *Equus hydruntinus*. After the butchery process, they transported parts of carcasses out of the site. The scarcity of lithic material and the lack of habitation structure confirm that Kabazi II was used as a kill and butchery site during the formation of these levels.

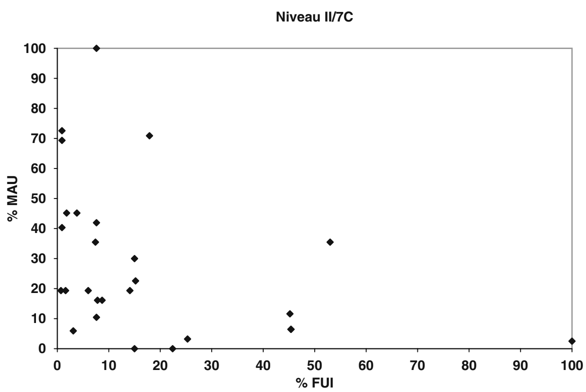

Fig. 7 *Equus hydruntinus* of Kabazi II, levels II/7C: Food Utility Index (FUI) Profile

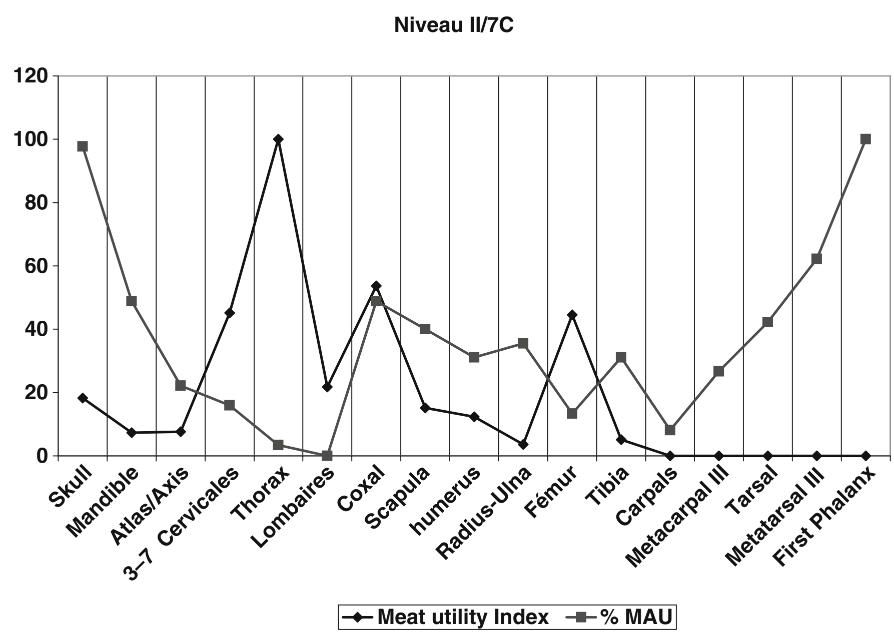

Fig. 8 *Equus hydruntinus* of Kabazi II, levels II/7C: Meat Index

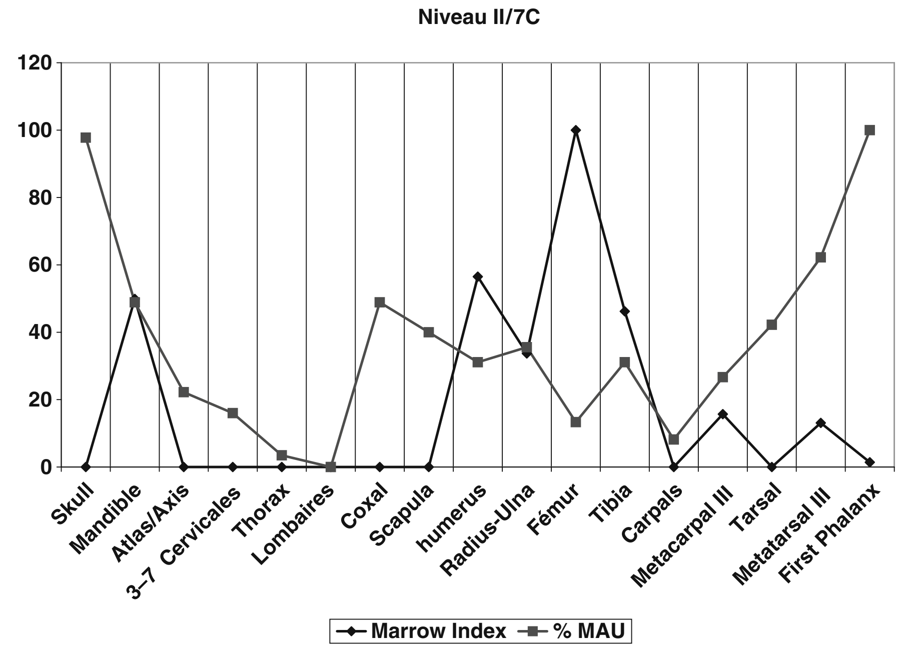

Fig. 9 *Equus hydruntinus* of Kabazi II, levels II/7C: Marrow Index

Buran Kaya III

Like Kabazi II, Buran-Kaya III is located on the second ridge of the Crimean mountains. This rock-shelter is situated on the right bank of the Burulcha River.

According to Tony Marks, who excavated the site, the Palaeolithic sequence is subdivided into five levels (Fig. 10). Level A consists of disturbed deposits, which contain the Middle Palaeolithic artefacts. In level B were found abundant artefacts of Kiik-Kobien, a Middle Palaeolithic industry, a

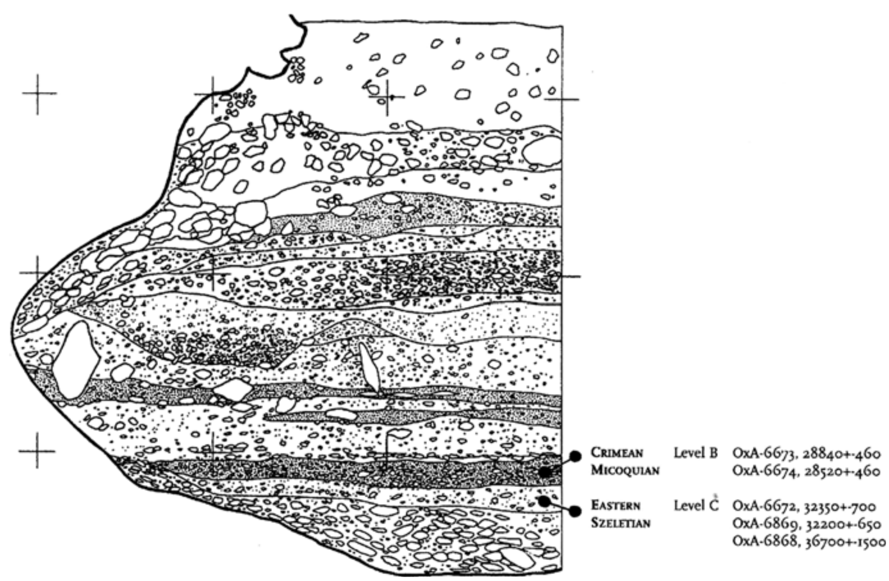

Fig. 10 Stratigraphy of Buran Kaya III

facies of the Crimean Micoquian. Level C contains a newly discovered Early Upper Palaeolithic industry: the Eastern Szeletian (with worked bones as *tubes*). Levels D and E produced only a few artefacts, making the assemblages uninformative for a study of the variability of the industry. For level B, the AMS dates are about 28,840 ±460 years bp and 28,520 ±460 years bp; and for level C, about 32,000 or 36,000 years bp (Pettitt 1998).

Analysis of the Large Mammal Remains of Buran Kaya III, Level B

The faunal material determinate from level B of Buran Kaya III, comprises 16,680 pieces; 99.9% of the bones are attributable to herbivores (Table 3). The identifiable faunal remains correspond to at least 32 individuals: 29 herbivores (6 species) and 3 carnivores (3 species). Saiga is the dominant species among the herbivores (Table 3). Among the carnivores, the remains of foxes are the most abundant (Table 3). The surrounding landscape of the site likely corresponds to a semiarid steppe with a few wooded areas near streams or rivers. The climate would have been harsh, especially during the winter months, and particularly dry.

Table 3 Large mammal from Buran Kaya III, level B (NR, MNE, and MNIc)

Species/Denombrement	NR	MNE	MNIc
Equus hydruntinus	3	3	1
Bison cf priscus	18	>7	1
Coelodonta antiquitatis	4	3	1
Mammuthus primigenius	38	>7	1
Mammuthus/Coelodonta	2		
Cervus elaphus	19	14	1
Saiga tatarica	1259	>749	24
*Artiodactyla**	15 328		
Sous-Total Herbivores	16 671	>>783	29
Canis lupus	1	1	1
Vulpes corsac/Alopex lagopus	4	4	1
Mustelidea (small)	2	2	1
Vulpes/Alopex/Mustelidea	2	2	
Sous-total carnivores	9	9	3
Total	16 680	>>792	32
*Artiodactyla**			
Size *Bison*	38		
Size *Eq. hydruntinus/Cervus*	310		
Size *Cervus*	111		
Size *Saiga*	14 869		
Sous-Total	15 328		

The weathering, the effects of climate, and plant root marks are rare (attested only on 15 pieces), probably because of the site configuration (a rock shelter), because the material was quickly recovered by sediments and because a dry climate prevailed. Carnivore action on this material was also slight: marks were observed on only 24 pieces. There are mostly fragments of long bone shafts; 97.8% of them are 2–5 cm in length. On the other hand, no diaphysis "cylinders" were found. These results demonstrate that humans were the main agent of fragmentation of this material. This rock-shelter was not used as a carnivore den, and human agency at the carcass treatment stage is preponderant.

Our study focused on the analysis of saiga bones, the predominant species. The analysis of the preservation of the saiga bones assemblage indicates that the bone material is relatively well preserved. Among the indeterminate fragments, at least 14,869 are from saiga antelope (according to the thickness of the cortical bone and their dimension). The hominids, very probably Neanderthals, practised a specialized hunting of saiga—a game easy to hunt, especially near waterholes. They killed 24 individuals: six juveniles, 2 males, and 16 adult females (Fig. 11). During summer, the hominids were able to hunt mainly females and young, from herds small to medium in size.

With the exception of the axial skeleton, all the major skeletal units are well preserved, especially the upper portion of the rear limbs and the cephalic skeleton (Fig. 12). The indices used to evaluate the degree of fragmentation of the bone material indicate that there was a high proportion of saiga bones in this layer. Four hundred and seven bones display evidence of human activities: breakage (35 bones show percussion marks), butchery (49 bones present cut marks, 83.6 % produced during disarticulation), and burning (323 pieces). Animals were killed and brought back to the site to be dismembered, probably just outside of the rock-shelter (maybe in front of the entrance).

The calculated Binford indices correspond to the global nutritive strategy and to the meat-procuring strategy, reflecting a "Reserve Bulk Strategy," while the index for marrow procurement corresponds to

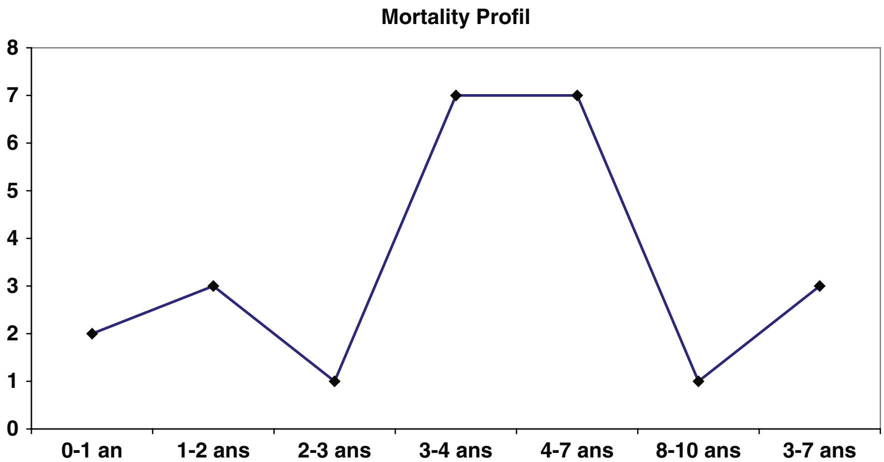

Fig. 11 *Saiga tatarica* of Buran Kaya III level B: mortality profile

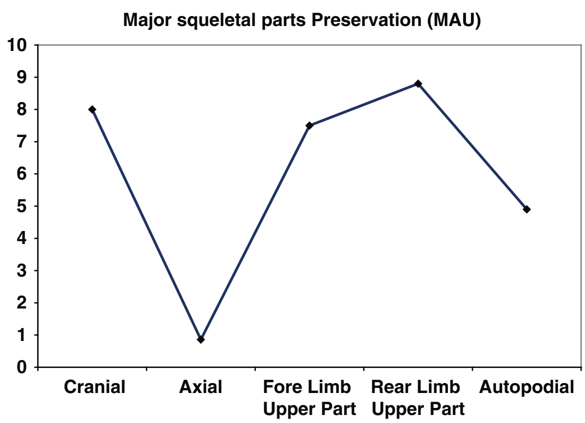

Fig. 12 *Saiga tatarica* of Buran Kaya III level B: Units Preservation (MAU)

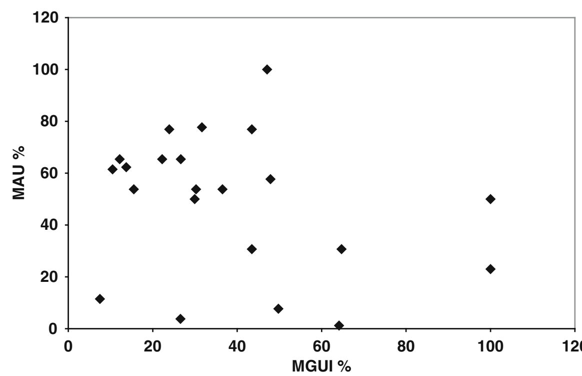

Fig. 13 *Saiga tatarica* of Buran Kaya III level B: FUI profile

the "Bulk Strategy" (Figs. 13–15). These results confirm that during the formation of layer B, the site was used as a butchery (where the processing of the game was done) and a consumption site. The modus operandi for saiga processing appears to have been complete and recurrent.

The prehistoric inhabitants of this site did little hunting of other herbivores: bison, deer—and maybe foxes, which seem to play only a minor role as game. The hominids also probably seized the opportunity during their daily movements to bring sections of fresh carcasses of mammoth, woolly rhinoceros, and *Equus hydruntinus* to their camp.

Based on the analysis of the spatial distribution of bone and lithic remains and on the results furnished by bones showing unequivocal human marks of disarticulation, we can propose that the studied area was a specific zone in the rock-shelter serving as the center of butchery activities. The abundance and distribution of burnt bones suggests the presence of one or more small hearths (likely not constructed), which were correlated with the butchery activities.

To conclude, during the occupation of level B, Buran Kaya III was a seasonal camp, used very probably many times.

Siuren I

Siuren I is a rock-shelter situated on the left bank of the Belbek river, on the second ridge of the Crimean mountains. During the 1990s, excavations were done by Marcel Otte and then by Tony Marks

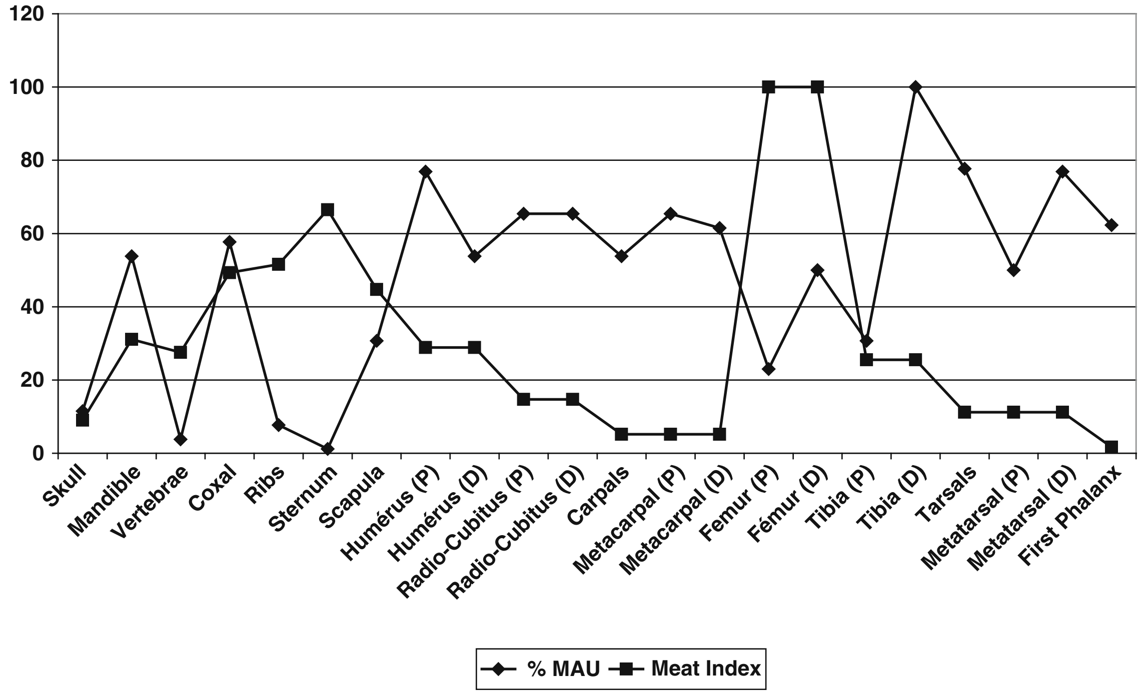

Fig. 14 *Saiga tatarica* of Buran Kaya III level B: Meat Index

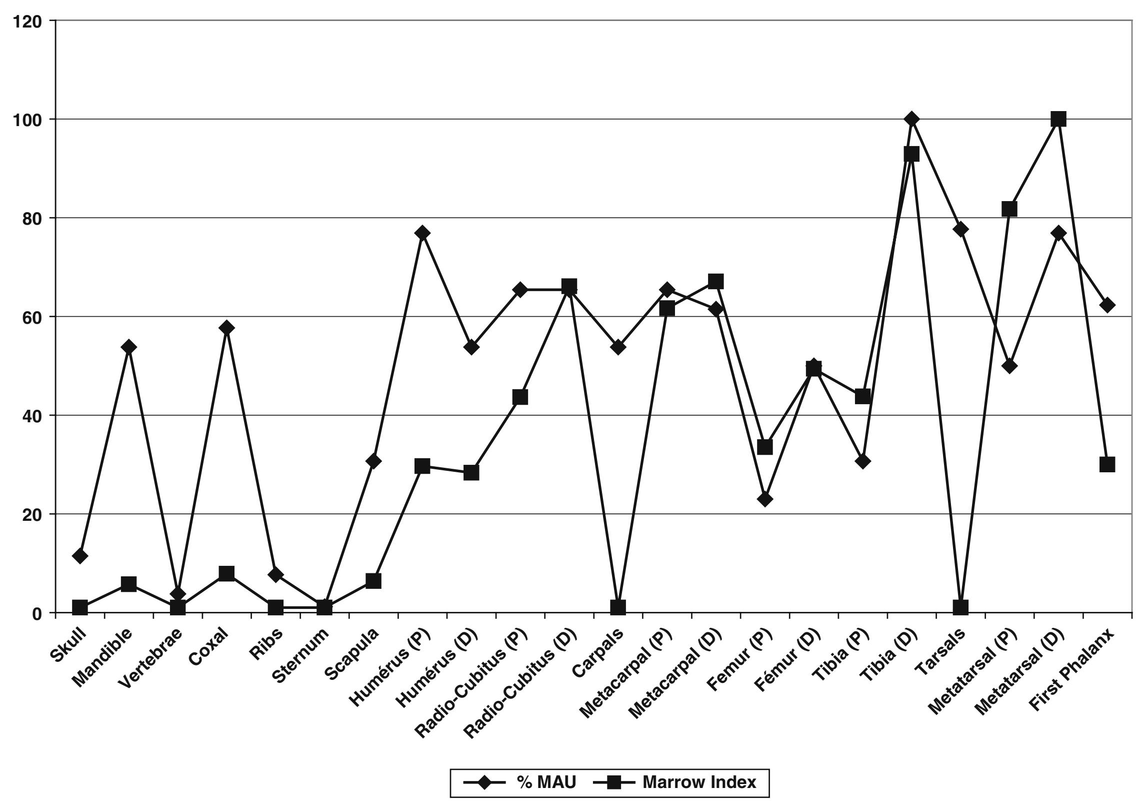

Fig. 15 *Saiga tatarica* of Buran Kaya III level B: Marrow Index

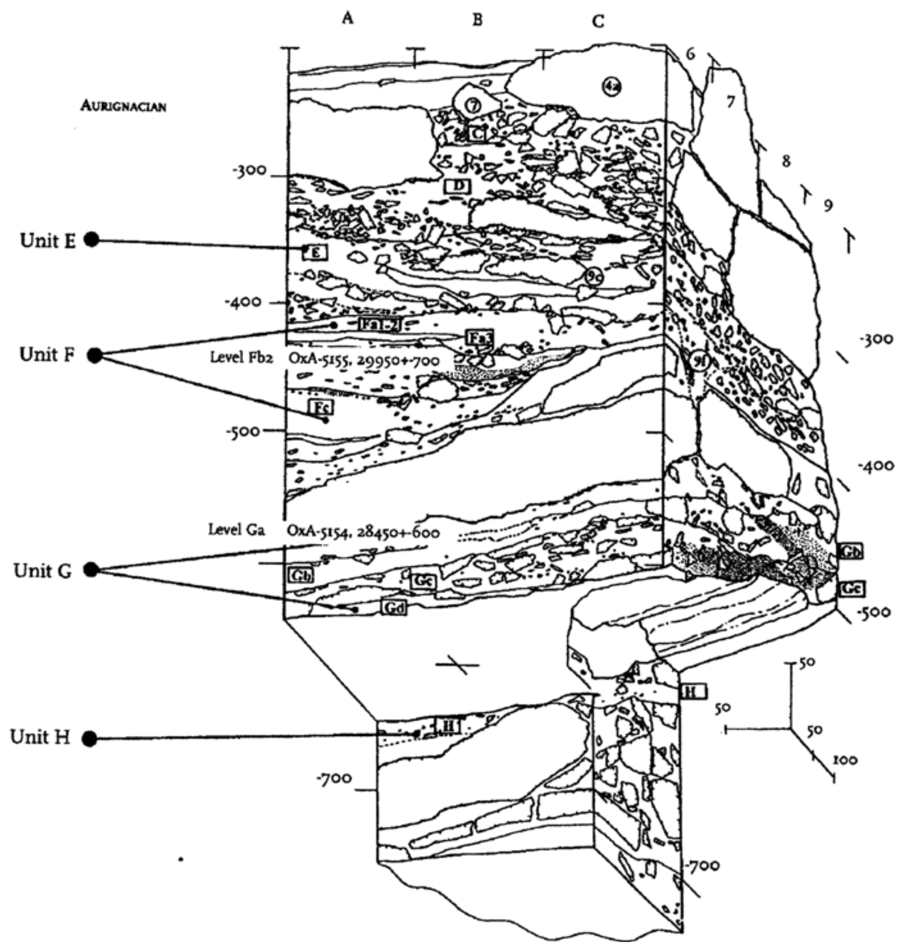

Fig. 16 Stratigraphy of Siuren I (Chabaï 2001)

(Demidenko and alii, 1998). An Aurignacian industry was discovered in the Units F, G, and H (Chabaï 2001; Fig. 16). Three AMS dates are available for the lower level of Unit F and the upper level of Unit G. Both levels are dated at about 28,000–29,000 years bp (Pettitt 1998). Unit G, the richest in archaeological material, is divided into four archaeological levels. In this Unit were found few lithic remains, some bone artefacts, and 8 shell pearls, attributed to the Early Aurignacian.

Preliminary Analysis of the Large Mammal Remains of Siuren I, Unit G

Since Unit G presented a low quantity of bone material, this archaeozoological study takes into account all the faunal remains (without subdividing the different levels). The fragmentation is very high: only 508 bones have been determinated. Carnivores are very scarce, represented by 2 fox species—*Alopex lagopus* and *Vulpes vulpes*—and wolves, and their intervention on the bones is modest. This rock-shelter was not used as a carnivore den, and the human agency at the carcass treatment stage is preponderant. The composition of large mammal fauna (saiga antelope, megaloceros, horse, bison, and red deer) points to the predominance of steppe with trees in the vicinity of the river. This environment corresponds to the "Mammoth steppe."

Men hunted only some herbivores (in the case of this preliminary study): 4 saiga antelopes, 3 megaloceros, 3 horses, 2 bison, and 1 red deer. These animals were brought to the site complete (saiga), or in parts (the other taxa).

The presence of burned bone fragments proves the existence of hearths.

This site, occupied during very short periods of time and recurrently, was used very probably as a hunting camp, with secondary butchery processing and local consumption.

Conclusion

The subsistence behaviour of prehistoric men from Kabazi II and Buran Kaya III (level B) was similar enough. Men organised recurrent seasonal hunts oriented on only one species: a small horse, *Equus hydruntinus,* in Kabazi II, and saiga antelope in Buran Kaya III. They killed animals in the prime of life and juveniles within herds composed of females and young animals. The processing of these animals was complete and relatively intensive in both sites. The subsistence behaviour is different at Siuren I Unit G and Buran Kaya III level C. In these two sites, respectively with Early Aurignacian and transitional industries (Eastern Szeletian), very few bone remains were discovered. Hunting was opportunistic and occupations were very short. What does this difference of behaviours mean? Craftsmen who elaborated Mousterian and Micoquian industries were undoubtedly Neanderthals, but those who made the transitional industry remain unknown: were they Neanderthals or *Homo sapiens* like the Early Aurignacian?

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DISCUSSION 4: The Middle-to-Upper Paleolithic Transition: What News?

Erella Hovers

Abstract This chapter reviews the state of the research on the Middle to Upper Paleolithic transition following profound paradigm changes in the last three decades. The demise of the Eurocentric paradigm, which saw a linear shift from Neanderthals to moderns and from Middle to Upper Paleolithic lifeways, opened the field to a large number of competing hypotheses about the origins of modern humans and of modern behavior. It is suggested that the Middle-to-Upper Paleolithic transition is a complex phenomenon that constitutes regional processes. Some of the new models attempting to explain the Middle-to-Upper Paleolithic transition are a geographic and temporal projection of the Eurocentric thinking about the links between anatomical and behavioral modernity. While some researchers still employ empirical data as the building stones of their models, others strive to come up with theory-driven explanations for the shift from "archaic" to "modern" behavior.

Keywords Paradigm shift • Modern behavior • Out of Africa

"The Middle to Upper Paleolithic Transition" is a term that was coined in the good old days when the prehistoric record of Europe was a yardstick of human prehistory. The notion of a linear shift from archaic to modern anatomy, which was inseparably tethered to a change from Middle Paleolithic ("archaic") to Upper Paleolithic ("modern") lifeways was elegant and attractive. It had been taken as a given that the cognitive potential for modern behavior evolved with (some would say as a result of) modern anatomy, and its emergence directly led to tangible archaeological evidence of such behavior (e.g., parietal and mobile art or personal ornaments; Mellars, 1996; Noble and Davidson, 1993). Moreover, the notion of a combined biocultural "package" of modernity catered to a sense of "species self-esteem," as it emphasized the uniqueness of "us" (i.e., *Homo sapiens*) compared to all those extinct hominins that "had not made it" across the rubicon of modernity. Any different outlook on how modern behavior emerged and evolved had implications that were too difficult to handle conceptually: if one allowed for the existence of latent modern capacities that were not expressed in the material record, or assumed that hominins other than modern *Homo sapiens* were capable of modern behavior, all bets would be off. Detailed schemes of cultural stages and our understanding of the tempo of behavioral and cultural evolution could become unfounded scenarios (Hovers and Belfer-Cohen, 2006). The strength of the paradigm was such that there was not much of a theoretical framework from which models were derived. The shift from a Neanderthal to an Upper Paleolithic "stage" was perceived as a preordained process of cultural evolution, and the archaeological record—namely the skeletal and archaeological evidence—was deemed pretty much self-explanatory. Modern behavior—i.e., Upper Paleolithic behavior—was simply recognized through a number of traits that were thought

E. Hovers (✉)
The Institute of Archaeology, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem, Israel

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to represent its existence accurately and appropriately (Henshilwood and Marean, 2003).

The major challenges to the Eurocentric paradigm came from regional records outside of Europe, as well as the application of new analytical tools. Findings in the Levant from as early as the 1920s have been pivotal in this change. While the discovery of the Tabun C1 Neanderthal skeleton with Mousterian lithics was par for the course within the then-dominant worldview of prehistory, this was not the case with the Skhul skeletal remains, which were found associated with classic Mousterian assemblages despite their *Homo sapien*-like anatomical features (McCown, 1934; McCown and Keith, 1939). Qafzeh Cave presented a similar dilemma (Tillier, 1999; Vandermeersch, 1981). Based on their anatomy, the Skhul remains were variably classified, first as a "Palestinian variant of Neandertals" (Keith in McCown, 1934), and then as intermediate forms between generalized Neanderthals and the modern humans succeeding them ("Proto Cro-Magnon," Howell, 1958). Yet the strength of the biocultural paradigm was such that as late as the 1980s, these Levantine caves were widely regarded as providing the clearest evidence for a transitional phase between Neanderthals and modern humans, with a relatively late date for the transition (Howell, 1959; Suzuki and Takai, 1970; Wolpoff, 1996). The postulated transitional phylogenetic status of the hominins was argued to have been reflected in cultural manifestations as well, specifically in the characteristics of lithic assemblages made by these transitional forms (Jelinek, 1982; Watanabe, 1970).

Anatomical studies of Levantine fossils (Rak, 1986, 1990; Vandermeersch, 1981, 1982) argued against anagenetic change, and supported the view that there were two different taxa in the Levantine Middle Paleolithic (e.g., Aiello, 1993; Klein, 1995; Rak, 1993; Vandermeersch, 1982). Additionally, a geochronological database for Levantine Mousterian sites, including those with skeletal remains, has begun expanding since the mid-1980s. This database now indicates that in the Levant modern humans may have antedated, or were to some degree contemporaneous with the Neanderthal-like hominins (Bar-Yosef, 1998; Grün et al., 2005; Rink et al., 2001; Valladas et al., 1999). Moreover, the dates of 120,000–85,000 years ago for Skhul and Qafzeh render these sites contemporaneous with Neanderthals in Europe itself (the dating of Tabun, in which the longest sequence was found, unfortunately remains problematic; Bar-Yosef and Callander, 1999; Grün and Stringer, 2000; Meignen et al., 2001; Mercier and Valladas, 2003). Some level of coexistence between Neanderthals and modern humans can no longer be considered a uniquely Levantine trait. Some Neanderthal groups continued to exist in Europe well after the arrival of *Homo sapiens* (Higham et al., 2006; Mercier et al., 1991; Schmitz et al., 2002). Still, one telling difference is that there are no known instances in Europe of modern humans that produced Mousterian lithic assemblages, whereas Neanderthals are by and large associated with Mousterian assemblages. In the Levant, both Middle Paleolithic populations produced their lithic assemblages by applying Levallois flaking, and used a comparable range of typological forms. Additionally, faunal residues found at sites with human skeletal remains show that both groups exploited similar faunal species by hunting (Rabinovich and Hovers, 2004; Rabinovich and Tchernov, 1995; Speth and Tchernov, 1998, 2001; Stiner, 2006; Ysehurun et al. 2007). Thus, the Levantine Mousterian record that has been emerging in the last three decades not only refutes the notion of a linear anatomical transition between Neanderthals and moderns, but also severs the conceptual Gordian Knot between a package of "biocultural" modernity on the one hand vs. archaic anatomy and Middle Paleolithic tool types on the other (Hovers, 2006, 2009).

Genetic studies, which became part of the analytical arsenal of modern human origin research, played a major role in the demise of the old paradigm. While the results are by no means unanimously accepted, they are consensual in pointing toward Africa as the geographical origin for the genetic configuration of extant humans. Multiple lines of genetic and anatomical data currently coalesce in Africa as the place of origin of *Homo sapiens*. Yet, the mechanisms of its emergence and of its becoming a colonizing species are still being debated. The genetic and fossil data are sometimes interpreted as suggesting the emergence of *Homo sapiens* from a speciation event in Africa, followed by bottle necks, dispersals, and the subsequent replacement of archaic populations in Eurasia.

Such seemingly decisive analyses of modern and fossil human DNA, interpreted as supporting a recent African origin of anatomically modern humans, continue to be challenged on both methodological and interpretive grounds. The data are alternatively viewed as indicating an African origin followed by periods of gene flow. A third view endorses a process of wave-diffusion, including hybridization and assimilation at the wave front. Similarly, the chronological framework for such events and processes is as yet unresolved (see Arcadi, 2006; Bazin et al., 2006; Cann, 2001; Caramelli et al., 2003, 2006; Eswaran, 2002; Eswaran et al., 2005; Green et al., 2006; Harpending et al., 1998; Krings et al., 1997, 2000; Mellars, 2005; McDougall et al., 2005; Noonan et al., 2006; Relethford, 2001; Templeton, 2002; White et al., 2003 for recent discussions).

Things are as confusing on the cultural side. On the African continent itself, various behaviors that are accepted as markers of modernity emerged during the Middle Stone Age, such as composite tool making, the use of symbolic paraphernalia, long-distance raw material transport, and the use of marine food resources (Ambrose and Lorenz, 1990; Botha, 2008; Bouzouggar et al., 2007; d'Errico et al., 2005; Henshilwood et al., 2002; Lombard, 2005; Marean et al., 2007; McBrearty and Brooks, 2000; Watts, 2002; Würz, 1999; to name but a few). Initially, the Middle-to-Upper Paleolithic transition was "projected" from Europe onto Africa and pushed back in time to accommodate the early dates of *Homo sapiens* in sub-Saharan Africa (e.g., Mellars, 2006; McBrearty and Brooks, 2000; McBrearty and Tryon, 2006). Not all of the cultural changes, however, evolved continuously, and some disappeared in the later stages of the MSA in order to re-emerge again in the Late Stone Age (Soriano et al., 2007). In the Levant, intentional burials exist among both modern humans and Neanderthals, similar to the European Neanderthals (Belfer-Cohen and Hovers, 1992; Hovers et al., 1995, 2000). Symbolic use of pigments and shells is encountered among the modern populations of the region in the Middle Paleolithic (Bar-Yosef Mayer et al. 2009; Hovers et al., 2003; Taborin, 2003; Vanhaeren et al., 2006), who also used pyrotechnology to obtain the red color of iron ores (Godfrey-Smith and Ilani, 2004). Yet, the earliest Upper Paleolithic cultures in the Levant do not demonstrate any of the traits of a "full-fledged" Upper Paleolithic. In fact, were one to adhere to the trait list, we'd have to argue that Levantine populations did not reach "modernity" prior to the beginning of the Natufian, some 15,000 cal BP (Belfer-Cohen and Hovers, n.d.)! Interestingly, Sahul shows a similar pattern. This continent was first occupied by modern humans ca. 45,000 years ago (O'Connell and Allen, 2004), presumably soon after the major "out of Africa" event through which modern humans spread all over the world. Still, many of the supposed hallmarks of a "symbolic revolution" did not appear until the mid-Holocene, and occur sporadically, if at all, in the archaeologically visible manifestations of the Pleistocene (Brumm and Moore, 2005; Habgood and Franklin, 2008; O'Connell and Allen, 2007).

The long duration of the Middle Paleolithic and Middle Stone Age entities could not have occurred without behavioral flexibility and dynamic responses of hominins to the particular challenges of their environments (both social and cultural). Yet these dynamics too often go unrecognized because they did not necessarily evolve toward what eventually became the Upper Paleolithic (Hovers, 1997, 2006; Hovers and Belfer-Cohen, 2006). One can envision Middle Paleolithic hominins (as well as some Upper Paleolithic groups in some regions) existing in an evolutionary "rugged fitness landscape" (Palmer, 1991), with variable peaks of suboptimal fitness values separated by troughs of low-fitness adaptive states. The landscape can thus host several populations in suboptimal conditions. "If ... we imagine a very rugged fitness landscape, with many peaks and troughs, then ... Middle Paleolithic populations were in fact evolving behaviorally, their fitness was increasing locally, but they happened to be ascending a peak (or more likely several peaks) different from the one that anatomically modern Upper Paleolithic populations eventually climbed" (Kuhn, 2006:118).

To summarize, it has become apparent in the last two decades that biological and cultural changes during the Upper Pleistocene—including those idiomatically described as the Middle to Upper Paleolithic transitions—did not necessarily coincide across time and space, nor did they follow a single, repetitive pattern when they occurred (Bar-Yosef and Pilbeam, 2000; d'Errico et al., 1998; Hovers, 1997, 2009; Hovers and Belfer-Cohen, 2006; McBrearty and Brooks, 2000). Nor should we expect homogeneity of the process. Because the Middle Paleolithic differed from one region to the other, regional historical processes to which it gave rise could hardly be uniform or follow a single path to a single transition. This argument should hold regardless of the specific model of population interactions one chooses to endorse. The "Upper Paleolithic Revolution" is essentially technological and very likely may have had a single region of origin (Bar-Yosef, 2002), but it seems that it was implemented in many different ways.

In the early 21st century, one cannot in good faith talk about *A* single Middle to Upper Paleolithic transition. They may all be linked to the dispersal of modern humans out of Africa some 50,000 years ago, but they were many and varied—in Europe as much as in other places on the globe. Indeed, the various papers in this section, explicitly (e.g., Olszewski, Riel-Salvatore) or implicitly endorse this changing world view and emphasize regional differences in the "transitions" that they discuss. Practically all the authors recognize that the "Transition" across Europe, as well the specific cases with which each writer deals, are mosaic events rather than many manifestations of a monolithic process.

Archaeologists—perhaps more than researchers in other disciplines of paleoanthropology—need to go back to the drawing board. A scientific revolution has been completed, and the formidable paradigm that served us for many years has been overthrown. We are no longer looking at a process that is simple or elegant. The emerging complexity of the time period between 50,000 to 30,000 years ago requires special attention to theoretical considerations, calling into question the conventional time-stratigraphic units that are used to divide the Upper Pleistocene material record, as emphasized also by Harrold. The very same situation also calls for emphasis on (literally) down-to-earth aspects of the archaeological record. If we are to make sense of the mosaic of behaviors that are encountered globally at the 50,000–30,000 years ago time interval, we should be able to generate theory-motivated research rather than empirically-driven "trait lists" that cannot be tested independently of the archaeological data themselves (Henshilwood and Marean, 2003; Marean and Assefa, 2004). Riel-Salvatore tackles this very issue with regards to Uluzzian lithic technology. While the label "transitional" for the multiple industries at the Middle to Upper Paleolithic transition is devoid of any implicit behavioral meaning (Bar-Yosef, 2006a; Kuhn, 2003), the Uluzzian (and other "transitional" industries) is still perceived as evidence for Neanderthal acculturation by moderns. This allows Riel-Salvatore to set a series of questions about specific links between the Uluzzian and the preceding Mousterian, including the geographic space in which the two industries are known, and the similarities in particular technological practices. In other words, the "transitional" status of the industry is not assumed; rather it is examined and tested according to a model of cultural evolution. In this particular case, it is concluded that the Uluzzian represented a distinct behavioral package, detached from the preceding Mousterian. And because it lasted for several thousand years, it cannot be termed a "transitional" industry. To the extent that the Uluzzian is one of the "big three" Middle-to-Upper Paleolithic transitional entities in Europe (the others being the Chatelperronian and the Szeletian), this raises interesting questions about the two other industries. Interestingly, the Buhonician, which many workers view as *the* transitional industry in Europe due to its manifested technological ties with the transitional or very early Upper Paleolithic assemblages of Boker Tachtit in Israel (e.g., Bar-Yosef, 2006b; Tostevin, 2003), is not discussed here. Other contributors to this section do not explore such theoretical questions to the same degree, yet clearly have them on their minds when writing about the situation in Iberia, for example.

On the other hand, the many variants of the newly recognized Middle to Upper Paleolithic transition require that archaeologists be very careful with the raw data that they retrieve. It is all too easy to create new transitional industries where a geological mixture of sediments is not taken into account. Three papers in this section (Adams, Zilhão and to some degree, de Quiros and Maillo) explicitly explore this very topic in their studies of three caves in different regions of Europe. Each of these case studies illustrates how site formation processes, if not monitored properly, introduce stratigraphic artifacts into the record and distort the understanding of time depth and industrial variability.

A number of contributors to this section adopt a holistic approach to the transition, alternating between cultural and biological data sources to support either cultural or biological arguments. The gradual elimination of modern human fossils from the Upper Paleolithic record of Europe is indeed frustrating (Bednarik). Most scholars still maintain that the authors of the Aurignacian are in all likelihood modern humans, but with Neanderthals' long-term survival in some areas of Europe, the point is that much more difficult to logically defend. Currently, there is no positive proof in the form of skeletal remains as to the identity of the makers of the earliest Upper Paleolithic industries, whereas Neanderthal authorship of "transitional" (i.e., Châtelperronian) assemblages has been claimed (and hotly debated) in only a handful of cases (at Saint Césaire and Arcy-Sur-Cure; Bordes, 2002; d'Errico et al., 1998; Gravina et al., 2005; Mellars and Gravina, 2008; Vandermeersch, 1984; Zilhão and d'Errico, 1999; Zilhão et al., 2008a, b). Neanderthal acculturation is the basic premise of Riel-Salvatore's null hypothesis that the Uluzzian is a transitional industry, while Harrold's review runs the gamut of acculturation to various forms of replacement models to fortuity, with the arrival of moderns and the demise of the Neanderthals perceived as unrelated events (Finlayson, 2004). Obviously, lithics and other material remains were made by hominins that belonged to either one or the other taxonomic groups. However, we must bear in mind that links between biological taxonomy and material culture (specifically, lithics) are loose, if they exist at all (Hovers, 2006; Lieberman and Bar-Yosef, 2005); and the two data sets should be handled independently where possible to avoid collapsing the various lines of evidence uncritically.

Research on the transitions from the Middle-to-Upper Paleolithic is practically starting anew, particularly in Europe. These are exiting times for workers on these industries who have at their disposal an unprecedented variety of genetic, biomolecular, anatomical and cultural models, and data sets to help streamline their thoughts and works. As noted by Harrold, the influence of the alternative models is already evident in recent studies. The collection of papers in this section reflects the difficulties imposed by a legacy of research history and tradition combined with the intellectual excitement of making new headways in research. "The Middle to Upper Paleolithic Transition" is not a topic that will disappear from center stage anytime soon.

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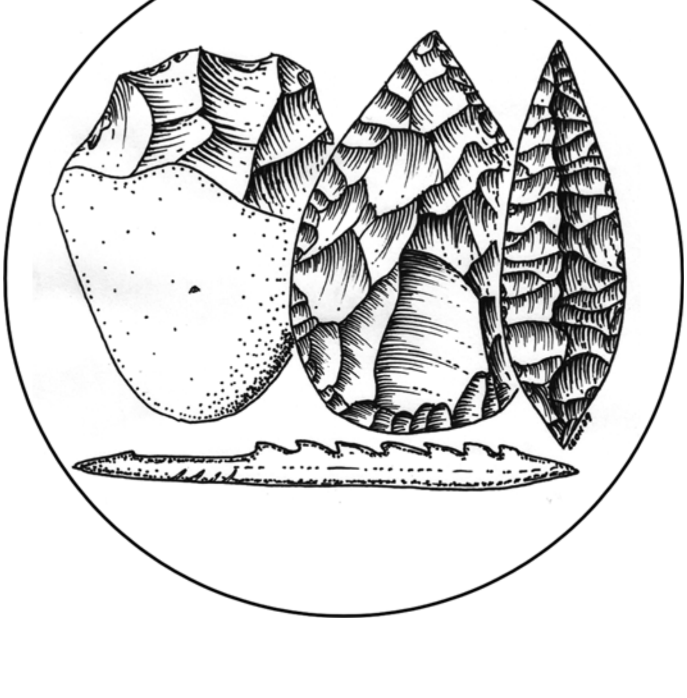
Part V
The Later Paleolithic



Investigating the Aurignacian/Gravettian Transition in the Bistriţa Valley (NE-Romania)

Leif Steguweit

Introduction

Our understanding of the Aurignacian/Gravettian transition has changed focus during the last decade: while former investigations mainly tried to define technotypological units of artefact types and their evolutionary macrotrends, the evaluation of geoscientific data in improved chronological frameworks now provide surprising potential. Specifying the data record can at the very least contribute to the question of a possible "late Aurignacian" or "Epi-Aurignacian" (Kozlowski 1996, 1999) in Eastern Europe, and may even offer some new scenarios of that cultural change.

The introduction of Gravettian inventories in Central Europe occurs at about 30–28 kyr uncal. BP over a wide region ranging from Western France to the Upper/Middle Danube region, Southern Poland, and the Ukraine in the East (Conard and Bolus 2003; Haesaerts et al. 1996, 2004; Otte and Noiret 2004). In general there is no continuity of Aurignacian inventories after 27 kyr uncal. BP, not even in sites with long stratigraphical sequences. The isolated "Epi-Aurignacian" set of three radiocarbon dates from Langmannersdorf (Lower Austria) is poor evidence (Angeli 1953; Mayer 2001), as are the four heterogeneous dates from Bockstein-Törle IV–VI in Southern Germany (Conard and Bolus 2003, 336). As the "updating" of Alberndorf (Lower Austria) shows, the "Epi-Aurignacian" character assumed in these three cases was based on an imprecise ^{14}C record (Trnka 2005 vs. Bachner et al. 1996). In contrast, several sites in Moravia have been classified as unquestionable "Epi-Aurignacian" by Oliva (1996)—although he argues that there was a contemporaneity with the Gravettian. A chronologically isolated revival of the Aurignacian was recently rejected by Terberger (2003), in his discussion of the ^{14}C dated sites of the LGM in Central Europe. Recapitulating the scientific consensus, the introduction of the Gravettian can be seen as a relatively coherent stage, while the continuity, the "fade out," or recurrence of the Aurignacian is controversial (Palma di Cesnola et al. 1996).

Contemporary data for both the Gravettian and the Late Aurignacian/Epi-Aurignacian were collected from several sites in Romania, Bulgaria, Greece, and the former Yugoslavia (Kozlowski 1999). The continuity of the Aurignacian after 27 kyr BP—until the last glacial maximum (LGM)—was especially predicated for Eastern Romania. The Eastern Carpathian river valleys as well as the Moldavian plain with their huge loess deposits contain at least 100 Upper Palaeolithic sites (Noiret 2004). Only a few of them were recovered by systematic fieldwork. The best investigated region in northeastern Romania is the Bistriţa Valley, where rescue excavations were carried out in the late 1950s before the building of a dam flooded the lower terrace and some of the Upper Palaeolithic sites (Nicolăescu-Plopşor et al. 1966). Most of the 16 Upper Palaeolithic sites are situated on the terraces south of the river in the upstream Răpciuni Basin (Figs. 1 and 2). A few more were identified in the Bicaz Basin (Drăgotescu 1968; Mogoşanu and Matei 1981, 1983), and two

L. Steguweit (✉)
Universität Erlangen-Nürnberg, Institut für Ur- und Frühgeschichte, Erlangen, Germany

M. Camps, P. Chauhan (eds.), *Sourcebook of Paleolithic Transitions*, DOI 10.1007/978-0-387-76487-0_31,

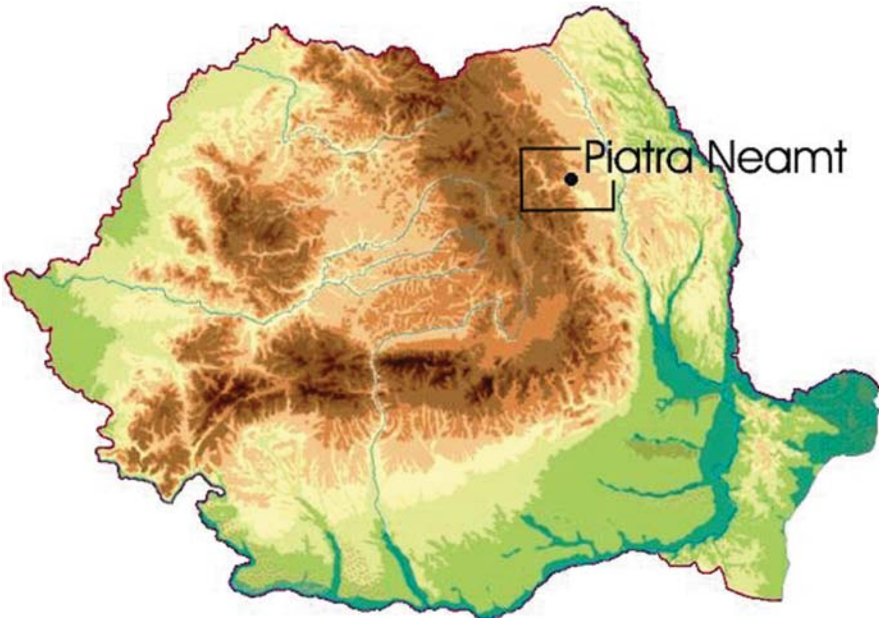


Fig. 1 Poiana Cireşului: site location on Romania's map

Fig. 2 Upper Paleolithic sites on Bistriţa Valley and localities mentioned in the text (source from Google Maps, modified by L.S.): 1 : Poiana Cireşului, 2 : Bistricioara, 3 : Ceahlău-Dârţu, 4 : Podiş, 5 : Cetăţica, 6 : Bicaz, 7 : Buda, 8 : Lespezi

others (Lespezi and Buda) south of Piatra Neamţ on the plain (Căpitanu 1967; Bitiri-Ciortescu et al. 1989). Near Piatra Neamţ lies the pluristratified site of Poiana Cireşului, which was the focus of systematic research in three main stages: in the 1960s (Scorpan 1976), in the late 1980s (Bitiri-Ciortescu et al. 1989), and recently by our team (Cârciumaru et al. 2006). Fortunately, the sites with the richest archaeological layers from the upstream Răpciuni Basin are situated on the middle terrace (about 40 m above the Holocene niveau) and have not been destroyed by the Bistriţa storage lake. A. Păunescu

Table 1 List of all radiocarbon dates from selected UP sites in the Bistriţa Valley. For the Lab-ID: Beta = Miami, Florida; Bln = Berlin; Erl = Erlangen; GrN = Groningen; Gx = Cambridge, Massachusetts

Cultural units (Plopşor et al. 1966/ Păunescu 1998)→ new determined	Archaeological site location	^{14}C kyr uncal. BP (Păunescu 1998)	Lab number	^{14}C BP (AMS Erlangen)	Lab number
"Upper Gravettian"	Cetăţica I, level 3	19,760±470	GrN-14631		
→ Older Epigravettian	Poiana Cireşului			19,459±96	Erl-12162
				20,053±188	Erl-9964
				20,076±185	Erl-9965
				20,154±97	Erl-12163
"Middle Gravettian"	Podiş, level 3	16,970±360	GrN-14640		
→ Gravettian	Dârţu, level 3	17,860±190	GrN-12672		
	Bistricioara-Lutărie,	16,150±350	GrN-10528		
	level 4	19,055±925	Gx-8730		
	Lespezi, level 2	17,620±320	Bln-805		
	Lespezi, level 3	18,110±300	Bln-806		
	Lespezi, level 5	18,020±350	Bln-808		
"Lower Gravettian"	Bistricioara-Lutărie,	20,995±875	Gx-8729	21,541±155	Erl-11854
→ Gravettian	level 3	18,800±1200	Gx-8728	22,181±112	Erl-12164
	Cetăţica I, level 2	23,890±290	GrN-14630		
	Buda, level 1	23,810±190	GrN-23072		
("Pre-Gravettian/	Bistricioara-Lutărie,	18,330±300	GrN-12670	24,213±299	Erl-9968
Upper Aurignacian")	level 2	20,310±150	GrN-16982	24,370±300	Erl-9967
→ *Old Gravettian*		20,300±1300	Gx-8726	24,396±192	Erl-11855
		23,450 + 2000/–1450	Gx-8727		
	Poiana Cireşului			26,070±340	Beta
	"Gravettian II" layer			26,185±379	206707
				26,347±387	Erl-9963
				26,677±244	Erl-9962
				27,321±234	Erl-11860
					Erl-11859
"Middle Aurignacian"	Cetăţica II, level 2	21,050±650	GrN-14632		
→ Evolved	Dârţu, level 2	21,100 + 490/–460	GrN-16985		
Aurignacian	Bistricioara-Lutărie,	23,560 + 1150/–980	Gx-8845	26,869±447	Erl-9970
	level 1	24,100±1300	GrN-10529	28,069±452	Erl-9969
		24,760±170	GrN-11586		
		27,350 + 2100/–1500	Gx-8844		
	Dârţu, level 1	24,390±180	GrN-12673	30,772±643	Erl-9971
		25,450 + 4450/–2850	Gx-9415	35,775±408	Erl-12165
"Lower Aurignacian"	Cetăţica I, level1	>24,000	GrN-14629		
(?)	Cetăţica II, level 1	26,700±1100	GrN-14633		

continued the excavations in the Upper Bistriţa Valley until the 1980s. His ^{14}C-datings in the 1980s produced amazing results: four of the pluristratified sites (Bistricioara, Dârţu, Cetăţica I and II) provided ^{14}C-dates of c. 25–21 kyr uncal. BP for the Aurignacian and 24–18 kyr uncal. BP for the Gravettian (Păunescu 1996, 1998) (Table 1).

Recent excavations in the Moldavian Plains led to different results: the well documented profiles of Mitoc–Malu Galben (Prut, Eastern Romania) and Molodova (Dnistr, Ukraine) fit in the Central European timescale which puts the Aurignacian/ Gravettian transition between 27 and 28 kyr uncal. BP (Haesaerts et al. 2003, 2004). The radiocarbon record from the latter site is convincing not only because of the greater depth of the covering loess (from 5 to 8 m), but also because of its connection to some preserved interstadial episodes. The contradictory implications of the data set in the same topographical and ecological region are obvious, if workers do not expect—only for Eastern Romania—an exception of 5,000 years of overlapping technical traditions. Since no interstratification or mixing of Aurignacian and Gravettian toolkits has been observed, a focus on the multilayer sites provides useful answers to this question.

Results of Fieldwork in 2005–2006

The focus of this investigation is on new data from sites with long Upper Palaeolithic archaeological sequences. The sites of Bistricioara-Lutarie-I and Ceahlău-Dârţu in the Răpciuni Basin were thus the best choice, and were also the only two sites where it was possible to find the measurements of the older excavations. Therefore the new trenches can be pinpointed in the old plans (Figs. 3 and 4). While the site of Cetăţica-I can only roughly be relocated because of imprecise maps, the site of Cetăţica-II is situated on the lower terrace and was flooded in the early 1960s.

Bistricioara-Lutarie I

The site is situated on the 40m terrace of the Upper Bistriţa. A description of all investigations carried out so far was published by A. Păunescu (1998, 120–170). Given some landmarks, it was possible to correlate the 2006 trench with the plan of the excavations from 1957–1958 and 1980–1984 (Păunescu 1998, 121) (Fig. 3). By cutting through a part of trench C from Bistricioara-Lutarie-I, we could be sure to precisely border the old excavation area. According to the publication, the only old profile rich in content was situated in the middle part of trench 2 of Bistricioara-Lutarie-II, about 80 m from the new trench (Nicolăescu-Plopşor et al. 1966, 37). It was newly interpreted by A. Păunescu (1998, 122), when he tried to synthesize the pedological separated layers with the expected cultural units. Summarizing the publications and an unpublished field report (copy by M. Anghelinu, 2006), the stratigraphic-cultural succession is as follows (Table 2):

The synthetic profile of stratigraphic units of the Bistriţa Valley sites in connection with the general cultural succession (Nicolăescu-Plopşor et al. 1966, 17) confirms local observations in Bistricioara-Lutarie-II (Fig. 5). The new profile of our team

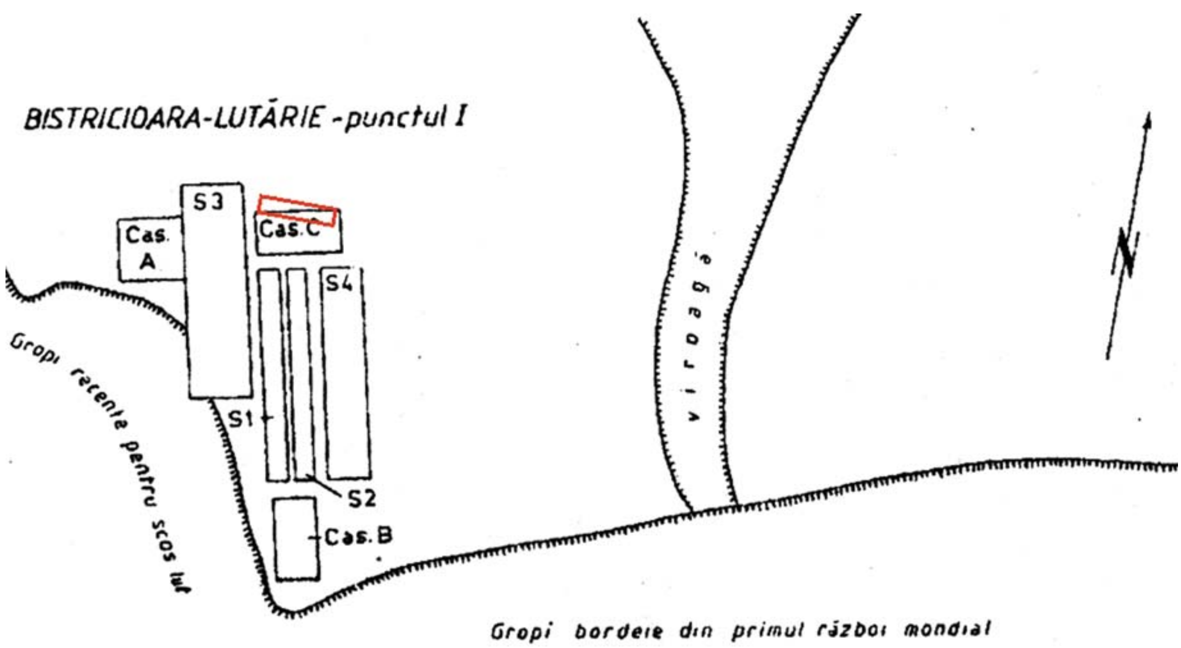


Fig. 3 Plan of the excavations in Bistricioara-Lutarie I (after Păunescu 1998, 121)

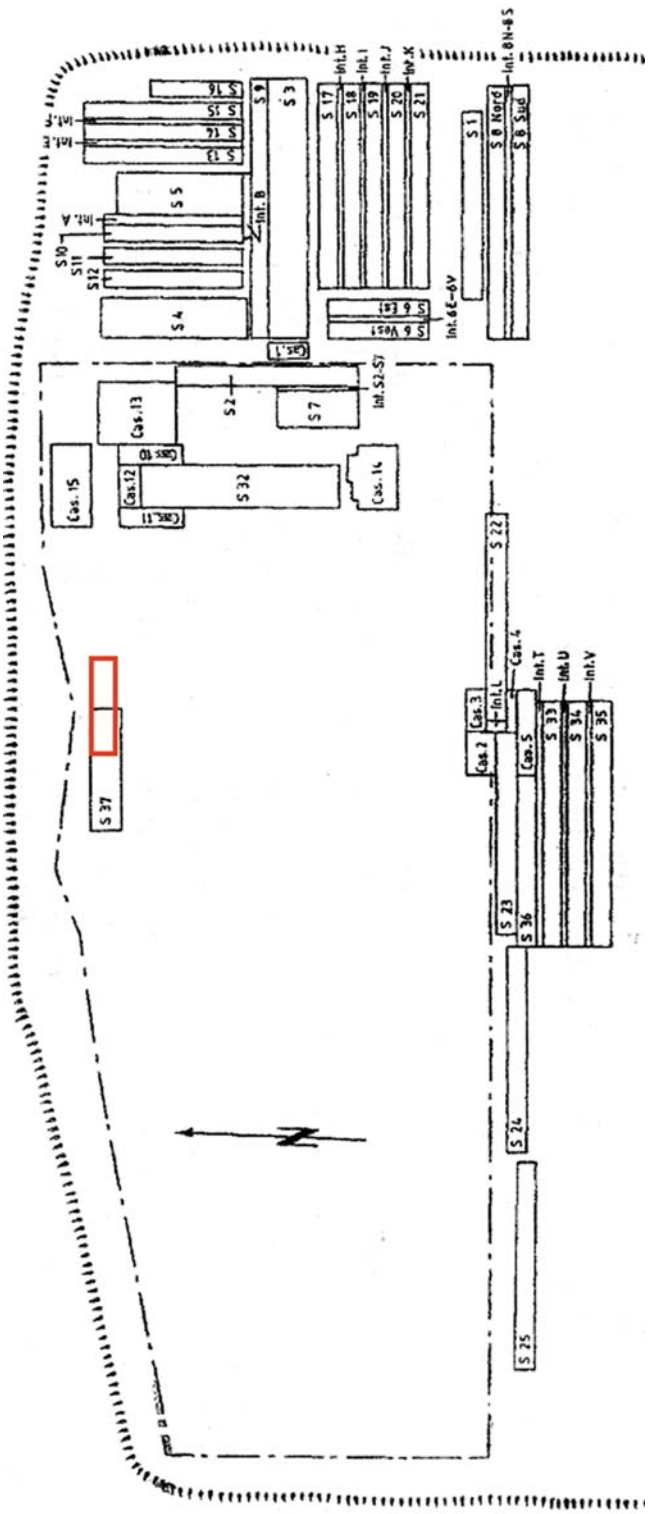


Fig. 4 Plan of the excavations in Ceahlău-Dârţu (after Păunescu 1998, 193)

Table 2 General stratigraphic-cultural succession in the Bistriţa Valley

0.20/ 0.30–0.50/ 0.60 m	A reddish-brown soil formation free of cultural layers. It is covered by a very thin grey loess layer containing the uppermost Gravettian level VI ("Epigravettian").
0.65/ 0.50–1.65/ 1.50 m	The whole Gravettian complex (levels II–V) is about 1m in depth, according to Păunescu (1998), and begins with level II ("Pre-Gravettian"). Nicolăescu-Plopşor et al. (1966, 37) call this cultural layer *"Aurignacien superieur."* At about 1.10 m Nicolăescu-Plopşor et al. (1966) describe a sedimentological change from the grey loess with pseudomycelian structures to decalcified reddish-yellowish loess.
1.10—1.80/ 1.90 m	Grey loess with pseudomycelian structures. In Bistricioara-Lutarie-II the lowest cultural layer "Aurignacian I" (= *Aurignacien moyen*) appears at 1.50 m as an ashy loess layer of about 0.20–0.30m. In other sections the "Aurignacian I" ^{14}C -samples were taken from 2.15 to 1.95 m (varying loess accumulation).
1.80/ 2.00—2.00/ 2.20 m	A reddish-greyish, reworked loess (0.2 m depth) without archaeological traces is deposited on the terrace base.

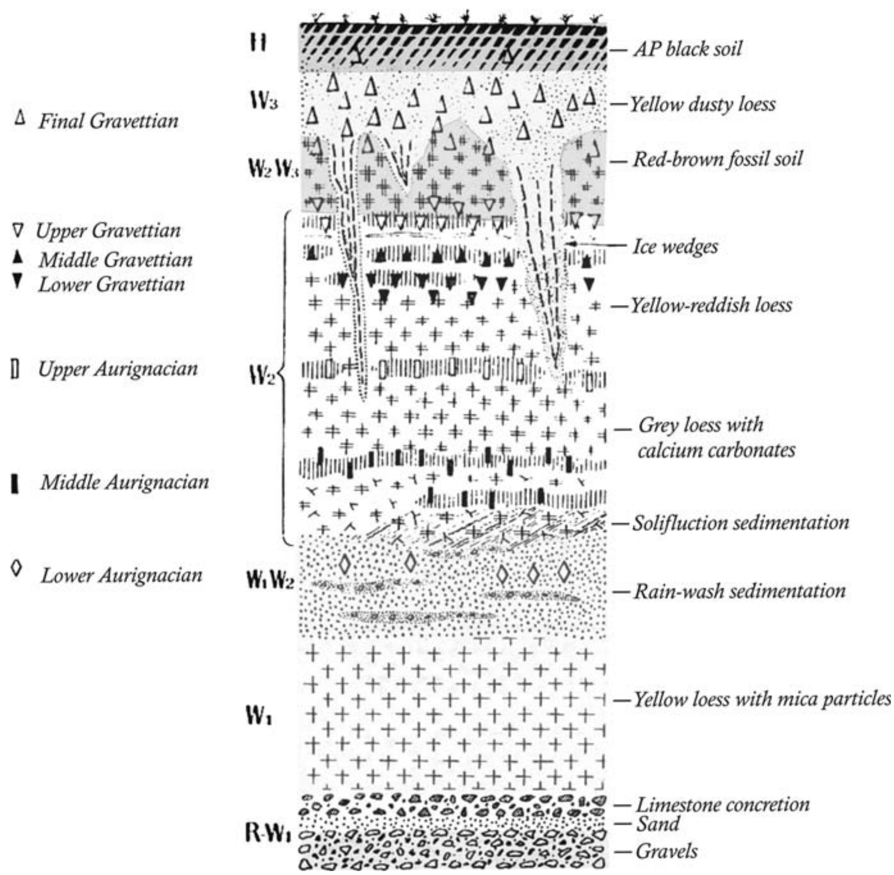


Fig. 5 Synthetic profile of the Bistriţa Valley (Nicolăescu-Plopşor et al. 1966, 17)

contains the same stratigraphic units (Fig. 6). The ^{14}C data of the charcoal concentrations in "hearth 2, 3, and 4" fits in the European framework: the unspecific Aurignacian inventory (called "Middle Aurignacian") now dates to about 27–28 kyr uncal. BP, and the lowermost Gravettian horizon to about 24–24.5 kyr uncal. BP (Table 1). The interesting question of an omnipresent soil formation (gelistagnic cambisol) in the upper part of the Bistriţa loess archives will be discussed elsewhere.

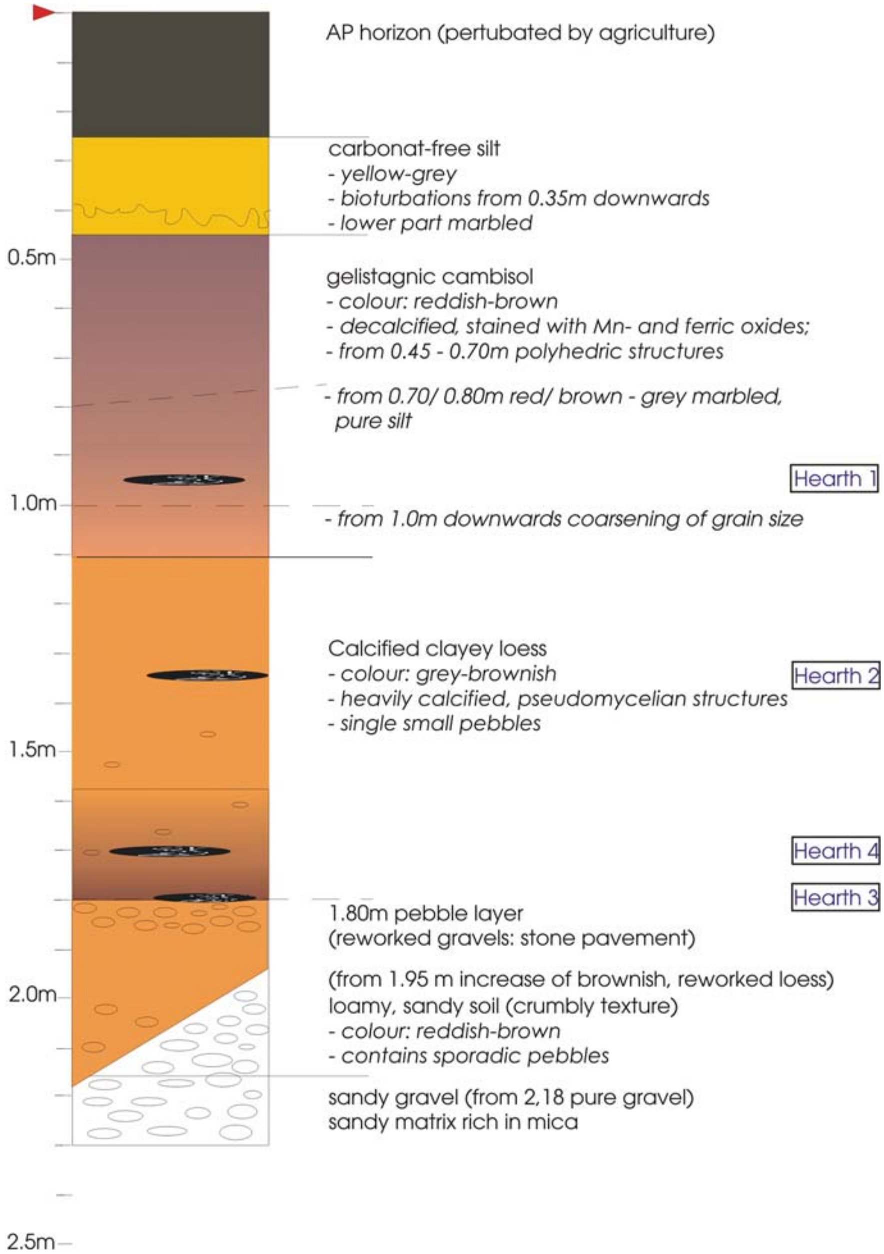


Fig. 6 Bistricioara-Lutarie I (2006)—synthetic profile North + West

In respect to the Aurignacian/Gravettian transition timeline, level II is the most interesting. It contains only Gravettian artefacts (Păunescu 1998, 138) and no single carinated piece or other Aurignacian implement. The lowermost level yielded only three typical carinated endscapers in an inventory of 1049 stone artefacts. A standardised bladelet production is missing, as is backed bladelet production in the lower Gravettian layer. Generally speaking, the standardisation of both layers is relatively poor. While the technological change is not very clear, the different raw material procurement can be taken as the most significant feature of the cultural change. In accordance with the Romanian terminology, the local lithic raw materials are "black schist" (a type of lydite) and the local "menilith." The latter black or dark brown silicious rock is characterised by a rhythmic lamination, due to the alternation between opal and organic (calcedony) sequences. Besides siliceous sandstone, these local raw materials are mostly represented by rounded pebbles or prismatic blocks in the river gravels. A completely different picture is given by the import of Cretaceous flint, probably only sourced in the 200 km distant Prut Valley. In Aurignacian level I, siliceous sandstone (42%) and black schist (30%) dominate, followed by 9% menilith, 8% flint, and 7% black sandstone. In contrast, the lowermost Gravettian level II inventory of similar size is predominated by flint with a white-blue patina (37%), followed by black schist (30%), menilith (21%), and siliceous sandstone (10%).

Ceahlău-Dârţu

The site of Ceahlau-Dârţu is situated on a plateau on the middle terrace of the right Bistriţa shore, about 5 km downstream from Bistricioara-Lutarie. It was investigated from 1955 to 1956 (Nicolăescu-Plopşor et al. 1966) and again in 1980 to 1983 (Păunescu 1998, 192–237). The excavations were done in regard to a cemetery from the early 20th century in the central part of the area. With the 2006 trench we again touched the old section "S 37" (Fig. 4).

The stratigraphy and depth of the loess deposits is very similar to that of Bistricioara-Lutarie. The earlier researchers pointed out that two Aurignacian ashy layers (I and II) were embedded in the greyish, pseudomycelian loess. The two older ^{14}C dates on layer I were won at a depth of 1.70 and 1.60 m and are approximately the same age as the Aurignacian from Bistricioara-Lutarie (Table 1). Levels III and IV are Gravettian and level V is Epigravettian (Păunescu 1998, 192–237). The new investigation can confirm the Aurignacian dating with 35.5 kyr BP for the depth of 2.30m below the ground and 30.5 kyr BP for the depth of 2.17 m, both measured on charcoal remains (Table 1). They were sampled at the base of the greyish pseudomycelian loess, which is heavily calcified and contains many fossil root channels. One remarkable fact is the sharp boundary between the greyish pseudomycelian and the upper reddish loess-loam at about 1.30 m below the surface. That boundary was obviously caused by water influence during soil formation—probably during the Late Glacial, which modified the texture and chemistry of the loess. This observation is supported by the pedogenetic lamination in its lower part, from 1.00 to 1.30 m below ground level (Fig. 7). The boundary also marks the chemical front of the pedogenetic decalcification.

Clear differences can be seen again between the lithic assemblages (Păunescu 1998):

- *Aurignacian I, lowermost level* (484 artefacts): 54% silicious sandstone, 37% black schist, 6% menilith, 2% flint, 1% yellowish marne stone;
- *Aurignacian II* (level II from the bottom, 1112 artefacts): 57% siliceous sandstone, 20% black schist, 12% menilith, 3% siliceous spongolite ("silicolit"), 7% flint, 1% yellowish marne stone;
- *Gravettian I* (level III, about 200 artefacts): 50% menilith, 45% flint, 5% black schist, 3 artefacts from siliceous sandstone, 1 from black sandstone;
- *Gravettian II* (level IV, 668 artefacts*):* 31% menilith, 59% flint, 7% black schist, 1% siliceous sandstone.

Again the main difference between the Aurignacian and Gravettian is the different raw material use, which changes from local sources to imported Prut flint. In addition, the *pinus* macroremains preserved as charcoal in the Aurignacian I layer mark a relatively temperate climate. The uppermost layer yielded a large Epigravettian inventory of about 10,000 lithic artefacts. More fieldwork has to be done here to document that succession in detail.

Poiana Cireşului

In addition to Bistricioara-Lutarie and Ceahlau-Dârţu in the upper Răpciuni Basin, the site of Poiana Cireşului—situated 60 km downstream near

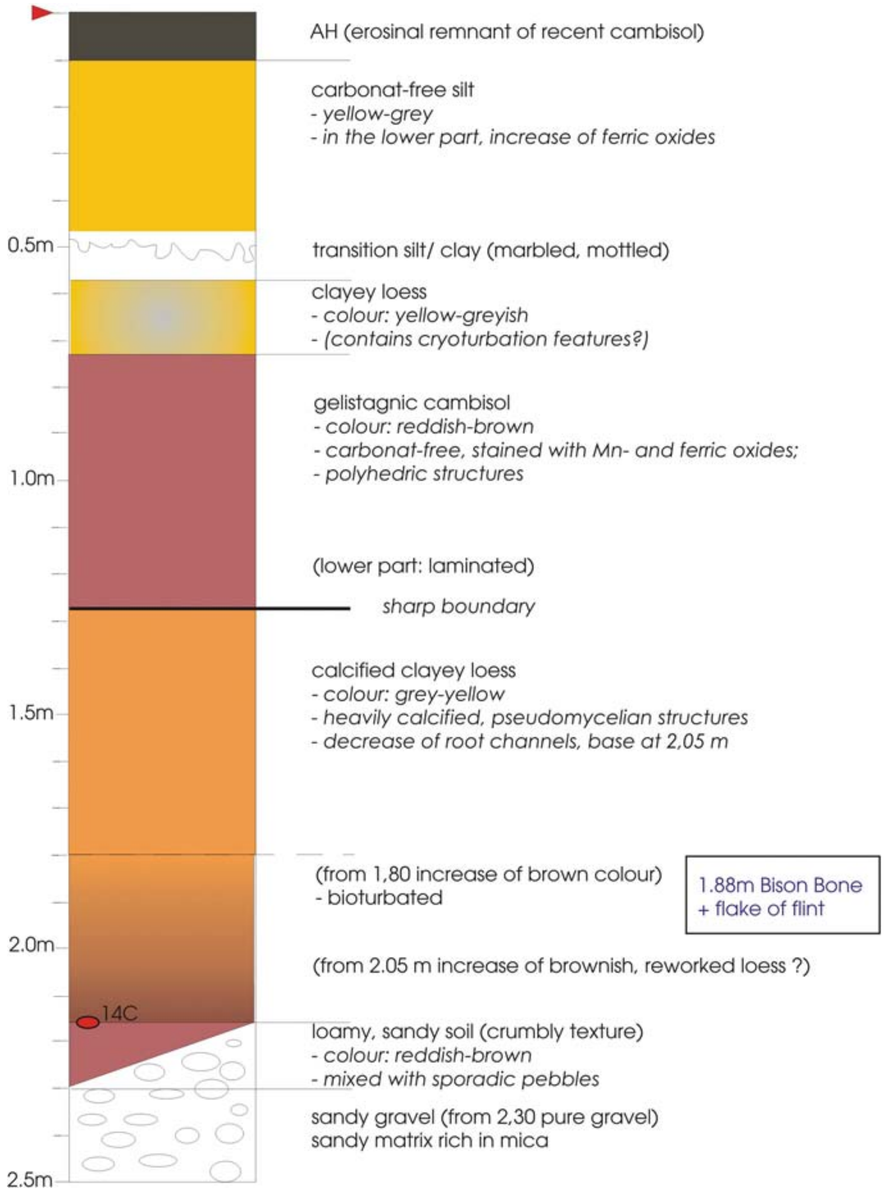


Fig. 7 Ceahlău-Dârţu (2006)—profile South

Piatra Neamţ—is embedded in a huge loess sequence which was not redeposited. The human occupations of Poiana Cireşului took place at the confluence of the small river Doamna and the Bistriţa, precisely in the spot where the river leaves the Eastern Carpathians mountain area (Fig. 2). The settlement is situated in a dominant position, on an erosion level cut into flysch deposits, roughly equivalent to the middle terrace of the Bistriţa River. Due to the relatively soft bedrock, the area surrounding the slope was seriously affected by erosion, landslides, and anthropogenic activity. The only area spared by these erosion processes is the northern "promontory" (around 200 m^2), which was a relatively flat area before anthropogenic changes (pathways) were made in historic times (Fig. 8). Today it is used as a meadow, marking the only glade on that forested slope. All archaeological investigations were concentrated here, while most of them uncovered only the uppermost Epigravettian layers. During the last phase of research (1998–2006), 47 m^2 were exposed through systematic excavation (Cârciumaru et al.

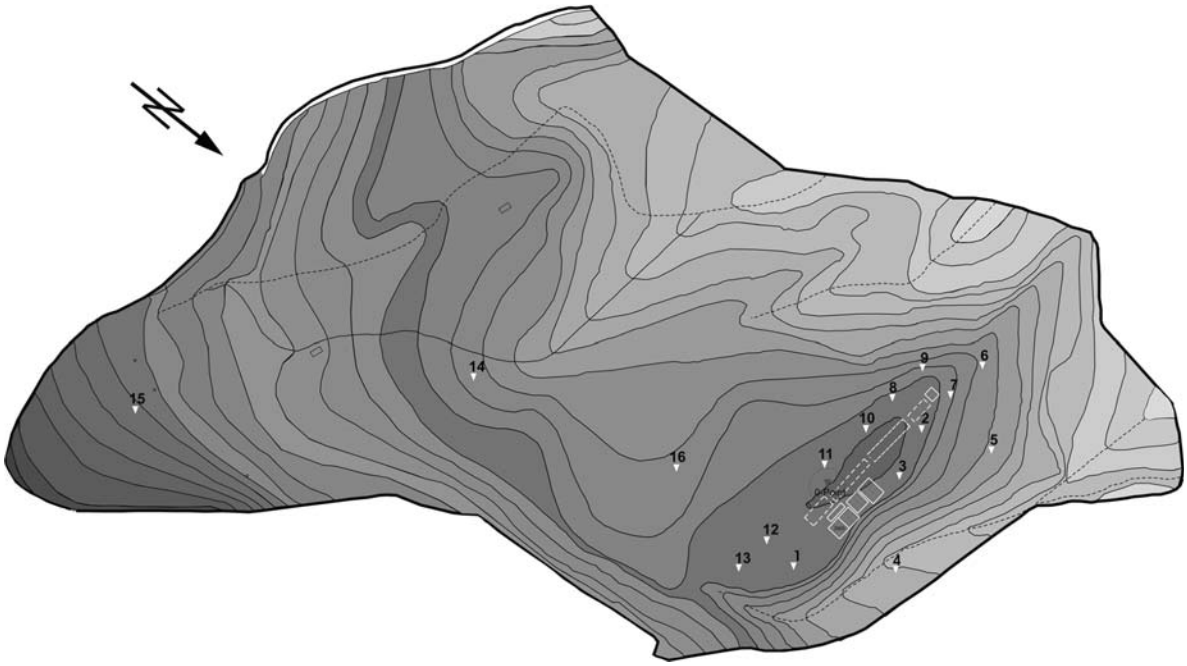


Fig. 8 Poiana Cireşului—Topographic map, location of excavation and drills

2006). Two Gravettian and two Epigravettian layers with a rich archaeological record have been recovered since then (Cârciumaru et al. 2006, 323–328). Before 2005, five main stratigraphical units were identified from the top down to 3.50 m: a Holocene cambisol, a yellow Late Glacial loess, a decalcified tundra-gley; a heavily carbonated clay-loessic layer and a calcic olive sandy-loessic layer. The lowermost known Gravettian layer (II) was ^{14}C-dated to 26,070 ± 340 uncal. BP (Beta 206707) (Cârciumaru et al. 2006, 321). This can be confirmed by four more AMS dates from the Erlangen lab, ranging from about 26.0 to 27.5 kyr uncal. BP (Table 1).

Although more than 4 m in depth were excavated in the campaigns since 1998, the loess base was still not reached. In order to obtain a general view of the lower parts of the loess sequence, 16 drillings were made during the 2005 season (Cârciumaru et al. 2006, 322) (Fig. 8). The first amazing observation was the length of the loess sequence, which reaches down to 7 m from the surface in the eastern area of the investigated plateau. The geological sequence from Poiana Cireşului displays clear similarities with the general stratigraphical succession from Bistriţa's middle terrace (Nicolăescu-Plopşor et al. 1966). The drills furthermore allow us to complete this succession with some new information, such as the presence of two soils below the lowest excavated layer. These incipient gelic gleysoils (synonymous with "tundra gley") formed under environmental conditions where loess sedimentation competes with pedogenesis and waterlogging due to permafrost (Antoine et al. 2001). In 2006, we opened a trench up to 7.50 m below the ground, continuing the investigation below the excavated sequence in the central part of the settlement. We recovered two more cultural layers embedded in the soils below the Gravettian II, represented by a significant charcoal accumulation from 5.05 to 5.25 m and a second one at about 6.15 m below zero (Fig. 9a and b). The same observation was made in 2005 from a drilling core nearby (drill 16),

Fig. 9 **a**,**b** Poiana Cireşului—Western stratigraphic profile, section V: middle and lower parts

where a bone fragment at a depth of 6 m and a flake at 6.80 m were found. A piece of charcoal from 6.90 m below zero in drill core 3 could be dated by AMS to 55,923 ± 12,196 uncal. BP (Erl-11858). Despite the large error, the data indicates a long succession with basal loesses next to the limit of radiocarbon measurement. Looking ahead, Poiana Cireşului contains an exceptional chance to record a loess sequence with both Aurignacian and Gravettian, with the relatively highest sedimentation rate known in the Bistriţa Valley. This site with its long stratigraphy can furthermore provide standard proxies of the palaeomagnetic intensity as a significant value of climatic change (pers. comm. U. Hambach).

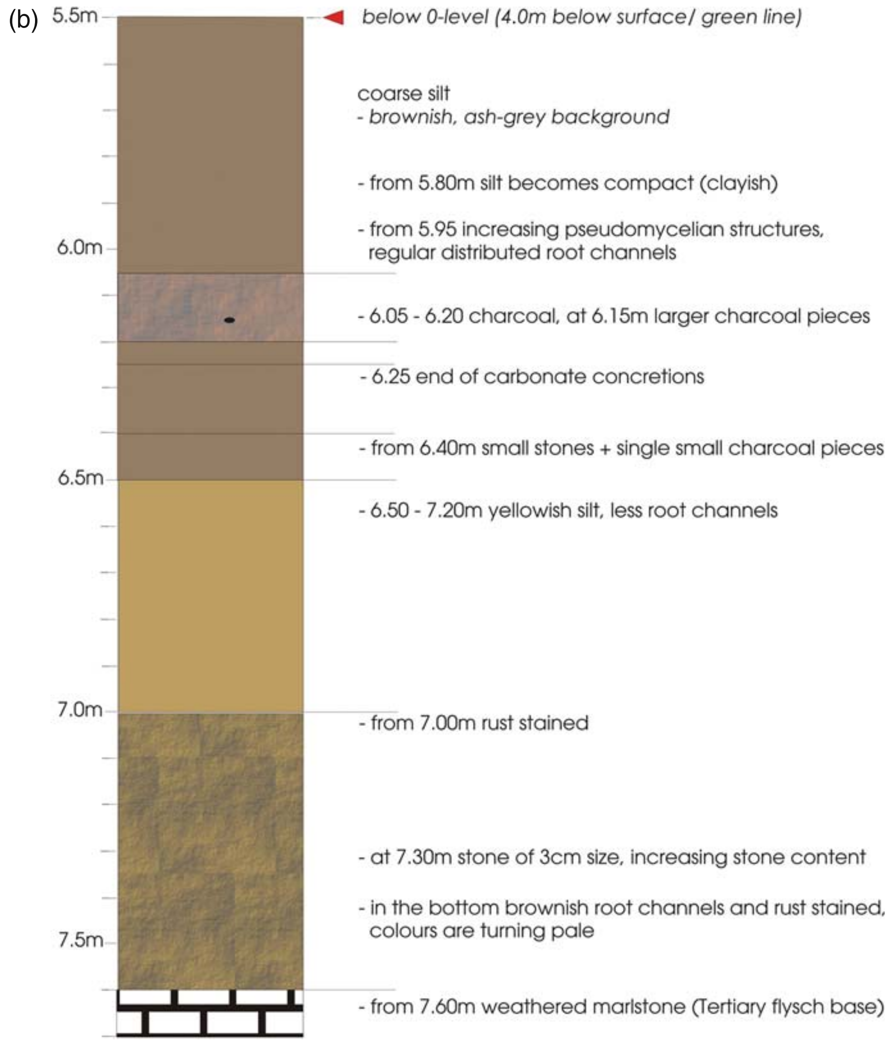


Fig. 9 (continued)

Conclusions

Three recently investigated East Carpathian sites with a long Upper Palaeolithic sequence displayed archaeological layers with Aurignacian and Gravettian inventories, and delivered AMS data compatible with Central and East Central Europe. All data were measured from charcoal samples. The new data series is consistent in its stratigraphical order, and fits together with geological observations of loess accumulation rates and soil formations. The significantly younger dates from A. Paunescu's sampling in the early 1980s could be caused by mixed materials. In some cases bone and charcoal were sampled together.

The assumption of a "Late Aurignacian" contemporary to the Gravettian in the Bistriţa Valley as one of the key regions in Southeastern Europe can now be rejected (Hahn 1977, 11–28, 298–304). While the circulation of lithic raw materials (Prut and Dnistr flint sources) is evidence of connections to the Moldavian-Ukrainian plains and the Northern Black Sea region, a synchronous development of the material culture in the wide plains east of the Carpathians is most likely. Some researchers consider an Epi-Aurignacian from 22–21 to 18–17 kyr uncal. BP there, especially in Lower Don River region and near the southern Bug River in the Ukraine (Demidenko and Nuzhnyi 2004; Demidenko 2008). Unfortunately, all these sites were excavated in the 1960s and 1970s, when standards of documentation were quite low (Demidenko 2008). Even when pollen records support an age determination around the LGM, typological attributes like small retouched microliths associated with atypical carinated endscrapers are the main arguments. If the old ^{14}C dates are likewise questionable, a refugium of Aurignacian toolkits in the Northern Black Sea region (which had no Gravettian, but only Epigravettian occupation) must be left for future investigations.

In addition to a better ^{14}C record, other dating strategies provide a large potential for the Eastern Carpathians: The northern boundary of the Campanian Ignimbrite (Y5), blown far to the northeast to Kostenki at the Don River (Pyle et al. 2006), has not been investigated in Eastern Romania so far. Besides the long sequences of Mitoc and Molodova, the site of Poiana Cireşului also has the potential to help solve this puzzle.

Acknowledgements I am very grateful to the whole Romanian-German team working in the Bistriţa Valley. Especially I want to thank Marin Cârciumaru and Mircea Anghelinu with their team from the University of Targoviste (Romania) for their close and friendly collaboration. At the same time I want to thank Ulrich Hambach from the University of Bayreuth (Germany) for his support concerning geology. Since 2006, the fieldwork has been supported by the German Science Foundation. A "thank you" to all students who participated in the fieldwork, and to Linda Owen for supporting me with the translation. Last but not least, I want to thank Marta Camps and Parth R. Cauhan for the fruitful UISPP colloquium in Lisbon.

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Modern Human Colonization of the Siberian Mammoth Steppe: A View from South-Central Siberia

Kelly E. Graf

Abstract Was the transition from the middle Upper Paleolithic (MUP) to late Upper Paleolithic (LUP) in Siberia the result of gradual, in situ cultural change or abrupt change that resulted from multiple recolonization attempts? Past studies have primarily focused on chronology and typology in attempts to reconstruct culture histories. As a result reconstruction of hunter-gatherer ecology has been limited to broad overviews and generalizations. Questions regarding the processes of human colonization have largely remained unanswered. Explaining the differences between MUP and LUP behavioral adaptations and decision-making in the Siberian mammoth steppe is critical to achieving full understanding of the process of human colonization of the North during the late Pleistocene. This study uses both radiocarbon and lithic technological data from MUP and LUP sites located in the Enisei River valley of south-central Siberia to address the problem from a more comprehensive behavioral perspective. Chronological data demonstrate the MUP and LUP in the Enisei region were separated by a 4000-year gap straddling the LGM, while lithic data suggest MUP foragers before the LGM were making different technological provisioning decisions than LUP foragers after the LGM. Results of this study indicate that the Siberian mammoth steppe was colonized during multiple dispersal events.

K.E. Graf (✉)
Center for the Study of the First Americans, Texas A&M University, College Station, TX, USA

Keywords Siberian Upper Paleolithic • MUP • LUP • Mammoth steppe • Last Glacial Maximum • AMS • Provisioning strategies

A long-time concern in Paleolithic archaeology has been to define large-scale transitions from one archaeological phase to another (e.g., Middle to Upper Paleolithic Transition) (Adams, 1998; Akazawa et al., 1998; Goebel, 1993; Klein and Edgar, 2002; Hoffecker, 2002). These large transitions are interesting and important in our understanding of human biocultural evolution; however, what about the countless small-scale transitions that are commonly neglected?

It is often an accumulation of small transitions that lead to the large changes we see in the archaeological record of hominid behavior and biocultural evolution (Kuhn, 2006). This chapter focuses on a small-scale transition: the "transition" from the middle Upper Paleolithic (MUP) to late Upper Paleolithic (LUP) in south-central Siberia. The MUP to LUP transition is a much less known, but not any less significant, transition that occurred in the evolution of modern human behavior, allowing modern humans to successfully spread into the periglacial regions of the North (Straus, 1995; Goebel, 1999, 2002).

Modern Human Dispersal into Northern Asia

Modern humans dispersed into temperate regions of the globe such as Australia and Europe rather rapidly (Gamble, 1994; Klein, 2000; Lahr and Foley,

M. Camps, P. Chauhan (eds.), *Sourcebook of Paleolithic Transitions*, DOI 10.1007/978-0-387-76487-0_32,

1994); however, their expansion into empty, periglacial regions of northern Eurasia may have been an episodic process, taking tens of thousands of years (Goebel, 1999). Upper Paleolithic settlement of northern landscapes was constrained by extreme environmental challenges that required the development of complex technological and behavioral adaptations (Binford, 1990; Hoffecker, 2002; Oswalt, 1987). Today, the Arctic extends south to latitudes between 70°N and 60°N (Krupnik, 1993; Young, 1989); however, during the late Pleistocene, arctic conditions extended much further to the south—as far as 50°N (Velichko, 1984; Vorob'eva and Medvedev, 1984; Zykina, 1999, 2003). The climate across northern Eurasia during the late Pleistocene would have been extremely continental and cold, producing a Holarctic (often treeless) biome that sustained large herbivorous faunal populations; a biome often referred to as steppe-tundra (Vereshchagin and Baryshnikov, 1982; Yurtsev, 1982) or mammoth steppe (Guthrie, 2001) (Fig. 1). Consequently, the dispersal of modern humans into the mammoth steppe was a significant event in our past—one involving important changes in technology and behavior.

What We Know About the MUP and LUP in Siberia

Hundreds of archaeological sites with Paleolithic cultural occupations are known in Siberia. Many sites are not dated by absolute techniques, but are assigned to the Paleolithic based either on stratigraphic contexts and/or typological comparisons (e.g., Abramova et al., 1991; Astakhov, 1986). Of these, at least 100 sites have been dated by radiometric methods (Vasil'ev et al., 2002), and most are situated along major river drainages and occur south of 55°N latitude (Fig. 2).

Although several sites reported to have Lower Paleolithic artifacts have been offered as evidence for initial human populations in Siberia (Astakhov, 1986; Chlachula, 2001; Drozdov et al., 1990, 1992, 1999; Mochanov, 1988, 1993; Okladnikhov, 1972; Okladnikhov and Pospelova, 1982; Okladnikhov and Ragozin, 1984; Waters et al., 1997, 1999), the earliest unequivocal evidence comes from a handful of southern Middle Paleolithic sites dating from about 125,000 to 50,000 years ago, and located in relatively temperate regions (Abramova, 1984; Goebel, 1999; Powers, 1973). Based on lithic typology, these sites likely represent a far eastern incursion into the area by Neanderthals (Astakhov, 1990; Derevianko, 1998; Derevianko and Markin, 1990; Goebel, 1993; Goebel et al., 1993; Vasil'ev, 2001).

Southern Siberia was first settled by anatomically modern human populations, represented by early Upper Paleolithic industries, as early as 46,000 calendar years before present (cal) BP (Bazarov et al., 1982; Dolukhanov et al., 2002; Goebel, 1993, 1999, 2004a; Goebel and Aksenov, 1995; Goebel et al., 1993; Lbova, 1996; Muratov et al., 1982). Similar to earlier hominids, early modern humans do not seem to have penetrated subarctic Siberia. Modern human settlement of the subarctic did not transpire until about

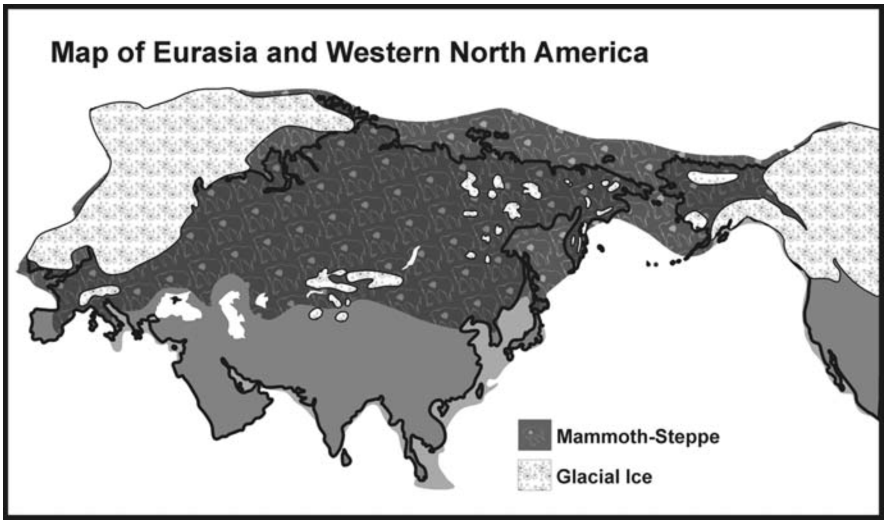

Fig. 1 Map of R. Dale Guthrie's mammoth steppe (after Guthrie, 1990)

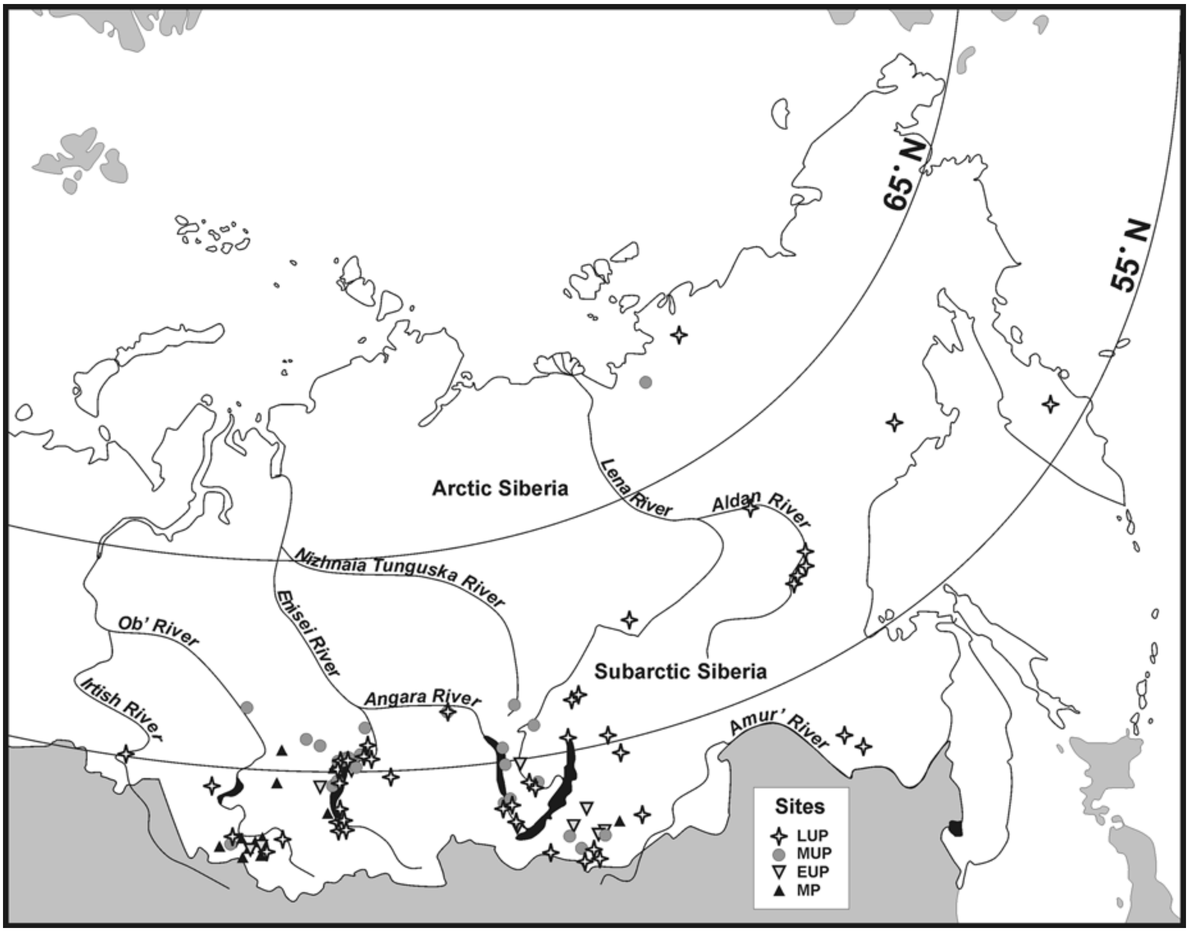

Fig. 2 Map of Siberia with locations of major paleolithic sites

33,000 cal BP, when MUP hunter-gatherers may have spread as far north as 71°N, as evidenced by the Yana RHS Upper Paleolithic site (Pitulko et al., 2004).

The MUP occupation of Siberia lasted for about 9,000–10,000 years (33,000–24,000 cal BP), and is represented by typical Upper Paleolithic technologies broadly similar to those found in other regions of Eurasia during this time period (Goebel, 1999; Vasil'ev, 1993, 2000). MUP technologies are characterized by flake and blade[1] production on fine-grained silicate raw materials (or toolstones) (Fig. 3). Blade size is variable, with small blades or bladelets being most common. Although formal microblade[2] technologies appear to be absent (Abramova, 1989; Goebel, 1999, 2002), some have argued that they were actually incipient in the MUP (Derevianko, 1998; Kuzmin and Keates, 2005a, b; Kuzmin and Orlova, 1998; Lisitsyn, 2000). Secondary reduction is characterized by unifacial, bifacial, and burin technologies, and tool forms include end scrapers, side scrapers, bifaces,[3] gravers, burins, and retouched

[1] MUP blade cores are typically of the informally produced, "flat-faced" blade core variety noted in early Upper Paleolithic sites of Siberia (Goebel, 1993). Only when they are heavily reduced do they take-on a subprismatic shape.

[2] Microblades are defined as very standardized, miniature blades measuring 8 mm or less in width and less than 20 mm in length with the width maintained along the entire length of the blade. Also, these are detached from specially prepared microblade cores (Abramova, 1971, 1979b; Anderson, 1970; Markin, 1986).

[3] Bifaces in MUP and LUP assemblages were not hand-axes. MUP bifaces may have been choppers, knives, or scrapers. LUP bifaces could have been projectile points, knives, scrapers, or wedge-shaped core performs.

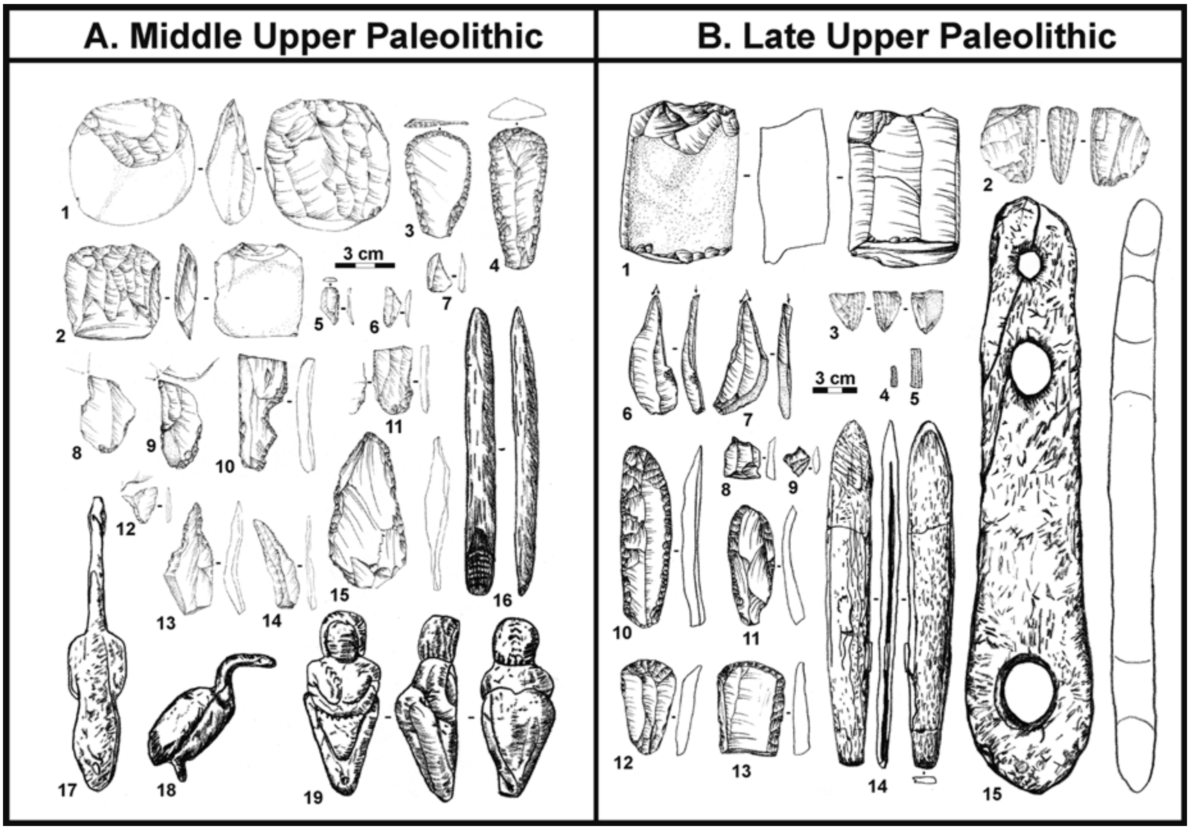

Fig. 3 Middle Upper Paleolithic (**A**) artifacts: flat-faced blade core (A.1); bladelet core (A.2); end scrapers (A.3–4); retouched bladelets (A.5–7); burins (A.8–9); notch (A.10); retouched blade (A.11); gravers (A.12–13); retouched blade-like flake (A.14); side scraper (A.15); bone point (A.16); ivory figurines (A.17–18: birds, A.19: Venus). A.1–4, A.9–10, A.15: Sabanikha (Enisei River); A.5–8, A.11–14: Afanas'eva Gora (Enisei River); A.17–19 Mal'ta (Angara River). (A.1–15 drawn by author; A.16 redrawn from Lisitsyn, 2000; A.17–19 redrawn from Abramova, 1995). Late Upper Paleolithic (**B**) artifacts: subprismatic blade core (B.1); wedge-shaped microblade core (B.2); *tortsovyi* microblade core (B.3), retouched microblade mid-sections (B.4–5); burins (B.6–7); gravers (B.8–9); side scrapers (B.10–11); end scrapers (B.12–13); slotted ivory point with intact microblade mid-section (B.14); ivory *bâton de commandement* (B.15). B.1–3, B.6–8, B.10–13: Kokorevo-1 (Enisei River); B.4–5: Kokorevo-2 (Enisei River); B.9: Kokorevo-3 (Enisei River); B.14–15: Listvenka (Enisei River). (B.1, B.6–8, B.10–13 redrawn from Abramova, 1979b; B.2–5 drawn by author; B.9 redrawn from Abramova, 1979a; B.14–15 redrawn from Akimova, et al. 2005)

blades and flakes. Osseous tools (e.g., awls, needles) and nonutilitarian artifacts (e.g., beads, figurines) are common. Faunal assemblages primarily include mammoth, reindeer, woolly rhinoceros, bison, horse, red deer, hare, wolverine, fox, and birds (Ermolova, 1978; Vasil'ev, 2003b). Large semisubterranean dwellings (often slab-lined with storage pits and hearths) were constructed, and a wide variety of site types are reported (Abramova, 1989, 1995; Abramova et al., 1991; Bokarev and Martynovich, 1992; Ermolova, 1978; Medvedev, 1982; Vasil'ev, 2000, 2003a).

During the Last Glacial Maximum (LGM), roughly 23,500–19,000 cal BP (Bowen et al., 2002; Owen et al., 2002; Yokoyama et al., 2000), large ice sheets expanded across northwestern Eurasia, climatic conditions were extremely harsh, and large mammal populations declined (Guthrie, 2003; Svendsen et al., 2004). Sites dating to this time are rare in Siberia and central Asia (Davis, 1998; Davis and Ranov, 1999; Dolukhanov et al., 2002; Goebel, 1999; Graf, 2005; Surovell et al., 2005), suggesting possible abandonment of the north by humans (Fig. 4). This idea has been rejected by some who argue that site density decline could be the result of sampling biases and postdepositional processes, and sufficient evidence indicates sustained settlement

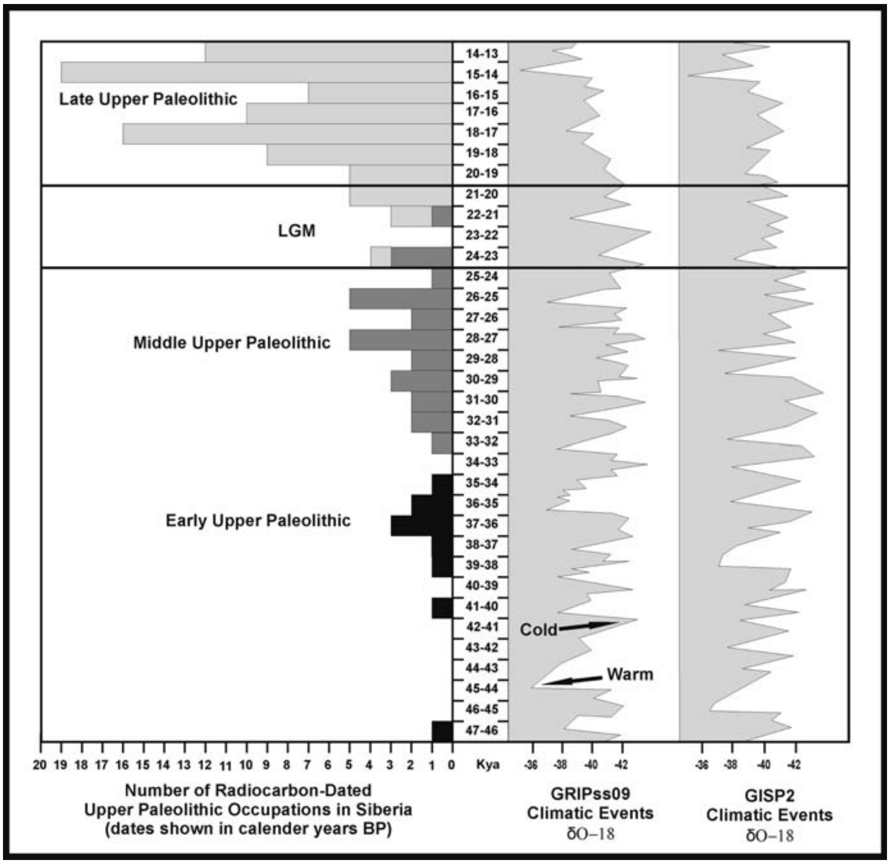

Fig. 4 Number of radiocarbon-dated human occupations across Siberia (data from Goebel, 2004a, b; Vasil'ev et al., 2002) alongside the GRIPss09 and GISP2 oxygen-18 curves showing warm and cold oscillations during the last third of the Upper Pleistocene (data from Johnsen et al., 2001; from Graf, 2005)

of Siberia during the LGM (Barton et al., 2007; Kuzmin and Keates, 2005a, b; Kuzmin and Orlova, 1998; Surovell and Brantingham, 2007; Vasil'ev et al., 2002).

As climate ameliorated following the LGM, LUP sites and associated technologies emerged in southern Siberia and soon after appeared north and east in arctic Siberia and Alaska by 14,000 cal BP (Dolukhanov et al., 2002; Goebel, 1999; Hoffecker and Elias, 2007; Vasil'ev et al., 2002; Yesner, 2001). LUP tool stones are predominantly fine-grained silicates, and primary reduction is typified by bifacial wedge-shaped and *tortsovyi*[4] microblade core technologies as well as blade and flake core technologies (Fig. 3). Microblades are exceedingly standardized, measuring 5–8 mm wide (Abramova, 1971; Anderson, 1970; Markin, 1986). Secondary reduction is characterized by unifacial, burin, and bifacial technologies. Common tool forms are transverse burins, large side scrapers, small end scrapers, gravers, retouched microblades, retouched blades, and retouched flakes. Osseous implements consist of slotted points and knives inset with microblade midsections (Abramova et al., 1991), and beads and pendants are typical nonutilitarian artifacts. Faunal remains include reindeer, red deer, bison, mammoth, roe deer, argali sheep, wolf or dog, hare, fox, and birds (Ermolova, 1978; Vasil'ev, 2003b). Single mammal species often dominate faunal assemblages (Goebel, 1999). Dwellings, when present, are ephemeral, containing a central hearth with few lithic and faunal remains (Vasil'ev, 2003a). Sites typically occur on low terraces near

[4] The closest English approximation of the Russian term "tortsovyi" is "end." Tortsovyi microblade cores are produced on flakes, sometimes cobbles, in which microblades are detached from the ends or margins of the flake or cobble (Abramova, 1979b). In contrast, wedge-shaped microblade cores begin as bifaces.

rivers and lack interassemblage variability (Abramova, 1979a, b; Abramova et al., 1991; Derevianko, 1998; Ermolova, 1978; Petrin, 1986; Vasil'ev 1992).

The MUP to LUP Transition in Siberia: Lingering Issues

Archaeologically, the transition from MUP to LUP in Siberia is most characteristically distinguished by the addition of microblade technologies to the tool-making repertoire. Typically, the transition is viewed as a gradual process with in-place development of microblades directly from Siberian MUP blade technology (Derevianko, 1998; Lisitsyn, 2000). In contrast, Goebel (1999, 2002) has viewed the transition as abrupt, resulting from the sudden appearance of microblades after a hiatus in cultural occupation (Goebel, 1999, 2002). This disagreement seems to center on differing ways researchers explain technological change in prehistory and the problematic dating of several MUP and LUP cultural occupations.

Microblade Emergence and Technological Change

Since early Soviet times and the inclusion of Marxist thought in socio-economic studies, Russian archaeology has been considered a historical science with archaeologists explaining cultural change as the result of in-situ evolution of one cultural phenomenon into another (Davis, 1983; Gellner, 1980). Archaeological technologies have deep-seated origins within previous technologies in an area. Therefore, microblades emerged slowly from in-situ microlithization of blade technology of the MUP (Artem'ev, 2003; Derevianko, 1998; Derevianko et al., 2003; Lisitsyn, 2000; Mochanov, 1977; Vasil'ev, 1996).

Although specific definitions of microblade core reduction techniques are available in the literature (Abramova, 1979b; Anderson, 1970; Artem'ev, 1999; Bleed, 2002; Flenniken, 1987; Kobayashi, 1970; Markin, 1986), many studies ignore these exact definitions and assign exhausted subprismatic cores and associated bladelets as "microcores" and "microblades" (Derevianko et al., 2003; Lisitsyn, 2000, 1987; Vasil'ev, 1996). A direct link is assumed between the increased use of small blades in MUP sites and use of the formal microblade technologies of the LUP. Therefore, MUP bladelet technologies are regularly suggested as the progenitors of wedge-shaped and *tortsovyi* microblade technologies (Akimova et al., 2003; Artem'ev, 2003; Lisitsyn, 2000; Vasil'ev, 1996). If this was the case, then why did LUP flint-knappers continue to produce small blades after microblade technologies were invented? Surely small blade cores and bladelets could have resulted from cores with relatively long use-lives and may have nothing to do with the appearance of microblades. Goebel (1999, 2002) contends that the specialized wedge-shaped and *tortsovyi* microblade cores and associated composite microblade tools of the LUP may actually have roots outside of Siberia.

Timing of Microblade Emergence and LGM Abandonment

The exact timing of microblade emergence is riddled with several problems. Not only are there disagreements about what microblades represent, but problematic dating of sites has further muddied the waters. If the transition from the MUP to LUP entailed gradual emergence and incorporation of microblades into pre-existing Siberian Upper Paleolithic toolkits, then there should be overlap in time between the two techno-complexes. In contrast, if the transition was abrupt and microblade technology was novel to Siberian LUP toolkits, then there should be a chronological gap between MUP and LUP sites.

Goebel (2002) proposed a chronological gap and abrupt transition of the MUP to LUP, pointing mainly to the equivocal nature of dates reportedly spanning the LGM. Goebel (1999, 2002) suggests MUP human populations dwindled to archaeologically invisible levels during the LGM because the Siberian landscape lacked crucial fuel supplies necessary for human survival. Similarly, other treeless Asian biomes may also have been devoid of humans during this harsh climatic event (Davis and Ranov, 1999).

Recent work investigating the latest Pleistocene human colonization of the high Tibetan Plateau and the potential use of yak dung as an alternative fuel source suggests the amount of dung needed to survive may not have been available until human pastoralists domesticated the yak (Brantingham et al., 2007; Madsen et al., 2006; Rhode et al., 2007). Therefore, dung may have been an unreliable fuel source during the LGM since large mammal numbers were low at this time. In Goebel's (1999, 2002) scheme, humans recolonized Siberia after the LGM, when large mammal populations and trees increased and fuel resources were more readily available. This recolonization event is recognized by the post-LGM arrival of the LUP and associated microblade technologies (Goebel, 1999, 2002, 2004b). Various analyses of the radiocarbon (^{14}C) data from Siberia have been found to support his interpretation (Dolukhanov et al., 2002; Graf, 2005; Surovell et al., 2005).

In contrast, Kuzmin and Keates (2005a, b; Vasil'ev et al., 2002) argue that several sites date to the LGM, and abandonment did not occur. Such sites include the MUP cultural layers from Tomsk and Shestakovo (Cultural Layer 17) in the Ob' River region, Tarachikha, Shlenka, and Ui-1 (Cultural Layer 2) in the Enisei River region, Ust' Kova and Mal'ta in the Angara River region and LUP layers from Mogochino-1 and Shikaevka-2 in the Ob', Novoselovo-6 in the Enisei, Krasnyi Iar-1 in the Angara, Studenoe-2 in the Transbaikal region, Mamakan-2 and Tesa in upper Lena River drainage, and Ikhine-2 and Verkhne Troitskaia in Iakutia. Each case is problematic; either the age is based on a single date from a cultural occupation, the geologic context of the date is questionable, or the date is incongruent with other associated ^{14}C determinations from the site. Pettitt et al. (2003) have warned against these various problems, arguing that archaeologists should consider such ^{14}C age determinations unreliable.

Keeping Pettitt et al.'s (2003) concerns in mind, the only compelling LGM-aged ^{14}C date comes from the Mal'ta burial: 19,880 ± 160 (OxA-7129) BP (Richards et al., 2001). Although it does not overlap with other dates from the site (Medvedev et al., 1996), it is a direct age determination on human bone and, as reported, seems to have resulted from a properly pretreated sample (Richards et al., 2001). More dates will confirm the reliability of this age determination, but as it stands, this direct date on human remains suggests MUP peoples may have lingered in the Angara River valley until the very beginning of the LGM at about 24,000 cal BP. Even if this Mal'ta date can be replicated, it does not suggest a direct tie to the LUP sites that seem to post-date the LGM. Clearly, we need to better understand the age and character of the first microblade technologies in Siberia, and studies testing chronological gaps and technological differences need to be undertaken on a site-by-site and region-by-region basis.

The above interpretations have been largely based on the development of chronologies and typologies (Abramova et al., 1991; Akimova et al., 2005; Derevianko, 1998). Recently, a few attempts have focused on reconstructing Upper Paleolithic hunter-gatherer behaviors that generated site assemblages (Goebel, 2002, 2004a; Vasil'ev, 1996), but most of these are limited to literature reviews (Goebel, 1999, 2004b; Vasil'ev, 1992, 1993, 2000). Considerations of MUP and LUP hunter-gatherer ecology and adaptive responses are largely lacking. As a result, the questions addressed above remain unanswered.

In this chapter, I take a first step in addressing the emergence of microblades and abandonment issues by comparing blade and microblade technologies of the MUP and LUP from one region—the Enisei River in south-central Siberia. By doing so, I characterize the nature of the transition in this region to explain how it relates to the colonization of the Siberian mammoth steppe.

Enisei River-Front Property: Sites and Lithic Assemblages

Sites considered here are located along the Enisei River between the city of Krasnoiarsk to the north and the small village of Maina to the south (Fig. 5). For several reasons, this region provides an interesting laboratory for pursuing the MUP to LUP transition. First, the area has witnessed intensive archaeological fieldwork during the past century, providing several Upper

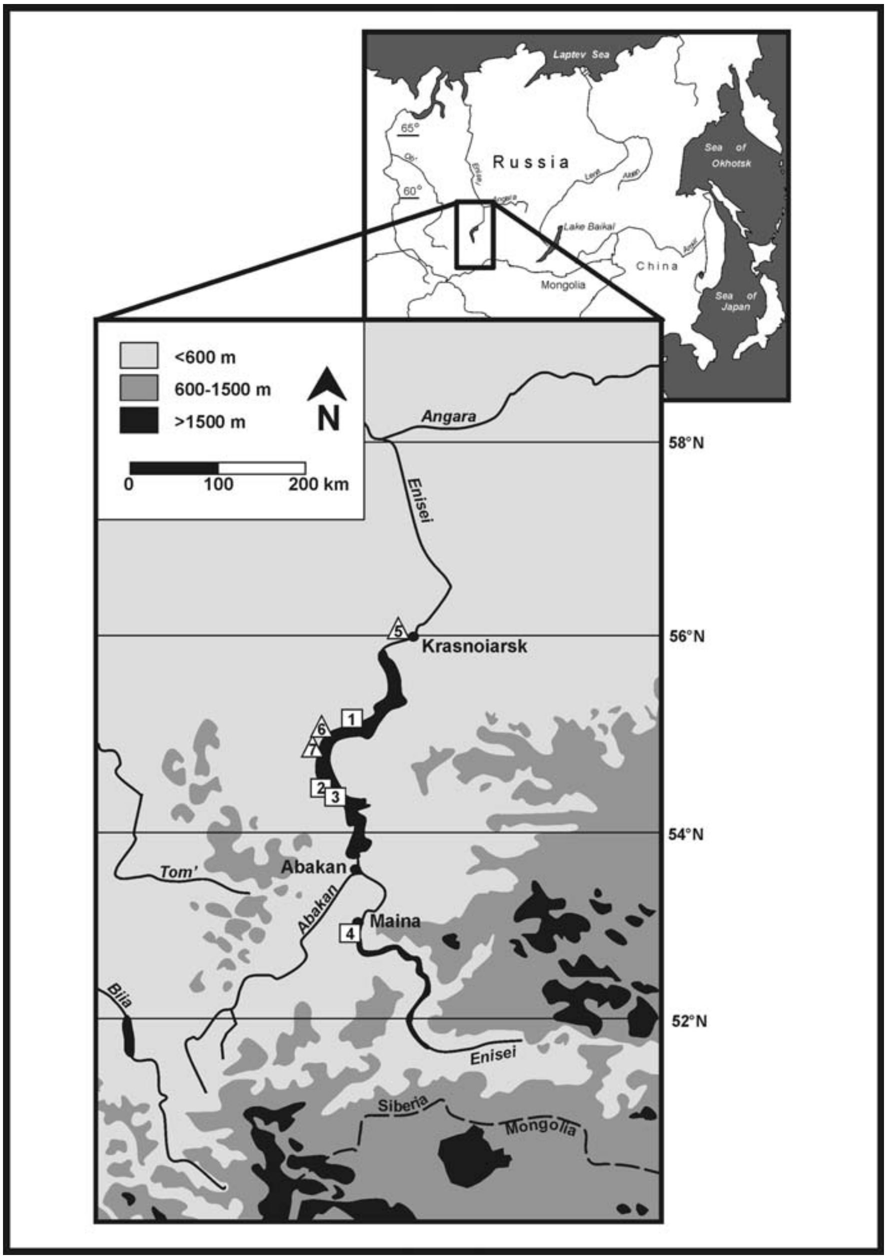

Fig. 5 Site location map. MUP sites: (1) Kurtak-4, Kurtak-5; (2) Afanas'eva Gora; (3) Sabanikha; (4) Ui-1. LUP sites: (5) Afontova Gora-2, Afontova Gora-3; (6) Novoselovo-7; (7) Kokorevo-1, Kokorev-2

Paleolithic sites clustered in a single region. Second, several artifact assemblages are relatively large, and from well-documented and buried contexts. Finally, the Enisei River valley has also been the focus of much paleoecological work, providing a place where paleoenvironments can be reconstructed for large parts of the last glacial cycle (e.g., Frechen et al., 2005; Haesaerts et al., 2005; Nemchinov et al., 1999; Tseitlin, 1979; Zander et al., 2003). Chronological considerations and lithic analysis presented in this chapter come from five MUP and five LUP sites briefly discussed below.

Studied materials came from MUP and LUP cultural layers from sites positioned in loess or fluvial deposits of river terraces along the Enisei River (Table 1). Artifact distributions and features are generally well-documented for these sites, and all

Table 1 Assemblage data for MUP and LUP sites

Site; latitude	Cultural layer	Dates[a,b]	Lithic assemblage samples: Debitage	Cores	Tools	Total	References
MUP							
Sabanikha; 54°35′N	Main	26,950–21,940 ^{14}C BP 31,500–26,500– cal BP	1,218	69	357	1,644	Lisitsyn (2000)
Kurtak-4; 55°10′N	1	26,230–23,070 ^{14}C BP 31,000–27,600 cal BP	1,163	84	44	1,291	Lisitsyn (2000), Svezhentsev et al. (1992) and Drozdov et al. (1990)
Kurtak-5; 55°10′N	Main	26,000–23,000 ^{14}C BP 31,000–27,500 cal BP	4	8	51	63	Lisitsyn (2000)
Ui-1; 52°58′N	2	23,890–16,520 ^{14}C BP 28,800–19,600 cal BP	1,247	75	173	1,495	Vasil'ev (1996) and Vasil'ev et al. (2005)
Afanas'eva Gora; 54°40′ N	Main	≥20,000 ^{14}C BP ≥24,000 cal BP	1,209	51	205	1,465	Lisitsyn (2000)
LUP							
Novoselovo-7; 55°00′N	Main	16,200–13,900 ^{14}C BP 19,500–15,500 cal BP	1,245	84	133	1,462	Abramova (1979b) and Lisitsyn (1996)
Afontova Gora-2; 56°00′N	C_3	21,500–20,300 ^{14}C BP 26,000–24,400 cal BP	15	16	62	93	Tseitlin (1979), Astakhov (1999) and Abramova et al. (1991)
Afontova Gora-3; 56°00′N	2	16,000–13,500 ^{14}C CP 19,000–15,300 cal BP	179	188	420	787	Astakhov (1999)
Kokorevo-1; 54°56′N	2-3	16,400–12,400 ^{14}C BP 19,500–14,300 cal BP	1,190	75	158	1,423	Svezhentsev et al. (1992), Abramova (1979a) and Abramova et al. (1991)
Kokorevo-2; 54°56′N	Main	13,530–11,890 ^{14}C BP 16,300–13,800 cal BP	1,300	112	286	1,698	6,1

[a] Radiocarbon ages are given at 2-σ. These were calibrated using the Calib 5.0.1 (Intcal04 Curve) program (Reimer et al., 2004) for dates ≤21,300 ^{14}C BP and CalPal-Online (Calpal 2005 SFCP Curve) (Danzeglocke et al., 2005) for dates >21,300 ^{14}C BP.
[b] No radiocarbon dates have been reported for Afanas'eva Gora and Afontova Gora-3. Ages for these sites are based on correlation with radiocarbon-dated sites in similar stratigraphic situations.

Table 2 AMS radiocarbon samples and ages

Site	Provenience (cultural layer; excavation square)	Lab number	Material	$\delta\,^{13}C$	F Value	Age estimate
Sabanikha	CL	AA-68665	Bulk Charcoal (*Picea*/*Larix*)	–22.5	0.0368±0.0011	26,520 ± 250
Sabanikha	CL	AA-68666	Bulk Charcoal (*Picea*/*Larix*)	–24.4	0.0395±0.0012	25,960 ± 240
Sabanikha	CL	AA-68667	Bulk Charcoal (*Picea*/*Larix*)	–24.0	0.0410±0.0013	25,660 ± 250
Kurtak-4	Upper CL; K28-30/L28-29	AA-68668	Hearth Charcoal (*Picea*)	–23.7	0.0315±0.0012	27,770 ± 310
Kurtak-4	Upper CL; K28-30/L28-29	AA-68669	Hearth Charcoal (*Picea*)	–23.6	0.0436±0.0015	25,160 ± 280
Kurtak-4	Upper CL; K28-30/L28-29	AA-68670	Hearth Charcoal (*Picea*)	–24.8	0.1099±0.0016	17,740 ± 120
Novoselovo-7	CL; A5	AA-68674	Bone	–19.3	0.1794±0.0032	13,800 ± 140
Novoselovo-7	CL; A4	AA-68672	Bone	–18.3	0.1868±0.0032	13,480 ± 140
Afontova Gora-2	C3; D2	AA-68663	Dispersed Charcoal (*Salix*/*Calluna*)	–25.4	0.1757±0.0017	13,970 ± 80
Afontova Gora-2	C3; D2	AA-68664	Dispersed Charcoal (*Salix*/*Calluna*)	–25.0	0.1778±0.0018	13,870 ± 80
Afontova Gora-2	C3; D1	AA-68662	Dispersed Charocal (*Salix*/*Populus*)	–24.6	0.2168±0.0021	12,280 ± 80

sites have yielded rich sets of faunal remains. MUP materials came from the sites of Sabanikha, Kurtak-4, Kurtak-5, Ui-1, and Afanas'eva Gora, and reportedly date from about 31,500–19,600 cal BP. LUP materials reportedly span from about 24,400–14,000 cal BP and include assemblages from the sites of Novoselovo-7, Afontova Gora-2, Afontova Gora-3, Kokorevo-1, and Kokorevo-2 (Abramova, 1979a, b; Astakhov, 1999; Lisitsyn, 2000; Vasil'ev, 1996).

The Transition

The spread of modern humans into subarctic and arctic Siberia and the transition from the MUP to LUP are considered by addressing both the timing of these techno-complexes and the technological changes associated with them. Charcoal and bone samples were gathered from curated collections and submitted for AMS ^{14}C dating to aid in developing a firmer understanding of the timing of MUP and LUP industries in the Enisei River region. Lithic assemblages were analyzed to inform on the technological changes from the MUP to LUP and, ultimately, help define the behaviors that produced these techno-complexes, such as the way in which MUP and LUP foragers[5] were provisioning and organizing themselves on the landscape.

Chronology

To assess whether a chronological gap exists between the MUP and LUP, both previously published and new ^{14}C dates obtained from the sites discussed above were evaluated using several criteria to "clean-up" equivocal ^{14}C age estimates. The set of criteria I used are discussed in more detail elsewhere (Graf, 2008), but they are based primarily on Pettitt et al. (2003) with added consideration of specific stratigraphic and paleoecological contexts from each site. Any ^{14}C ages deemed reliable were retained to establish a chronology of occupation. Following evaluation, multiple ^{14}C assays from the same cultural layer were averaged by calculating a pooled mean to determine the age of a cultural occupation. Next, the ^{14}C age ranges for each "occupation" were converted to calendar years using the Calib 5.0.1 (INTCAL04 curve) program for dates $\leq$21,300 ^{14}C BP and Cal-Pal-online (2007 H curve) for dates $>$21,300 ^{14}C BP (Danzeglocke et al., 2007; Reimer et al., 2004).

A total of 49 ^{14}C age estimates are reported for the sites studied here (Fig. 6). Of these, 11 are new AMS determinations obtained at the NSF-Arizona AMS facility in Tucson, Arizona and recently reported in Graf (2008) (Table 1). Figure 6 shows several noticeably problematic ^{14}C estimates that cannot reliably date the age of these sites, ranging from incredibly large standard deviations to the abundance of outliers. After carefully considering every date, 16 dates were found to be unreliable. For instance, some of these dates did not overlap with others from the same cultural layer at 2-σ and could be discounted based on questionable geological contexts. Other dates had 1-σ errors of $>$1,000 ^{14}C years, and therefore 2-σ age ranges of $>$4,000 ^{14}C years, making them meaningless in establishing a chronology. Figure 7 presents the reliable ^{14}C dates remaining after evaluation.

Cultural occupation ages were identified by calculating pooled means of ^{14}C age estimates for each cultural layer that overlapped at 2-σ. Dates that did not overlap at 2-σ, but cannot comfortably be rejected, are shown with a singe bar that encompasses the entire age range possible. Figure 8 presents a new chronological curve in both ^{14}C and calendar years for these cultural occupations. None of these Enisei River sites unequivocally date to the LGM.

Technological Organization

One very productive means of understanding Paleolithic behavior is the study of the organization of lithic technologies and provisioning strategies (Binford, 1979; Kuhn, 1995; Nelson, 1991; Torrence, 1983). In this study, I reconstruct MUP and LUP technological organization and provisioning to explain similarities and differences in land-use organization. Hunter-gathers use their technologies to

[5] In this essay I use the term "forager" as a synonym for hunter-gatherer.

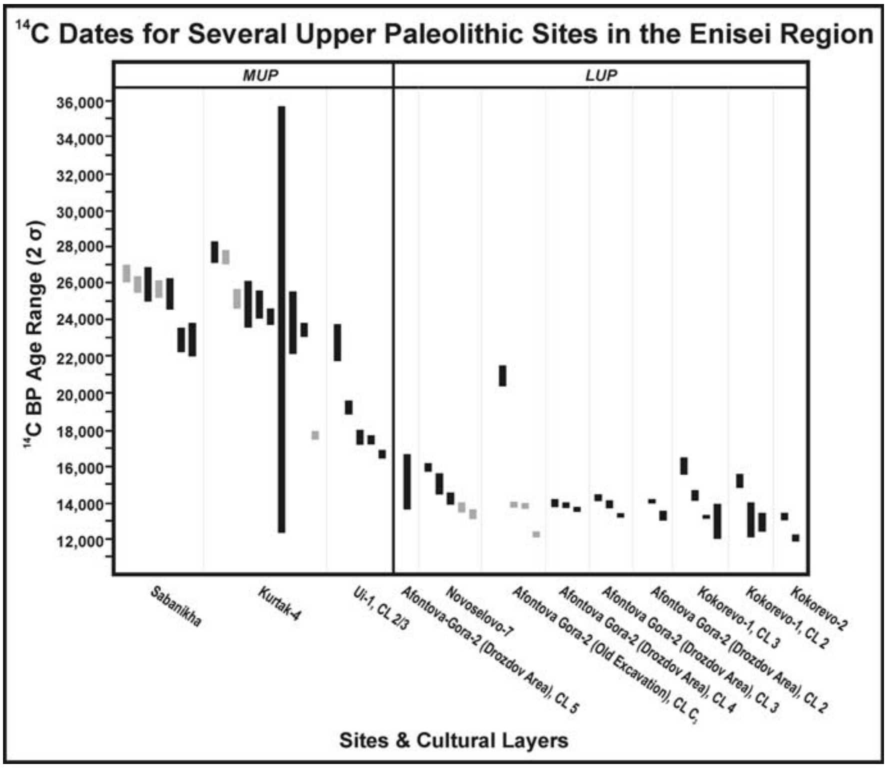

Fig. 6 Radiocarbon chart showing all age ranges at 2-σ (Abramova, 1979a, b; Abramova et al., 1991; Drozdov and Artem'ev, 1997; Lisitsyn, 2000; Tseitlin, 1979; Vasil'ev, 1996; Vasil'ev et al., 2005; this study). *Solid black bars* represent previously reported age ranges, and *gray bars* represent new age ranges obtained during this study

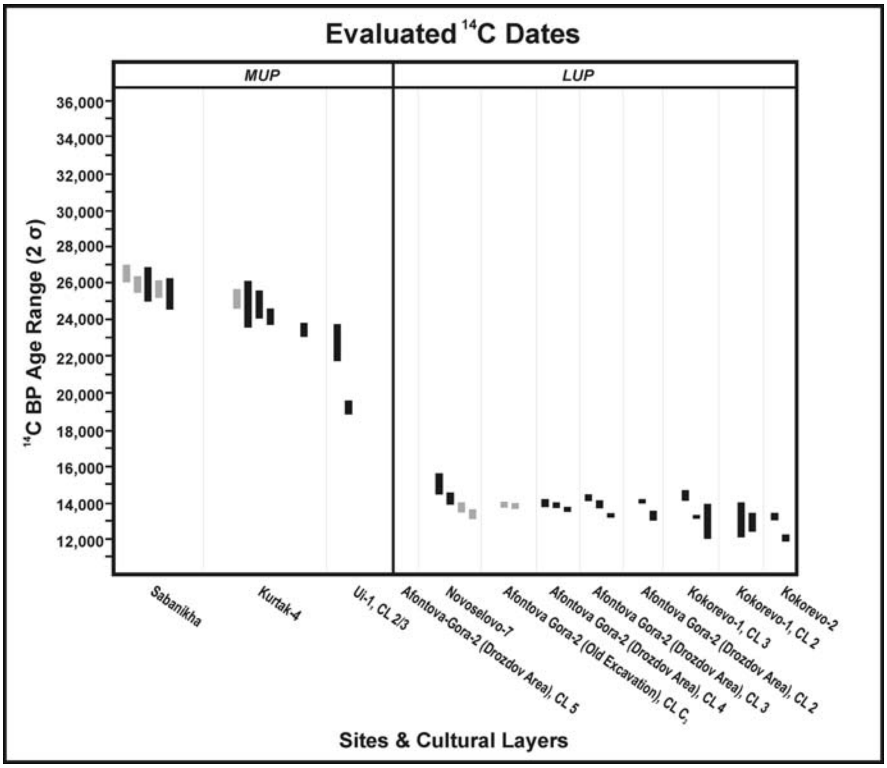

Fig. 7 Radiocarbon chart showing age ranges determined to represent good estimates after evaluation

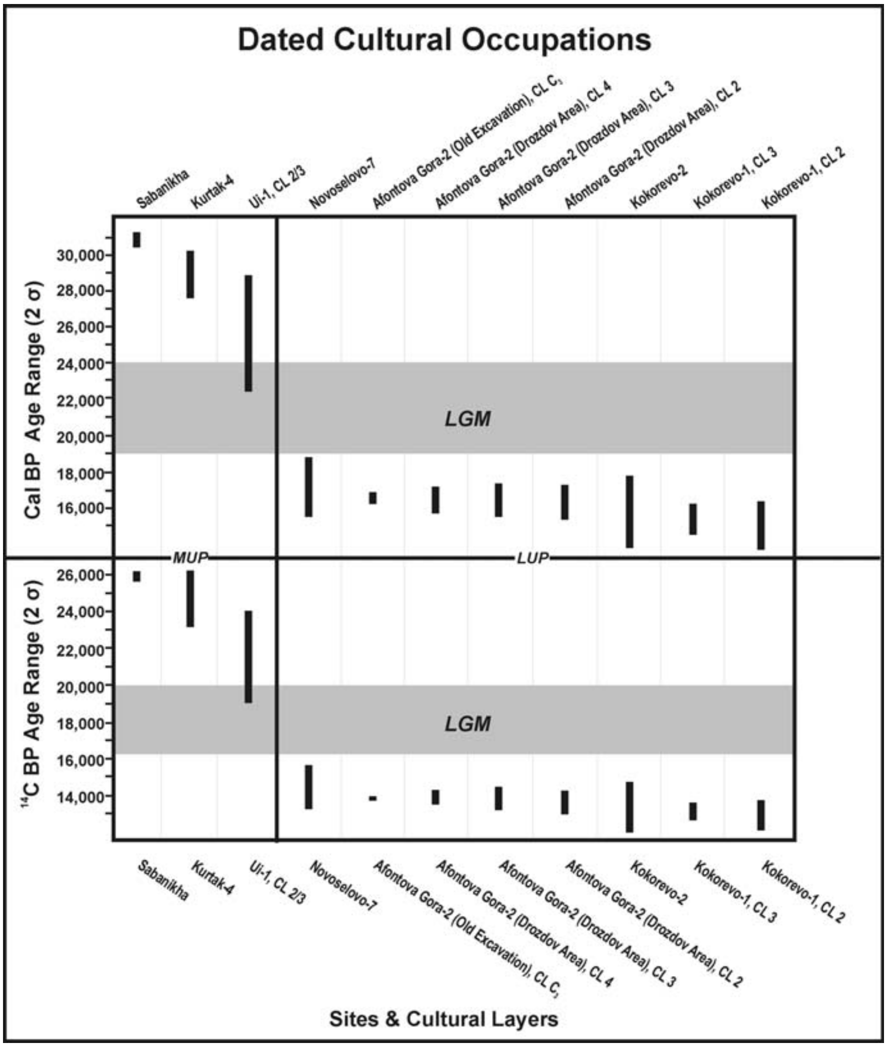

Fig. 8 Chronology for cultural occupations from Enisei River sites included in this study. Radiocarbon years are presented below and calendar years are above

extract food resources from the landscape; therefore, distributions of potential food resources guide hunter-gatherer foraging and land-use (Binford, 1980, 2001; Kelly, 1995). The decision to select alternative land-use strategies will influence foragers' chances in effectively acquiring food resources. The strategies used to exploit both lithic and faunal landscapes and allow hunter-gatherers to be consistently supplied or provisioned with resources are complementary (Binford, 1979). Therefore, the reconstruction of lithic provisioning strategies can inform on hunter-gatherer foraging and land-use (Kuhn, 1995).

With regard to technological provisioning, the hands-on time expended in manufacturing stone tools may not have been as important to hunter-gatherers' schedules as the actual time and energy spent directly procuring lithic raw materials. To some extent, hunter-gatherers have to plan for future exigencies by provisioning themselves with essential raw materials and stone implements needed in food acquisition and processing. Therefore, ensuring that lithic resources are always available, no matter the circumstances, is extremely important. Technological provisioning, as suggested by Kuhn (1995), can come in two basic forms—provisioning individuals and provisioning places.

Highly mobile foraging groups need to plan for future demands by supplying individuals with ready-to-use tools and light-weight cores. When on the move, predicting distance to toolstone sources and maintaining tools are challenges that must be anticipated. In situations where hunter-gatherers provision individuals, an optimal use of artifacts per weight is ideal, especially since carrying costs of heavy artifacts would be too great for mobile foragers (Kelly, 1988; Kuhn, 1995, 1992). Under these circumstances, a provisioning-individuals strategy minimizes the risk of not being prepared for the next hunting and/or processing opportunity, since lithic resource procurement is either unknown or distant.

Archaeologically, the more mobile groups are, the more we would expect to find them provisioning individuals with highly formalized toolkits. Toolstone procurement should be of both local and nonlocal toolstones. Core technologies should be formalized, prepared, and capable of withstanding long use-lives. Cores should have been highly standardized to ensure the tool-maker could always predict the outcome of production and maintenance. Further, cores should be lightweight for long-distance transport. Tool production should be geared toward the manufacture of formal implements because these can be made in advance of use and intensively curated or economized. Mobile foragers need to maintain a ready supply of tools or raw material at all times (Kelly, 1988, 1995, 1996, 2001; Kuhn, 1995; Odell, 1996; Parry and Kelly, 1987).

A hunter-gatherer group that consistently resides in one place or repeatedly revisits that place does not necessarily need to plan for future lithic resource shortfalls. This kind of hunter-gatherer can afford to provision each place of occupation (e.g., residential base, extraction location) with lithic raw material because future needs can be more effectively predicted. Such hunter-gatherers are more familiar with local resources, they can provision places with necessary toolstones by storing lithic resources acquired via logistical forays or by positioning site locations at high-quality raw material resource locations. Therefore, the strategy of provisioning places typifies less mobile hunter-gatherers (Kuhn, 1992, 1993, 1995).

Several aspects of the lithic artifact record can be expected from hunter-gatherers who were provisioning places. Toolstone procurement should be predominantly local with some relatively nonlocal resources obtained while foragers are out on logistical forays. Core technologies should be informal and unstandardized. Further, since transport of cores is highly unlikely, cores should be relatively heavy, since there would be no need for light-weight core technologies. Tool production should be geared toward manufacture of informal implements because there is no need to make tools in advance of use. Tool use-life should be relatively short with tools discarded while theoretically still usable (Kelly, 1988, 1995, 2001; Kuhn, 1995; Odell, 1996; Parry and Kelly, 1987).

This paper presents preliminary data on toolstone procurement and primary and secondary reduction technologies in an effort to reconstruct Siberian Upper Paleolithic technological organization and provisioning strategies. Lithic variables include (1) frequency of raw material, (2) frequency of secondary or alluvial cobble cortex, (3) frequency of informal cores, (4) frequency of primary reduction technology types, (5) comparison of blade and microblade widths, (6) frequency of tool production types, and (7) frequency of formal tools.

Toolstone Procurement

The lithic landscape of most of Siberia is not well-known, and unfortunately this is also case for the Enisei River region. Few geological surveys have been conducted, and the surface geology is nearly unknown via publication (but see Malkovets et al., 2003). Fine-grained lithic raw materials, especially cryptocrystalline silicates (CCS) and quartzites (Qzite), are readily available in river cobble form along the Enisei and its many tributaries (Elena Akimova, 2004, personal communication). Undoubtedly, we are limited in what we can say about the distances that toolstones traveled after being procured. Nevertheless, some information regarding their procurement can be gleaned from the data by investigating variables such as frequencies of raw materials and cortex types present in the assemblages.

A comparison of raw material frequencies from both sets of assemblages (Fig. 9) indicates that MUP and LUP flint-knappers were regularly procuring and utilizing relatively high-quality

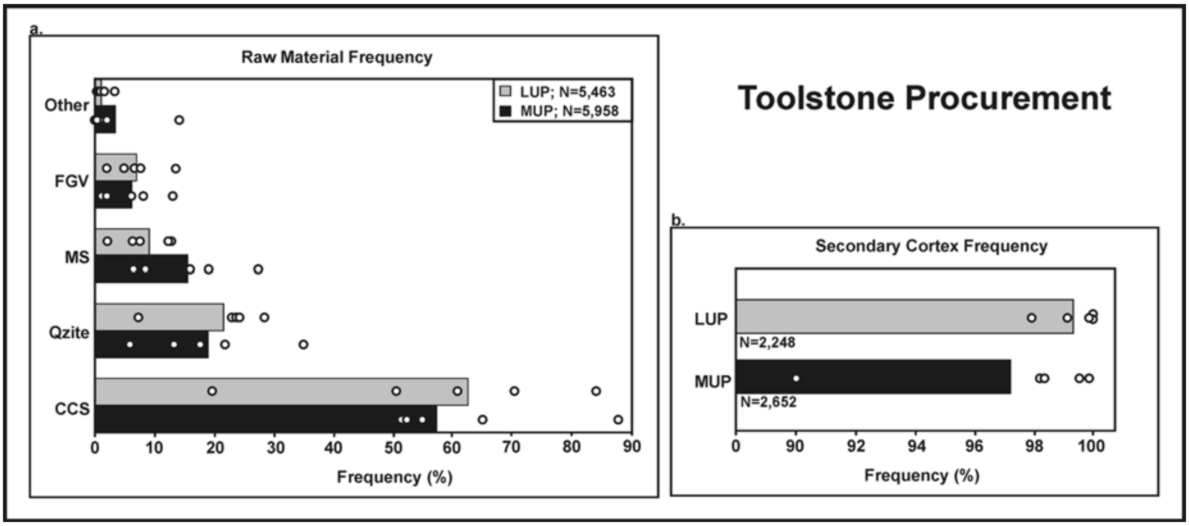

Fig. 9 A comparison of MUP and LUP toolstone procurement: **a**) mean raw-material frequencies, **b**) mean secondary-cortex frequencies. *Circles* represent individual assemblage frequencies

toolstones such as CCS, quartzite, meta-siltstone (MS), and fine-grained volcanic (FGV) materials in similar frequencies. Other lower quality toolstones (e.g., quartz, granite, diorite, sandstone) were procured much less frequently. Likewise, both techno-complexes do not vary in the frequencies of secondary cortex on artifacts. Overwhelmingly, secondary cortex is present on these artifacts, suggesting many local toolstones were being procured and consumed at all of the sites. These data indicate that both MUP and LUP sites served as retooling locations for high-quality toolstones.

Primary Reduction

Comparing MUP and LUP primary reduction, there are several differences (Fig. 10). The obvious difference between the two techno-complexes is the lack of microblade reduction technologies in the MUP. Microblade reduction technologies employed during the LUP include the manufacture of highly formalized, bifacial, wedge-shaped cores, as well as *tortsovyi* microblade cores.

Examination of the number of formal versus informal cores indicates LUP formal core production was much higher—nearly 40%, compared with about 22% for the MUP. Formal cores are those prepared before use and include blade, bladelet, and microblade cores; whereas informal cores are unprepared assayed cobbles, flake cores, and bipolar cores.[6] Individual assemblage frequencies show that LUP assemblages have much less variation in the frequency of formal core production than the MUP, possibly suggesting more standardization in core production than in the MUP.

To further consider blade versus microblade standardization, blade and microblade width measurements are compared (Fig. 11). Variability within MUP blades and LUP blades and between MUP and LUP blades is considerably high, while variability within microblades is extremely low. Therefore, LUP microblade standardization is significantly higher than either MUP or LUP blade standardization. Another interesting pattern is that most blades in the later MUP assemblages (Ui-1 and Afanas'eva Gora) are smaller than those in the more ancient Sabanikha assemblage, though large blades were still being produced at these later sites. These data indicate that blade cores were more intensively reduced, possibly to near-exhaustion at the sites of Ui-1 and Afanas'eva Gora.

Overall, primary reduction during the LUP was more formalized, standardized, and economized

[6] Bipolar cores were produced by percussor on anvil technique.

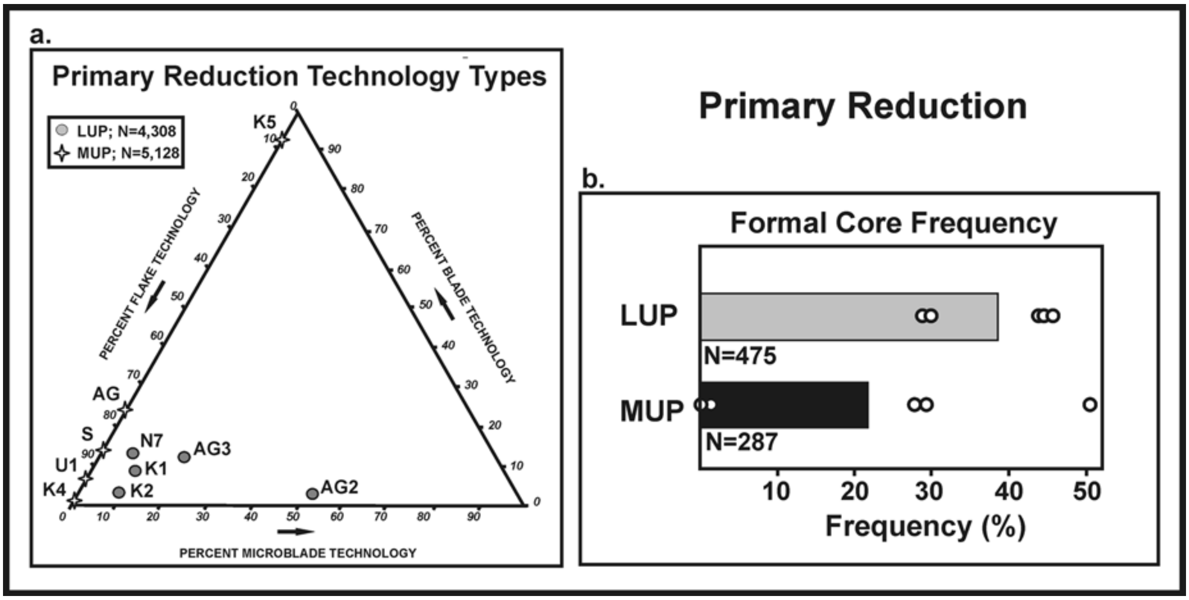

Fig. 10 A comparison of MUP and LUP primary reduction: **a**) relative frequencies of flake, blade, and microblade technologies by assemblage; **b**) mean formal core frequencies. *Circles* indicate individual assemblage frequencies

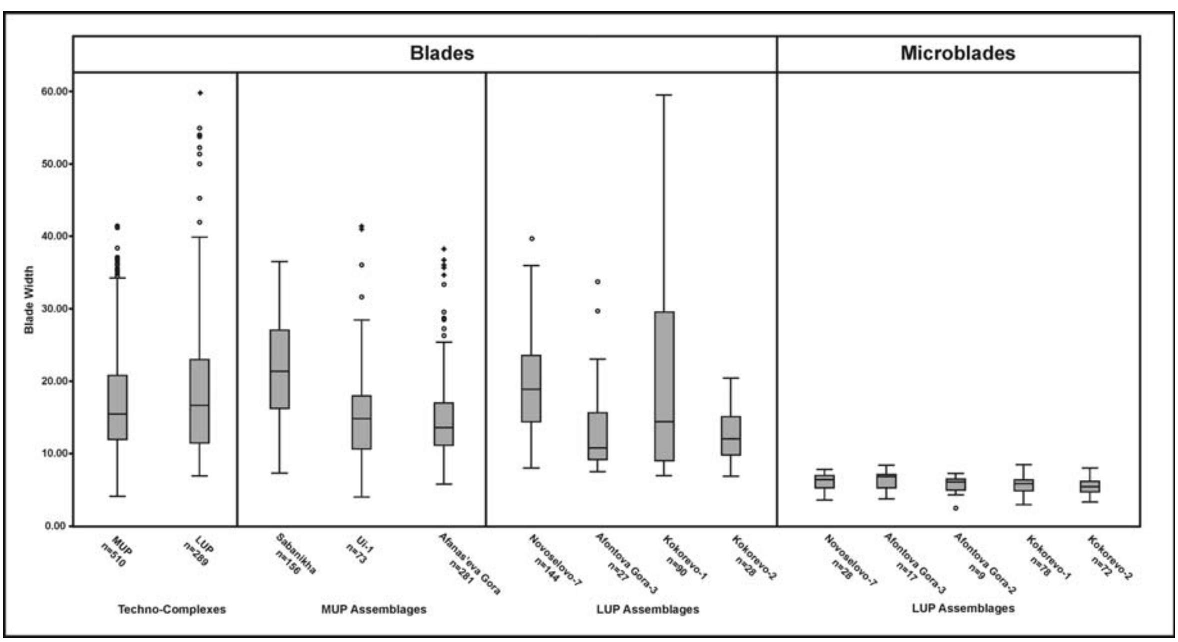

Fig. 11 MUP and LUP blade (width) standardization. Comparisons between the techno-complexes are made for macroblades only, and comparisons within the techno-complexes are made for MUP macroblades, LUP macroblades, and LUP microblades. *Boxplots* show medians, lower quartiles, upper quartiles, and outliers for each sample's width

than in the MUP. The use of highly formalized microblade cores was a time-intensive proposition that took several steps in preparation and maintenance compared with other core types. Nevertheless, their products—microblades—added a whole new dimension to the already existing primary reduction techniques previously available to Upper Paleolithic hunter-gatherers, by maximizing the number of cutting edges from small transportable microblade cores.

Secondary Reduction

An initial look at the manufacture of tools indicates there are clear differences between MUP and LUP assemblages. Considering the three major tool production types—unifacial, bifacial, and burin (Fig. 12)—more bifaces and burins were produced during the LUP than the MUP, while more unifaces were produced during the MUP. Bifaces are more formal tool types than most unifaces, lending themselves to maintainability and portability (Kelly, 1988). Burins were likely used in slotting osseous points that were then inserted with microblade midsections (Guthrie, 1983a, b), explaining their primary place as a component of this formalized LUP tool industry. A consideration of formal versus informal tool frequencies shows that more formal tools were produced in LUP (64%) than MUP (43%) assemblages. Formal tools include bifaces, side scrapers, end scrapers, combination tools, multiple spurred gravers, and burins. Informal tools include retouched flakes, retouched blades, single-spurred gravers, notches, denticulates, and unifacial knives. Individual assemblage frequencies are more varied for the MUP than LUP, indicating that during the LUP more formal tools were consistently produced compared to the MUP. Therefore, MUP tool production was relatively informal and expedient. In contrast, LUP tool production was formal, and highly curatable tools such as bifaces, burins, and combination tools were produced more regularly.

Discussion

The goal of this chapter is to characterize the nature of the MUP to LUP transition in Siberia and to understand the spread of modern humans into the North. Several sites from the Enisei River in south-central Siberia were studied to address this goal. Previous work in the Enisei region has provided several well-

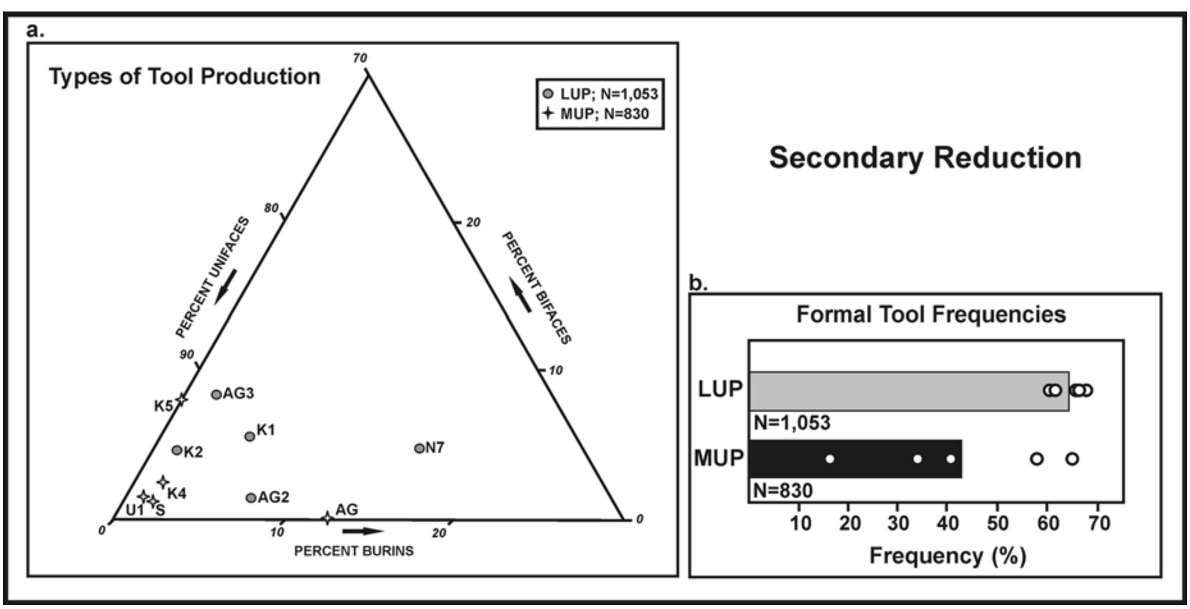

Fig. 12 A comparison of MUP and LUP secondary reduction: **a**) relative frequencies of unifaces, burins, and bifaces by assemblage; **b**) mean formal tool frequencies. *Circles* indicate individual assemblage frequencies

documented Upper Paleolithic site assemblages, making this region an excellent place to begin investigating modern human dispersals in Siberia.

Evaluation of the ^{14}C dates from Enisei River sites studied in this chapter indicates that none of these cultural occupations unequivocally date to the 4,000 year period between about 24,800 and 20,700 cal BP. These preliminary data also point to a possible chronological break in the region's archaeological record between the MUP and LUP; therefore, supporting a decline in human populations during the maximum of the last glacial cycle.

The lithic technological data indicate an abrupt behavioral transition between the two techno-complexes as well, with the lithic expectations for provisioning place generally met by the MUP, and those for provisioning individuals met by the LUP. Toolstone procurement was very similar between the MUP and LUP, with the majority of lithic raw materials locally procured by the makers of both techno-complexes. Three important conclusions can be drawn from these similarities. First, local raw materials, found in the form of river cobbles and readily available at numerous sites along the Enisei River, were selected by both MUP and LUP hunter-gatherers. Second, raw material scarcity was not a concern for either MUP or LUP flint-knappers, and therefore it did not affect their technological decisions. Finally, site locations were likely selected for their toolstone richness and thus became retooling locations during the MUP and LUP, regardless of the provisioning strategies employed.

Hunter-gatherers' provisioning place should not care to conserve lithic raw materials by preparing formal core technology, especially when high-quality raw materials are plentiful. When staying at the same place for long periods, or repeatedly visiting such locations, there is no need to standardize core technologies. In such cases, primary reduction will be expedient and informal. MUP hunter-gatherers of the Enisei region were consistently producing large amounts of expedient, informal primary reduction technologies, and many artifacts were discarded in still-usable condition. Also, the blade and bladelet cores that were produced were highly variable and not significantly standardized. In contrast, LUP foragers had added standardized, formal microblade production to their range of primary reduction techniques. Small, lightweight microblade cores could have produced many linear cm of cutting edge (Guthrie, 1983a) so that the microblades from a single core provided mobile LUP hunter-gatherers with more cutting-edge per unit weight than any other primary reduction technique, including the oft-touted maximum cutting-edge producer, the biface (Flenniken, 1987; Guthrie, 1983a, b; Parry and Kelly, 1987; Kelly, 1988). Likely, when LUP flint-knappers utilized less-formalized core reduction technologies, they selected these detached pieces for use as either microblade cores blanks or tool blanks. These data suggest LUP hunter-gatherers were maximizing usable pieces within their toolkits and provisioning individuals.

When hunter-gatherer provisioning is place-oriented, secondary reduction strategies should be informal and expedient, since there is no need to make implements ready for transport between sites. Tool production should focus on casual selection of ready-to-use tool blanks with minimum preparation of the business end or edge so that the majority of tools produced were informal such as lightly retouched blades and flakes. MUP hunter-gatherers produced higher quantities of informal than formal tools, indicating no need for tool economization. In contrast, tool production in LUP assemblages was formalized. There are more formal than informal tools, and microblade tool technology was employed. Thus, tools were manufactured in anticipation of future use and were capable of being repeatedly resharpened and economized. LUP hunter-gatherers were likely provisioning individuals.

The formalization and standardization of both primary and secondary reduction strategies indicate LUP hunter-gatherers were mobile foragers who provisioned individuals within the group. In contrast, the informal, nonstandardized, and expedient nature of primary and secondary reduction strategies of the MUP indicates these hunter-gatherers were provisioning place and less mobile. Since high-quality raw materials were readily available in the form of river cobbles found at both MUP and LUP sites, I must interpret these basic technological differences between the two techno-complexes as resulting from different human organizational strategies and not from the economization of scarce raw materials by the LUP.

The technological patterns of MUP and LUP assemblages were recognized throughout the MUP and LUP, respectively. Therefore, there seems to be more variation in technological activities, organization, and provisioning strategies between the two techno-complexes than within each. I argue that these changes were significant, indicating an abrupt transition between the MUP and LUP.

Conclusion

During the Upper Paleolithic in south-central Siberia, there was an abrupt transition, not just in technologies employed by hunter-gatherers, but in the organization of the people and the ways in which they were utilizing the landscape. Numerous settlements found between 51°N and 56°N across Siberia, dating from about 32,000 to 24,000 cal BP are evidenced by the presence of the MUP. From what we know about these people, they seem to have been utilizing local resources and various ecological zones and landscapes and maintaining low levels of mobility by provisioning place.

At about 24,000 cal BP, populations in south-central Siberia dwindled to archaeologically unrecognizable levels. Whether or not humans completely disappeared from Siberia during the LGM is not known; however, in the Enisei River basin populations seemed to have been quite low. Possibly during this time Upper Paleolithic Asians pushed into more temperate regions or refugia, where there may have been continuous occupation spanning the LGM (Izuho and Takahashi, 2005; Nakazawa et al., 2005).

With the end of the LGM, LUP foragers re-entered Siberia, bringing a different land-use strategy from that used during the MUP—one in which people were provisioning individuals and were highly mobile, likely moving their residences more frequently than before. Technology had altered to support these changes. Core and tool technologies became more formal and standardized. Highly flexible composite osseous and stone projectile points and knives were manufactured at this time. These implements would have been beneficial in hunting large-range herd animals, such as reindeer, that tended to occur in high frequencies in the LUP faunal assemblages.

The earliest reliably dated microblade technologies in northern Asia come from sites in Hokkaido, Japan dating to 22,000–20,000 ^{14}C (26,500–24,000 cal) BP (Izuho and Takahashi, 2005; Nakazawa et al., 2005; but see Chen, 1984; Chen and Wang, 1989; Lu, 1998 for earlier, but equivocal dates from the Xiachuan microblade site in northern China). While the earliest unequivocally dated microblade sites in Siberia appeared simultaneously in the Transbaikal of southeastern Siberia, and along the upper Enisei River in far south-central Siberia at about 18,000–17,500 ^{14}C (21,000 cal) BP (Astakhov, 1986; Goebel et al., 2000; Graf, 2008). Interestingly, along the Selemdzha River (a tributary to the Amur' River in the Russian Far East), the microblade site of Ust' Ulma-1 has one ^{14}C date of 19,360 ± 65 (SOAN-2619) (~23,000 cal BP) (Derevianko and Zenin, 1995). If this age can be corroborated, it would certainly provide good evidence for the spread of microblade technologies into southeastern Siberia from Japan via the Russian Far East. Perhaps the land-use strategies employed by Siberian LUP foragers and the development of microblade technology first arose in Japan from an LGM, productive mammoth steppe biome in a coastal refugium. Increased mobility may have allowed these foragers to rapidly spread into southern Siberia soon after the LGM.

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Shades of Gray: The Paleoindian–Early Archaic "Transition" in the Northeast

J.M. Adovasio and Kurt W. Carr

Abstract While many earlier (and not a few contemporary) treatments of the Paleoindian-Early Archaic Transition in the Northeast (of North America) often stress clear-cut macro or quantum changes in climate with resultant dramatic shifts in techno-adaptive strategies, the actual situation is far more opaque. Using data from several key sites in the Northeast, a different view of this moment in time is offered. In this perspective, the "transition" is seen as a series of micro-adjustments in which socio-technic and subsistence packages are gradationally and almost imperceptibly altered with some elements—like the fluting of projectile points—deleted and others added. Overall, however, there is no profound "signature" to the Paleoindian-Early Archaic Transition in this region.

Keywords Paleoindian • Early Archaic • Northeast • Transition • Paleoenvironment

Introduction

For many, the concept of the "culture area" has fallen into disuse and otherwise has lost whatever classificatory, analytical, or explanatory potency it may once have enjoyed (cf. Trigger 1978:1). However, as is often the case, convention has retained terms like "the Northeast" as a useful organizational device. Given that, the limits of the Northeast should be defined as they are used here. Following Trigger (1978:1), the northern boundaries of the Northeast are viewed as synonymous with the southern borders of the boreal forest. As noted by Trigger (1978:1), this usage subsumes the Atlantic provinces of Canada, despite the existence of considerable coniferous forest in those areas. The region's western border is the temporally fluid boundary between the Eastern Woodland margins and the prairie country of the Midwest, while its southern boundary is far less based on ecological parameters and considerably more arbitrary. As used here, the region's southern border extends in an admittedly arbitrary line from the lower Ohio drainage to the southern margins of Chesapeake Bay, roughly along the present northern political borders of North Carolina and Tennessee (Fig. 1).

Within this relatively large area, three subareas will be distinguished. We will differentiate the Middle Atlantic culture area, New England, and the Eastern Great Lakes. The former area consists of the Ridge and Valley, Piedmont, and Coastal Plain physiographic zones, extending from Pennsylvania to the North Carolina-Virginia border. The Appalachian Plateau physiographic zone separates New England and the Eastern Great Lakes from the Middle Atlantic region. The New England region is situated east of the Saint Lawrence Valley, and the Eastern Great Lakes are defined here as limited to southern Ontario and Michigan. These subareas are identified because they are archaeologically distinctive and they have their own research history.

J.M. Adovasio (✉)
Mercyhurst Archaeological Institute, Mercyhurst College, Erie, PA, USA

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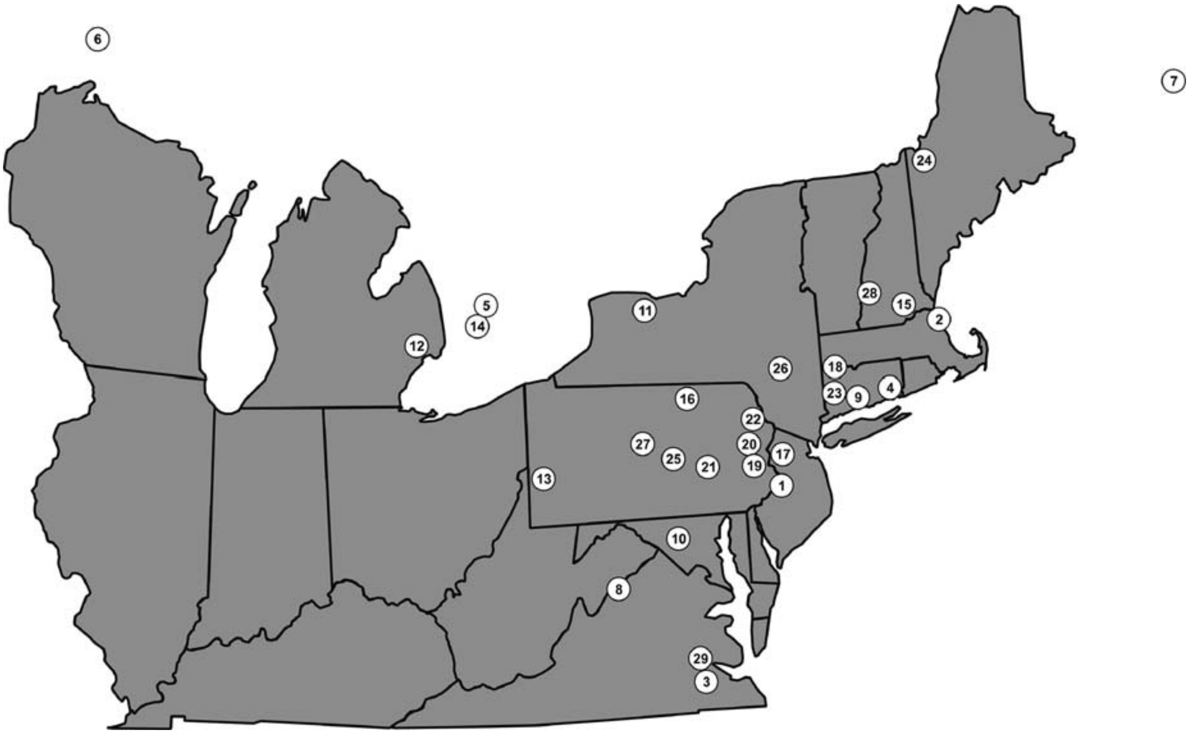

Fig. 1 Archaeological sites referenced in this text. (1) Abbott Farm; (2) Bull Brook; (3) Cactus Hill; (4) Cedar Swamp; (5) Crowfield; (6) Cummins; (7) Debert; (8) Flint Run Complex [Thunderbird & Fifty sites]; (9) Hidden Creek; (10) Higgins; (11) Hiscock; (12) Holcombe Beach; (13) Meadowcroft; (14) Nettling; (15) Neville; (16) Newton Mammoth; (17) Plenge; (18) Robbins Swamp; (19) Sandts Eddy; (20) Shawnee Minisink; (21) Shoop; (22) Tannersville bog; (23) Templeton [6Lf21]; (24) Vail; (25) Wallis (36Pe16); (26) West Athens Hill; (27) West Water Street; (28) Whipple; (29) Williamson

Historical Approaches

Within this heterogeneous area are a multitude of late Pleistocene and early Holocene archaeological manifestations—the historical approach to which has indelibly colored research in the Northeast to the present day. In 1953, A.D. Krieger prepared the first continent-wide classificatory scheme for the prehistory of what he called "Anglo-America," which implicitly included the Northeast. In this seminal schema, Krieger developed four major divisions, the first two of which—Paleoindian (later reflagged as Paleoamerican (Krieger 1953:15)) and Food Gathering—concern us here. In Krieger's own words, these constructs were developmental stages "... characterized by a dominating pattern of economic existence ... inferred from archaeological remains" (Krieger 1953:247).

Two years later, Willey and Phillips (1955) proposed six historical developmental stages, beginning with an Early Lithic that was followed by an Archaic that essentially corresponded to Krieger's Paleoindian and Food Gathering stages, respectively. Two years after their first essay into macrocultural taxonomic systematics, Willey and Phillips reduced their six stages to five and renamed their first construct simply "Lithic" (Willey and Phillips 1958:73). Significantly, Willey and Phillips' Lithic and Archaic stages had chronological, artifactual, economic, and paleoclimatic implications.

Based on the data then available, Willey and Phillips stated that the predominant economic activity in the Lithic stage was hunting, with a focus on large herbivores that specifically included extinct Pleistocene megafauna (Willey and Phillips 1958:80). This focal hunting pattern was thought to not only be the dominant subsistence strategy of the Lithic stage, but also to operate in environments very different from those that were obtained in the later Holocene.

Willey and Phillips did concede, however, that “other economic patterns were certainly present” and could, under unspecified local conditions, assume the dominant economic role (Willey and Phillips 1958:81). Artifactual markers of the Lithic stage included a wide range of flaked stone technology—notably, but not exclusively, including fluted points but with no evidence of ground or polished stone tools (Willey and Phillips 1958:87).

Willey and Phillips’ Archaic stage was defined in economic terms as a time of “migratory hunting and gathering cultures continuing into environmental conditions approximating those of the present” (Willey and Phillips 1958:107). They further assert that the focus of the Archaic was clearly on gathering as reflected by the appearance of a variety of ground stone seed-processing gear and, where preservation permitted, an array of perishable plant-fiber artifacts such as basketry, cordage, and sandals (Willey and Phillips 1958).

Shortly after Willey and Phillips’ highly influential stage formulation appeared, Caldwell (1958) introduced the concept of “Primary Forest Efficiency” as a fundamental defining aspect *ab initio* of the Archaic of virtually all of the Eastern Woodlands, including virtually all portions of the Northeast. This concept would enshrine yet another hallowed “given” into our consideration of the fundamental differences between Paleoindian and Archaic lifeways.

By the early 1960s, concurrent with the passing of Willey and Phillips’ Lithic stage concept, scholars throughout eastern North America perceived the Paleoindian period as an economic orientation that was very different from that of the succeeding Archaic period. This view holds sway in many quarters to this day, despite concerted efforts by many to alter this perspective (e.g., Carbone 1978; Custer 1989, 1996; Gardner 1974; Meltzer and Smith 1986). Indeed, it is safe to say that for many readers of this volume, Paleoindian (in the Northeast, at least) still equals big game hunting, usually in tundra or periglacial settings, and Archaic equals broad spectrum foraging in “modern” forest conditions. Moreover, this construct is attended by the corollary that the transition between these two fundamentally different lifeways is environmentally signaled, artifactually distinct, and relatively abrupt. The evidence, however, suggests otherwise.

The Database

To our knowledge, Gardner (1974) was the first to assert that the Early Archaic was an extension of cultural events or processes beginning in the Paleoindian period. He was essentially arguing that the Early Archaic was more similar to the preceding Paleoindian period rather than the succeeding Middle Archaic period. When he made this statement in 1974, the prevailing wisdom at the time envisioned mastodon- and mammoth-hunting Paleoindians at the early part of his continuum and practitioners of “Primary Forest Efficiency” at the other end of his continuum. As a theoretical framework for this presentation, we will examine Gardner’s argument for cultural continuity between the Paleoindian and Early Archaic in a circumscribed portion of the Northeast. Gardner maintains that the significant change in adaptation and cultural behavior occurs not at the Paleoindian-Early Archaic interface, but rather at the Early-Middle Archaic juncture. Artifactually signaled by the initiation of the so-called Bifurcate Phase, distinguished by the use of MacCorkle, St. Albans, and LeCroy projectile points, the Early-Middle Archaic interface at ca. 8,900 BP (dates are presented in uncalibrated radio carbon years ago) is considered by Gardner to represent a genuine socio-economic and behavioral transition.

Because both the “older” and newly posited transitions are singularly tied to putative environmental changes, the issues of paleoenvironmental changes and paleoenvironmental reconstruction in the Northeast must be addressed.

Environmental Reconstruction

Previous reconstructions of environments that were obtained at or near the Terminal Pleistocene-Early Holocene—or, if you prefer, the Paleoindian-Early Archaic boundary—were often framed in terms of stark, monotonal, black-white contrasts. Further, evolutionary alterations of these environments were usually considered to be essentially synchronous over wide areas, relatively dramatic, and more or less abrupt.

Though the preservation of climatically sensitive organic material that might serve to illuminate the environment(s) of this chronological period remains limited, current data does support the notion that the Late Glacial-Paleoindian-Early Holocene/Early Archaic timeframe was an interval of rapid and often significant change. However, it is also becoming clear that, at least in some parts of the Northeast, the contrasts between the Late Glacial and Early Holocene environments are far less pronounced and much more nuanced than previously thought. While space precludes a detailed discussion of these transformations, some of the salient points should be enumerated.

At the late Pleistocene maximum, (circa 18,000–20,000 BP), glaciers covered all of New England and the Great Lakes. They extended into the northern part of Pennsylvania in an arc stretching from the Delaware Water Gap in the east (thence 15 km north of Williamsport in central Pennsylvania) to 8 km south of New Castle at its western end. Sirkin (1977:210) argues that tundra existed directly in front of the glaciers in both Pennsylvania and New Jersey, although Guilday (1984:255) suggests that the tundra was less than 100 km wide. Recent data suggest that at lower elevations the tundra may not have been present at all.

With a drop in sea level of 100 m, the greatly enlarged coastal plain was a vast grassland. The coastline extended as much as 325 km to the east of its present location. The resulting climate of the Middle Atlantic region was somewhat more continental in character than it is at present (Eisenberg 1978). Glacial melting began around 16,500 BP, but consisted mainly of "thinning" until 14,000 BP (Sirkin 1977:212). From 14,000 to 12,600 BP, the glaciers receded about 100 km into New York and Canada. As this occurred, tundra would have followed the melting ice north, at least at the higher elevations. From 12,600 BP to approximately 11,500 BP, the glaciers and the attendant periglacial vegetation continued to retreat northward until the onset of the Younger Dryas at 10,950 BP (Isarin and Bohncke 1999). This was the last Pleistocene cooling episode, and it stabilized the glacial retreat until approximately 10,150 BP (Mayewski et al. 1993).

The Younger Dryas in the Middle Atlantic created or maintained a mosaic of ecological settings not found in the region today, but in a very broad way, they followed a zonal pattern. In general, the Middle Atlantic region was a spruce/pine forest characterized by a mosaic of ecological settings, including a larger number of wetland areas than present, and a variety of deciduous species mixed with the coniferous forest. This mixture of vegetation created a diversity of high biomass ecotones that offered a variety of food resources for humans. This scenario, first presented by Carbone (1976), is very important because, although the Younger Dryas environment was cool, Pennsylvania, the Great Lakes, and New England may have contained more food resources during this time than during the succeeding Pre-Boreal episode of the early Holocene.

A spruce/pine forest existed in the southern Middle Atlantic, associated with an increased number of wetlands. In the north, the forest was also mixed with large patches of grassland or open areas. Throughout the Middle Atlantic, oak pollen is consistently found wherever pollen is preserved, although at a frequency of less than 10% (McWeeney 1995). Deciduous elements existed in particularly favorable areas, such as sheltered, well-drained floodplains, although these were more common in the southern Middle Atlantic than in the north. Deciduous trees decreased in frequency to the north where grasses increased. However, a good example of the mosaic nature of the Younger Dryas is the presence of hickory dating to 10,900 BP at the Shawnee Minisink site along the Delaware River in Northeastern Pennsylvania (Gingerich 2004, personal communication).

The question concerning the presence of tundra or parkland in the Middle Atlantic between 11,000 and 10,000 BP (essentially the Younger Dryas) has been debated (Custer 1996), and we hesitate to use these terms. Pollen profiles for the region suggest that the elements of coniferous forest, grassland, and deciduous species coexisted in unusual combinations not presently represented. The exact distribution of these elements is not well-understood, but we believe that in northern Virginia at 11,500 BP, the coniferous forest was open, and further north a more tundra-like environment existed in New England. This description is influenced by the presence of caribou at several sites in New England and the likely exploitation of caribou at the Shoop site in central Pennsylvania.

Not surprisingly, given what Porter (1988) calls their ecologically anomalous character, Terminal Pleistocene environments were inhabited by a diversity of faunal species. Until the end of the period, this bestiary included Pleistocene megafauna. By the earliest Holocene, large mammal species included elk, moose, and caribou, all of which were probably present earlier, as well as smaller herbivores such as white-tailed deer.

Although there are hundreds of megafauna sites in the Northeast, none are unquestionably associated with Clovis (or earlier) Paleoindian material. Similarly, Terminal Pleistocene-Early Holocene faunal remains of any type in association with cultural remains are practically nonexistent. White-tailed deer are represented in the early levels at Meadowcroft Rockshelter (see below), while a large cervid, presumably caribou, is reported to come from Bull Brook (Gramly 1982), Whipple (Curran 1984), Cummons (Julig 1984), and Holcomb Beach (Fitting et al. 1966).

Delcourt and Delcourt (1986:32) argue that during both Glacial and Younger Dryas times, the geomorphologic instability caused by glacial conditions (especially cryoclastic activity) contributed to both the mosaic pattern of plants and animals and also the slow migration/return of deciduous elements into higher elevations. The main depositional processes effecting topography during Younger Dryas times were colluvial. These processes were continuously disrupting vegetational succession, so that pioneer species (such as grasses and conifers) were common, and deciduous forests could not get started. Based on the identification of the Younger Dryas, this was true until 10,100 BP along the higher elevations and in the Ridge and Valley province. The ridge tops acted as barriers to the migration of deciduous elements, which slowed the northward movement of these plants. Delcourt and Delcourt (1986:33) believe that after the Younger Dryas, alluvial processes were the predominant factors that modified the landscape. This discussion is very important for understanding the distribution of early Holocene flora and fauna in the Middle Atlantic because the northern section was glaciated or directly affected by glacial outwash. This may have not been the only factor, but it was probably one of several factors that contributed to the dominance of open environments and/or coniferous vegetation during Paleoindian times throughout most of the Middle Atlantic.

Based on data from Cedar Swamp, Connecticut, the vegetation in New England was a developing open parkland of spruce, fir larch, white pine, and birch (Jones & Forest 2003). With the Younger Dryas, there was an increase in alder, birch, and spruce along with fluctuating ground water levels resulting in a return to open water situations within the swamp. In contrast to these open water conditions, Stewart (2003) examined land use around the Holland Marsh in Ontario and documented how the lake gradually shrank throughout the Younger Dryas and eventually became a wetland during the Pre-Boreal. This correlates well with the dry conditions of the Younger Dryas. Ellis and Deller (1997:16) characterize southern Ontario as an open spruce parkland or woodland environment at 11,000 BP. However, by 10,500 BP, pine becomes the dominant species over spruce and nonarboreal species have decreased significantly. By 10,000 BP, southern Ontario is largely a pine forest with a "low biotic productivity" (Ellis and Deller 1997:16).

According to Delcourt and Delcourt (1986:33), at 10,000 BP, colluvial processes were replaced by alluvial processes as the most significant factors that modified the landscape. Referring specifically to Virginia, the Delcourts state that the "vegetational mosaic changed from the Pleistocene pattern (an open patchwork of tundra, open glades, and boreal forests) to a Holocene pattern of predominantly closed temperate deciduous forests" (Delcourt and Delcourt 1986:33). Vento (1994) also argues for significant environmental changes occurring around 10,000 BP. He states that the Susquehanna River went from lateral accretion to over-bank deposition at this time due to changes in storm patterns.

The change from the Younger Dryas to the Pre-Boreal to the Boreal climatic episodes, between 11,000 and 8000 BP, generally results in a warmer and dryer climate (Vento 1994). Davis (1983), Lundilius et al. (1983), and Jacobson et al. (1987:283) argue that the change in vegetation at 10,000 BP (i.e., the spread of forests)—or the beginning of the Early Archaic, as it is traditionally defined—represents the most rapid and dramatic change in vegetation for any period in the past 18,000 years. The pollen profiles of the Middle Atlantic region show a dramatic increase in conifer pollen usually just prior to 10,000 BP

The pollen profiles of the Middle Atlantic region, such as the Tannersville Bog (Watts 1979) or Newton Mammoth site (Barnosky et al. 1988), show an increase in pine or hemlock pollen, usually at the expense of spruce, and this generally occurs just prior to 10,000 BP or the beginning of the Early Archaic. After this date, oak pollen increases (e.g., Tannersville Bog, Watts 1979), reaching a high point by 8,000 BP, and appears to represent a relatively modern environmental situation. However, there are exceedingly few pollen cores or any other types of data from the Piedmont or Ridge and Valley zones that are representative of the vegetation from this time period.

During the period of 10,150 to 9,100 BP, the Middle Atlantic was characterized by increasing deciduous elements in central Virginia and, with a slower rate of increase, in Pennsylvania and a coniferous forest (mostly pine) in New England and the Great Lakes. Jones (1994) characterizes New England as a pine-birch-oak shrub forest. Essentially, mast-producing trees were replacing the conifers, especially spruce, in the south; the conifers continued to dominate the forests of northern Pennsylvania; white pine replaced spruce in the Great Lakes; and nonarboreal species continued to be common in northern New England. Working in the Upper Delaware River Valley of Pennsylvania, Dent (1985:156) found that the pine-oak boreal forest lasted until 9,211 BP. Because of the strongly disrupted glaciated regions of northern Pennsylvania and New York, deciduous trees could not migrate into these areas as quickly as they did in the nonglaciated areas of southern Pennsylvania, Maryland, and Virginia. Therefore, the deciduous forest did not predominate in this northern region until approximately 9,000 BP, which is at the end of the Early Archaic as defined by Gardner. Joyce (1988:200) also states that oak-dominated forests did not develop in the Middle Atlantic until 9,000 BP. As temperatures increased to that above present conditions, the deciduous forest expanded throughout the Middle Atlantic region, with an oak-hickory forest in Virginia and a northern hardwood forest beginning in northern Pennsylvania.

Along with the foregoing vegetational differences determined by latitude and complicated by glacially initiated geomorphologic instability, Carbone (1976) demonstrated that there were also differences caused by changes in topography and elevation. These changes can be characterized by the physiographic zones of the Middle Atlantic Region. Due to changes in elevation and slope, there was an increasing coniferous element from east to west in the Piedmont, the Ridge and Valley, and the Appalachian Plateau regions. Between 10,000 and 9,000 BP, the mixed coniferous forest of the Piedmont section contained the strongest deciduous element, and the Appalachian Plateau would have had the lowest frequency of deciduous elements. The floodplains of the major river valleys across the region, regardless of the physiography, also would have had relatively high frequencies of deciduous vegetation frequently in the form of hydrophyetic (wetland) vegetation, which contained a variety of food resources useful to human populations. Although the climate of 10,000 BP was warmer in comparison to Late Glacial times, the early Holocene conifer-dominated forest of the glaciated Middle Atlantic region "had a low species diversity" (Joyce 1988:199) and probably contained fewer food resources available to human populations. Those food resources present were probably concentrated in the floodplains, especially in the Piedmont and Ridge and Valley sections. On the Appalachian Plateau, food resources may have been more commonly located around swamps and bogs in upland settings. The intensive use of inland swamps is described by Nicholas (1988) for New England during the early Holocene, and an analysis of the early Holocene Appalachian Plateau may reveal similar features.

In summary, a cold spruce pine forest with patches of nonarboreal species (a parkland) dominated the Younger Dryas environment of the Northeast beginning 10,950 years ago. Three elements—coniferous forest, deciduous species, and nonarboreal species—were arranged in a mosaic pattern determined by latitude, elevation, migration rates, and local edaphic factors, forming a parkland setting not found in the region today. Mast-producing deciduous species were relatively common in the southern Middle Atlantic parkland area, and nonarboreal species dominated the parkland of New England and the Great Lakes. There were a variety of foods available to humans in this environment, but the instability caused by the colluvial processes of the Younger Dryas resulted in generally less predictable resources on a year-to-year basis.

With the abrupt warming of the Pre-Boreal period, the forests of the Northeast region were first dominated by pine and hemlock, and after 9,000 BP they became more deciduous in character. This occurred rapidly in the nonglaciated regions and more slowly in the glaciated region. Therefore, the Pre-Boreal was a period of long-term changes in the floral and faunal communities, and this situation did not stabilize until the Boreal Period.

During Younger Dryas and Pre-Boreal times, riverine environments of the Middle Atlantic region would have offered the most food resources for humans. In New England and the Great Lakes, for this same period, upland swamps would have offered the most food resources. This may have also been true for the Appalachian Plateau of western Pennsylvania and southern New York; however, the Pre-Boreal forest of New England and the Great Lakes contained fewer food resources compared to both previous and later environments. After 8,800 BP, human food resources in the oak forest also would have been greatly increased and available in a variety of upland settings.

The Younger Dryas and Pre-Boreal episodes both appeared somewhat suddenly, and produced opposite changes in vegetation and climate. However, within the Middle Atlantic riverine environments, food resources appear evenly distributed. In New England and the eastern Great Lakes, food resources are scattered in nonriverine lakes and upland bogs. These required different adaptive strategies and resulted in different settlement patterns within these three regions. Further, although the quantity of available food resources was less during the Pre-Boreal than the Younger Dryas in New England and the Great Lakes, they were more predictable during the Pre-Boreal, producing ecological settings that were more frequently revisited (Table 1).

We stress that—despite the transformational regularities identified here—local factors, much more than generalized trends, conditioned climatic and paleoenvironmental changes at the Pleistocene-Holocene boundary. Particularly informative in this regard is the long stratigraphic and occupational sequence from Meadowcroft Rockshelter (e.g. Adovasio et al. 1975, 1977a, b, 1978; Adovasio et al. 1987, 1979–1980a, b; Adovasio 1982).

Meadowcroft Rockshelter and the Pleistocene-Holocene Transition

Meadowcroft Rockshelter (36WH297) is a deeply stratified, multicomponent site 48.27 air km (78.84 km via road) southwest of Pittsburgh, and 4.02 surface km northwest of Avella in Washington County, Pennsylvania. The site is on the north bank of Cross Creek—a small tributary of the Ohio River that lies some 12.16 km to the west.

Meadowcroft Rockshelter is oriented approximately east-to-west and has a southern exposure. It is ca. 15.06 m above Cross Creek and 259.9 m above sea level. The area protected by the extant overhang is ca. 65 m^2, and the overhang itself is ca. 13 m above the modern surface of the site. In addition to water in Cross Creek, springs are abundant near the rock shelter.

Physiographically, Meadowcroft is on the Unglaciated Appalachian or Allegheny Plateau west of the Valley and Ridge province of the Appalachian mountains, and northwest of the Appalachian Basin. The rock shelter is formed beneath a cliff of Morgantown-Connellsville sandstone—a thick fluvial or channel sandstone within the Casselman Formation (Flint 1955) of Pennsylvanian age.

Meadowcroft Rockshelter is in a maturely dissected topographic region. More than one-half of the 14,164.3 ha encompassed by the Cross Creek watershed are in valley slopes; upland and valley bottoms are in the minority. Maximum elevations in the Cross Creek drainage are generally above 396 m. At the divides on the east, elevations are above 426 m. Elevations at stream level are 310 m at Rea

Table 1 The location of food resources in the three regions discussed in the text

Region	Glacial period	Younger dryas	Pre-Boreal	Boreal
New England	Swamps and bogs	Swamps and bogs but less predictable	Swamps and bogs more predictable	Riverine settings, swamps and bogs
Middle Atlantic	Riverine settings	Riverine settings	Riverine settings	Riverine settings and uplands
Eastern Great Lakes	Lakes and bogs	Lakes and bogs but less predictable	Lakes and bogs more predictable	Lakes, bogs and uplands

on the South Fork, 276 m at Avella, and 193 m normal pool level.

Present area topography developed during the latter Pleistocene when increased precipitation and run-off caused extensive down-cutting. The area was unaffected directly by glacial ice, as the mapped Wisconsinan Kent moraine (Woodfordian age) is some 50 km north of the site, while the later Lavery till is ca. 83 km to the north. At the time when Meadowcroft Rockshelter was initially occupied, the ice had retreated to the vicinity of modern-day Erie, Pennsylvania (e.g., Adovasio et al. 1975, 1977a, b, 1978; Adovasio et al. 1987, 1979–1980a, b; Adovasio 1982).

The excavation procedures employed at Meadowcroft Rockshelter are thoroughly detailed in other publications on the site (e.g., Adovasio et al. 1975, 1977a, 1977b, 1978; Adovasio et al. 1987, 1979–1980a, b; Adovasio 1982). During the 600+ working days of the 1973–1978, 1983, 1985, 1987, 1993–1994, and 2007 field projects, approximately 60.5 m^2 of the surface area inside the drip-line, and ca 46.6 m^2 outside the drip-line, were excavated. Over 230 m^3 of fill were removed. Nearly all of the excavation was conducted with trowels or smaller instruments, and extraordinary vertical and horizontal controls over the artifactual and "ecofactual" assemblage were maintained. The excavation protocols employed at Meadowcroft are still considered state-of-the-art, and the site is widely regarded as one of the most carefully excavated localities in North America (e.g., Custer 1996).

As explained in many other Meadowcroft publications, 11 natural strata were distinguished during excavation of its 4+ meter-deep deposits. The earliest stratum is termed Stratum I; the most recent is Stratum XI. Two of the eleven strata (VI and X) occur only inside the drip-line; the other strata are continuous across the site. In the interest of space, the reader is referred to Stuckenrath et al. (1982) for geoarchaeological details on the 11 Meadowcroft strata.

The Meadowcroft stratigraphic sequence is anchored by 52 radiocarbon dates that are remarkably consistent with the observed stratigraphy, and currently constitute the longest occupational sequence in the New World (e.g., Adovasio et al. 1975, 1977a, 1977b, 1978; Adovasio et al. 1987, 1979–1980a, b; Adovasio 1982).

Stratum IIa is the deepest and oldest culture-bearing depositional unit. For analysis and discussion purposes, Stratum IIa is subdivided into three subunits of unequal thickness, labeled upper, middle, and lower Stratum IIa. Each of these subunits is bracketed by major roof-spalling episodes, and each is well-dated by radiocarbon assay. Upper Stratum IIa has a terminal date of 8,010 BP from the uppermost living or occupation floor within this subunit and a date of 9,115 BP from a slightly deeper occupational surface within the unit. At the base of upper Stratum IIa is a substantial roof-spalling episode that marks the boundary between this subunit and middle Stratum IIa. While the top of the roof spalling event that separates upper from middle Stratum IIa is undated, an assay of 11,300 BP is available from directly beneath the roof spalling event at the top of middle Stratum IIa. Hence, for all intents and purposes, upper Stratum IIa dates ca. 10,950-7,950 BP and is of early Holocene age.

Middle Stratum IIa, sealed from upper Stratum IIa by a roof-spalling episode, is also terminated by a roof spalling episode. Directly beneath the latter roof spall is a date of 12,800 B. P. Middle Stratum IIa is therefore bracketed by dates ranging ca. 12,950-10,950 BP; it is of terminal Pleistocene age.

Lower Stratum IIa, which lies beneath the roof spalling episode that separates this subunit from middle Stratum IIa, has seven additional radiocarbon dates ranging from 19,600 BP to 13,240 BP. This subunit is clearly terminal Pleistocene in age.

The maximum excavated depth of Stratum IIa varies between 70 and 90 cm in different portions of the rock shelter. At the interface of lower Stratum IIa, and underlying Stratum I, are several lenses of charcoal that have produced radiocarbon dates in the twentieth and twenty-ninth millennia BP range. These dates are not associated with any cultural materials. The initial human occupation of the rock shelter is conservatively placed between 13,955 and 14,555 radiocarbon years ago with the possibility of an even earlier human presence (Adovasio and Pedler 2005). The latest radiocarbon date on purely aboriginal materials is 1225±80 AD from Stratum IX. Cross-dated lithics, ceramics, and Euro-American artifacts from Strata X and XI indicated continued occupation or utilization of the site into the Historic period.

Several of the discrete data sets from Meadowcroft Rockshelter are important both for paleoenvironmental reconstruction at and near the site, and for the Mid-Atlantic region as a whole. These data sets specifically include more than 900,000 vertebrate faunal remains representing 151 vertebrate taxa, some 5600+ invertebrate faunal remains, and ca. 1.4 million plant remains—all buttressed by detailed geological, geochemical, and sedimentalogical information. Extensive discussion of all the Meadowcroft data is provided in Adovasio et al. (1984, 1985), Carlisle and Adovasio (1982), and Volman (1981).

The diverse Meadowcroft data sets range from poor to very good in the scope of information that they offer for understanding the paleoenvironment and the process of paleoenvironmental change at the rock shelter throughout the Holocene, as well as the late Pleistocene.

All of the extant ecofactual information, including macrofaunal, microfaunal, macrofloral, and microfloral remains, as well as various categories of geological and geomorphological data, suggest that from ca. 11,250 or 10,950 BP to the present, the environment of Cross Creek was essentially modern in aspect. It also appears that the Late Pleistocene environment in that part of Cross Creek immediately adjacent to the rock shelter was a vast forest not radically different from that of today. Given these conditions, it appears that the Pleistocene/Holocene transition in this portion of Pennsylvania was a low-amplitude event of relatively short duration. While this scenario contrasts sharply with the “received wisdom” about the nature of the Pleistocene-Holocene transition derived from much higher elevation localities (Guilday et al. 1977), it is supported by accruing data from lower elevation microhabitats throughout the periglacial Northeast.

Gardner’s Model for Cultural Continuity

Based on his work in the Shenandoah Valley, Gardner (1989) identified five patterns that were shared by Paleoindian and Early Archaic adaptations, and he used these as evidence for basic cultural continuity between these two periods, as well as to distinguish them from the subsequent, Middle Archaic, bifurcate phase. Working in northern Virginia, he found that the Paleoindian/Early Archaic settlement pattern focused on (1) high-quality lithic sources, and (2) high-biomass ecotones, especially in riverine settings. A (3) curated tool assemblage was used, with many standardized tool types, along with a (4) staged biface reduction lithic technology. The settlement pattern is characterized by Jay Custer (1996) as a (5) cyclical pattern with the direct procurement of lithic sources. Gardner distinguished between macro-band base camps located at quarries, and micro-band camps located in high-biomass ecotones. For the Piedmont and the southern Ridge and Valley sections of the Mid-Atlantic, a seasonal round (or territory) of 40–150 km was predicted (Gardner 1983:53). Considering the relatively high biomass (compared to more northern latitudes), and probably the nonmigratory nature of the animals involved, this size seems reasonable. Finally, Gardner found an increase in sites and probably in human population at the beginning of the Early Archaic Period (Tables 2–5).

Table 2 Gardner’s criteria for demonstrating cultural continuity between the Paleoindian and Early Archaic Periods

Gardner’s Southern Middle Atlantic	Lithic preference and kilometers to quarries	Mode of lithic procurement	Preferred topographic setting	Lithic reduction technology	Tool technology
Paleoindian	High quality bedrock material less than 150 km.	Cyclical/direct procurement	Riverine settings	Staged bifacial reduction	Curated tools
Late Paleoindian	High quality bedrock materialless than 150 km.	Cyclical/direct procurement	Riverine settings	Staged bifacial reduction	Curated tools
Early Archaic	High quality bedrock and cobble material less than 100 km.	Cyclical/direct procurement	Riverine settings	Staged bifacial reduction	Curated tools
Bifurcates	Local bedrock and cobble material less than 100 km.	Serial/embedded procurement	Riverine and upland settings	Expedient flake cores	Expedient tools

Table 3 Gardner's criteria for demonstrating cultural continuity as expressed in the Middle Atlantic region

Middle Atlantic	Lithic preference and kilometers to quarries	Mode of lithic Procurement	Preferred topographic setting	Lithic reduction technology	Tool technology
Paleoindian	Both high quality and local bedrock material less than 200 km but some over 300 km.	Serial/embedded rarely cyclical direct procurement	Riverine settings	Staged bifacial and polyhedral cores	Curated tools
Late Paleoindian	Both high quality and local bedrock material more than 100 km but some over 300 km.	Serial/embedded Procurement	Riverine settings	Staged bifacial and polyhedral cores	Curated tools
Early Archaic	Both high quality bedrock and local material more than 100 km	Serial/embedded procurement	Riverine settings	Staged bifacial and polyhedral cores	Curated tools
Bifurcates	Both local bedrock and cobble material less than 100 km	Serial embedded procurement	Riverine and upland settings	Expedient flake cores	Expedient tools

Table 4 Gardner's criteria for demonstrating cultural continuity as expressed in New England

New England	Lithic preference and kilometers to quarries	Mode of lithic Procurement	Preferred topographic setting	Lithic reduction technology	Tool technology
Paleoindian	Both high quality and local bedrock material over 200 km	Serial/logistical rarely cyclical direct procurement	Pleistocene features, swamps and bogs and small streams	Staged bifacial and polyhedral cores	Curated tools
Late Paleoindian	Both high quality and local bedrock material over 100 km and rarely over 300 km.	Serial/logistical rarely cyclical direct procurement	Pleistocene features, swamps and bogs and small streams	Sstaged bifacial and polyhedral cores	Curated tools
Early Archaic	Local material less than 100 km	Serial embedded procurement	Glacial lakes, swamps and bogs and small streams	Expedient flake cores	Expedient tools
Bifurcates	Both high quality and local bedrock and cobble material less than 100 km.	Serial embedded procurement	Swamps, bogs and riverine settings	Expedient flake cores	Expedient tools

This pattern ended at approximately 8,900 BP with the introduction of bifurcate-based projectile points. Gardner felt that this signaled the end of the Paleoindian/Early Archaic Period and the beginning of the Middle Archaic. The Middle Archaic is characterized by an expedient or less-curated tool technology, a variety of convenient core-reduction strategies, a settlement pattern not focused on a single lithic quarry, the use of more upland settings, and a smaller seasonal round or territory. Following Jay Custer (1996), the bifurcate adaptation used a serial settlement pattern with an imbedded lithic procurement system.

Gardner (1983) also described the Paleoindian/Early Archaic cyclical use of quarries at the Williamson site in eastern Virginia and on the Virginia/North Carolina border. However, eventually he recognized that the cyclical, quarry-focused settlement pattern for the southern Mid-Atlantic region (and the South, in general) did not apply to the northern Middle Atlantic, New England, and the Great Lakes regions. In these areas, quarries did not necessarily represent the location of macro-band base camps, and the size of the seasonal round (or territory) was significantly larger than in Virginia. He identified the

Table 5 Gardner’s criteria for demonstrating cultural continuity as expressed in the Eastern Great Lakes region

Eastern Great Lakes	Lithic preference and kilometers to quarries	Mode of lithic procurement	Preferred topographic setting	Lithic reduction technology	Tool technology
Paleoindian	High quality bedrock material over 200 km.	Cyclical direct rarely serial procurement	Pleistocene features, lakes and bogs	Staged bifacial and polyhedral cores	Curated tools
Late Paleoindian	High quality bedrock material rarely over 200 km	Cyclical direct procurement	Pleistocene features, lakes and bogs	Staged bifacial and polyhedral cores	Curated tools
Early Archaic	High quality bedrock and cobble sources over 200 km	Serial embedded and cyclical direct procurement	Streams and lakes	Staged bifacial and polyhedral cores	Curated tools
Bifurcates	Local bedrock and cobble material	Serial embedded procurement	Streams and lakes	Expedient flake cores	Expedient flake tools

division between these two zones as the “biotic Mason-Dixon Line” (Gardner 1989:30).

Paleoindian in the Northeast

In the Great Lakes region and New England, Deller and Ellis (1988), Roberts (1984), Spiess (1984), and Storck (1984) have outlined territorial patterns that probably involve migratory game that are 200–400 km in aerial extent. For the most part, the serial use of lithic resources, covering hundreds of kilometers between quarry sites, is described (Storck 1984). These sites frequently have very high ratios of tools to debitage (Vail, Debert and Bull Brook are 40% or more), which is reminiscent of western North American kill sites. More frequently, sites in the north have relatively large numbers of finished projectile points, such as Debert (n = 141), Shoop (n = 70 +), Plenge (n = 117 +), Holcombe Beach (n = 100 +), Vail (n = 79), Crowfield (n = 29), and West Athens Hill (n = 24). Caribou are the most frequently suggested game animal, but, as noted above, their presence in the Northeast for this time period has only been weakly documented. Many of these sites are also large and seem to have “multiple, apparently contemporary, and interacting use areas” (Gardner 1989:30). Exceptions to this generalization are numerous, such as at the Templeton site (6Lf21) excavated by R. Moeller (1980, 1984), with a low-tool frequency involved in a serial lithic utilization pattern. This is to be expected, as not all sites were hunting/kill sites such as Vail, and many others simply served other functions in the seasonal cycle, such as exploiting other types of resources in a micro-band setting. Further, we are not suggesting that these people were year-round caribou hunters.

At all of these sites, the tool assemblage is characterized by utilized flakes, bifaces (both tools and preforms), and a variety of prepared flake tools. Utilized flakes usually comprise at least 32% of the tool assemblage, and frequently exhibit relatively low-edge angles. The remaining percentage of the assemblage consists of bifaces and prepared flake tools. The bifaces were used as tools or as preforms for projectile points. The most common formal flake tools are relatively small triangular end scrapers that usually represent 20–40% of the tool kit. Side scrapers, wedges, burins, gravers, and awls are also common. At some sites, such as Shawnee Minisink, a high percentage of end scrapers (37%) are notched, presumably for hafting (McNett 1985:89). Flake tools with multiple working edges are common, and graver spurs are frequently found on end scrapers (Witthoft 1952). In general, Paleoindian tool assemblages have all the characteristics of a highly curated technology. Ground and pecked woodworking or plant-processing tools are very rare from sites in the Northeast.

Gardner described the lithic reduction system for the Flint Run Complex as being based on bifacial cores. He was fortunate that he had several stratified sites adjacent to the jasper quarries, and he was able to document the reduction of bifacial cores through refitting studies. This has not been possible at many other sites, but bifacial cores are common at Paleoindian sites and are probably a characteristic of this technology throughout the Northeast.

In contrast to the recently reported Gault Site (Collins 1999), the regular and systematic production of blades (elongated flakes) is not a characteristic of Paleoindian fluted-point phase technology in the Northeast. Working with the Shoop site assemblage from Pennsylvania, John Witthoft (1952) was one of the first to report a blade technology that was associated with a Paleoindian assemblage. However, re-examinations of this material by Carr (1989), Cox (1986), Krieger (1954), and Wilmsen (1970) have demonstrated that the Shoop artifacts were produced on polyhedral cores and not "true" blade cores. The production of blade-like flakes may be a characteristic of some pre-Clovis sites, such as Meadowcroft and maybe Cactus Hill, but not of any of the later fluted-point assemblages in the Northeast. The production of blades occurs at sites in the midwest-central Mississippi Valley (such as the Adams site (Gramly and Yahnig 1991)). However, as stated by Haag et al. n.d.) "while it is true to say that blades form a component of some Clovis assemblages, they really cannot be said to characterize Clovis culture as a whole." A blade tool technology, such as that found in the Upper Paleolithic traditions of the Old World, involves the highly efficient systematic reduction of stone into elongated flakes of a very standardized shape. Sites of this period contain thousands of blades with a very high ratio of blades to nonblades. In many cases, the only nonblade artifacts are pieces resulting from the production of blade cores. There are no Paleoindian sites in North America that contain this type of technology. As remarked by Haag et al. (date needed), one Upper Paleolithic site near Beirut, Lebanon produced more blades than the entire sample of Clovis blades found in North America. On another technological note, the use of overshot flakes as a technique for biface thinning does not seem to be a common characteristic of Paleoindian technology in the Northeast.

The preference for "high-quality" lithic material has always been considered a significant characteristic of the Paleoindian period, and it was a diagnostic attribute strongly supported by Gardner. This is obviously true of the Flint Run Complex, located directly adjacent to nearby jasper quarries. This preference is also obvious at the Shoop site, where Onondaga chert was transported over 350 km from its source. However, the vast majority of Paleoindian and Early Archaic sites from the Middle Atlantic are surface or plow-zone sites, and the artifact assemblages are mixed with later materials. This has produced a biased description of the cultural assemblage. For example, as discussed by Moeller (1989), the analysis of surface collections from Paleoindian sites (and Early Archaic sites) has focused on "exotic" lithic types and formal flake tools. When these are compared to Paleoindian assemblages in stratified, unmixed contexts, a somewhat different picture appears.

In the Middle Atlantic region, there are few stratified Paleoindian assemblages that could be used to accurately document in detail the Paleoindian tool kit or Paleoindian technology. The Cactus Hill (McAvoy 1997), Fifty (Carr 1992), and Thunderbird (Verrey 1986) sites in Virginia, the Meadowcroft Rockshelter (Adovasio et al. 1975, 1977a, b, 1978; Adovasio et al. 1987, 1979–1980a, b; Adovasio 1982), and the Shawnee Minisink sites (Dent 2002) in Pennsylvania, the Higgins site in Maryland (Ebright 1992), and 6LF21 (Moeller 1980) in Connecticut are the only published sites with relatively in situ assemblages of tools and debitage. Although no final report has been produced, 36Pe16 (the Wallis site along the Susquehanna River) has been excavated by Miller and Bibler (2000) and they have graciously provided us with the appropriate data.

All of these sites contain high-quality materials, but at Cactus Hill, Higgins, Meadowcroft, Pe16, 6LF21, and Shawnee Minisink, poorer-quality local cherts (e.g., quartzite at Cactus Hill) predominated. At Pe16, 6LF21, and Shawnee Minisink, the "local chert" source was within 10 km of the site. Prepared flake tools and bifaces are frequently made from high-quality, nonlocal jaspers or cherts, but the dominant material is local and generally of a lesser quality. The curated tools may frequently travel long distances, but much of the stone used for making Paleoindian tools is not of the highest quality or locally available. The pattern of using the locally available material is probably much more common than currently recognized.

However, compared to the Archaic and Woodland periods, Paleoindian assemblages are much more likely to contain form tools in nonlocal lithic material, such as exotic cherts and jaspers. This can be clearly interpreted as a preference for high-quality material, as opposed to quartzite, quartz, rhyolite, or low-quality cherts. In addition, high-quality materials were more frequently curated and are more frequently found in the archaeological record.

If Paleoindian lithic technology, raw material procurement, and territorial patterns are still imperfectly understood, Paleoindian subsistence strategies are a much darker shade of pale. For Eastern North America, Paleoindian subsistence patterns are simply not well-defined. As noted above, the long-prevailing environmental reconstruction is not convincing, there are few preserved food remains, and the rare functional analyses of tools have not illuminated this issue. Direct evidence for Paleoindian subsistence in the Northeast has been found at the Shawnee Minisink site, consisting mainly of charred fruit seeds and fish bones of undetermined species (Dent and Kaufman 1985). This evidence demonstrates the variety of foods used by Paleoindians, but only the fish remains suggest a potential dietary staple. There are three other sites in the Northeast that also have very small amounts of charred bone. Caribou has been tentatively identified at Whipple (Curran 1984:5), Holcombe Beach (Fitting et al. 1966:14), and Cummins (Julig 1984:194). The Shoop site produced cervid (deer, elk, moose, or caribou) blood residue on one stone tool (Hyland et al. 1992). At the Vail site, the argument for hunting, specifically caribou, is also persuasive (Gramly 1982). Finally, Ebright (1992:242) reports hickory phytoliths and turkey feather fibers from the Higgins site in Maryland. As noted above, the Meadowcroft Rockshelter yielded white-tailed deer in terminal Pleistocene Paleoindian contexts, as well as eastern chipmunk, southern flying squirrel, and passenger pigeon. The meager floral remains from Paleoindian levels suggest possible utilization of hickory, walnut, and hackberry. While the database documenting subsistence is admittedly small, it does clearly suggest a broad spectrum, mixed foraging pattern for the unglaciated region of the Northeast. For the glaciated region, the database is equally diminutive but, again, suggests a mixed foraging pattern with some use of caribou (or other concentrated animal food resources). The Shoop site in south central Pennsylvania marks the southern border of this pattern.

Gardner (1989:30) identified the Mason-Dixon line as the border between these two patterns, and Meltzer (1988) identified the difference as being associated with glaciated and unglaciated environments. For a variety of reasons, this is probably an overly simplified environmental correlation (Meltzer 2002). However, we believe these two patterns represent different adaptive strategies, although probably by the same cultural groups. The tool technology and the tool types are very similar in both regions, but in the north they are sometimes found in different functional and sociocultural settings.

The remainder of this presentation examines how Gardner’s model of cultural continuity fits the Northeast. Our comparison focuses on Gardner’s criteria—a preference for high-quality lithic material, a curated tool technology, a technology emphasizing the use of bifacial cores, settlement patterns focusing on floodplains, and the direct procurement or cyclical exploitation of lithic material. We examine these traits as they apply to Early Archaic and so-called Middle Archaic or bifurcate point assemblages. Gardner’s work in northern Virginia focused on several well-stratified sites and artifact assemblages that were recovered from excellent archaeological contexts. He was able to document tool kits and lithic reduction techniques from a variety of Paleoindian, Early Archaic, and bifurcate functional site types. For tool technology and lithic utilization, we will focus our comparison using stratified Early Archaic and bifurcate sites where the components are relatively undisturbed and there has been little mixing of occupations.

Gardner (1989) has argued that in Virginia that there are very few differences between fluted point tool assemblages and Early Archaic tool assemblages. There seems to be a slight increase in the frequency of bifaces at the expense of formal flake tools, but this group continues to represent at least 50% of the tool assemblage compared to utilized flakes. This was demonstrated at all of the Flint Run Complex sites. A curated technology consisting of bifaces, prepared flake tools, and utilized flakes are also characteristic of the Early

Archaic components at Higgins, Meadowcroft, and Shawnee Minisink. The frequency of these tool categories may change, but bifaces and prepared flake tools continued to dominate the tool kit. The West Water Street site is situated on the floodplain of the West Branch of the Susquehanna in Lock Haven, Pennsylvania, and contains well-stratified Early Archaic, Middle Archaic, and Late Woodland deposits. Custer et al. (1994:226) characterized the Early Archaic assemblage as a "highly curated tool kit," composed of bifacial tools and prepared flake tools.

In terms of lithic utilization, Early Archaic assemblages from these sites (Higgins, Pe16, Shawnee Minisink, Meadowcroft, and West Water Street) follow the same pattern. The assemblage is dominated by local materials, but the tools are frequently higher-quality, nonlocal materials. The Early Archaic component at the West Water Street site (Custer 1996) also followed this pattern with an increase in the number of bifaces at the expense of prepared flake tools. Gardner noted that Early Archaic assemblages contained a wider variety of lithic types, especially rhyolite and quartzite. The same is true for the Pennsylvania sites where there is also an increase in the use of rhyolite. The Central Builders site is deeply stratified and located at the confluence of the North and West Branches of the Susquehanna River. The artifact assemblage is very small, but was dominated by a local chert, while the single form tool and projectile point were in rhyolite (130 km from the source). They were associated with a radiocarbon date of 9,165 + 210/–205 BP.

Gardner found that the bifurcate phase tool assemblages and lithic preferences were different from the Paleoindian-Early Archaic components. Although, these sites were adjacent to the jasper quarries, chert became more common in the bifurcate assemblages. Actually, the bifurcate components contained a greater variety of lithic types, including quartz, quartzite, and rhyolite. Gardner believed this was due to the increased use of a greater variety of ecological settings, especially in upland locations. Further, there was an increase in utilized flakes and a decrease in prepared flake tools. The same is generally true for the bifurcate components at West Water Street (Custer 1996), Pe16 (Miller et al. 2000), and the Sandts Eddy site (Bergman and Doershuk 1994). The bifurcate assemblage from these sites was not necessarily characterized as an expedient tool technology, but there was a definite drop in prepared flake tools. Custer (1996) characterized the West Water Street assemblage as "more expedient" than the Early Archaic assemblage, which he characterized as "highly curated." There is also a tendency for the prepared flake tools and bifaces to be made from local materials rather than those that have traveled long distances.

Custer (1996) noted the use of predominately polyhedral cores over bifacial cores associated with the bifurcate assemblage at the West Water Street site. We feel that it is unlikely that bifurcate projectile points were being produced in a staged biface reduction strategy. Several authors (Chapman 1975) have noted that bifurcates were made on thin flakes, and in our study of nearly 500 specimens at the State Museum of Pennsylvania and the Carnegie Museum, 6% exhibited the ventral surface of the original flake blank.

Finally, Custer et al. (1994) provides data that there may be a difference in the size of the social units used by Early and Middle Archaic cultures. At the West Water Street site, there was a wide range of tool types, suggesting that this was the location of a repeatedly occupied Middle Archaic base camp. An intensive analysis of the horizontal distribution of artifacts led Custer et al. (1994:211) to propose that the site represents a series of occupations by individual families. Stewart and Cavallo (1991:31) reached a similar conclusion in their analysis of community patterning in Area D at the Abbott Farm Complex near Trenton, New Jersey. They report a series of noncontemporaneous small clusters (2–3 m in diameter) of tools and debitage surrounding hearths at the site. These clusters were found in association with a number of Hunterbrook triangular points, constituting one of the most conclusive associations of triangular points with Middle Archaic assemblages. These two sites suggest that the standard Middle Archaic social unit was relatively small, possibly limited to the nuclear family. This implies a different type of base camp than Gardner has defined for either the Paleoindian-Early Archaic or the Late Archaic settlement pattern. It is a definition based on tool variation and the presence of features, but not necessarily a large social unit.

Based on the work of Coe (1964), Broyles (1971), and Gardner (1974), Early Archaic changes in technology and projectile point styles have been well-documented in the Middle Atlantic and American Southeast. Moving north, much of the basic cultural history has been generally confirmed by work throughout Pennsylvania and New Jersey (Carr 1989, Custer 1996, Miller et al. 2000, Siemon and Johnson 2000). However, in New England and the Great Lakes, it has taken longer to find sites in good context from this period, and an accurate characterization of this time is still in gestation. It would seem that the technological correlates with the Middle Atlantic are not as common. Initially, Ritchie (1965) and later Fitting (1968) proposed that there was a significant reduction in the human populations of the region compared to Paleoindian populations. What became to be known as the Ritchie-Fitting hypothesis proposed that the low-carrying capacity of the Pre-Boreal, pine-dominated forest required a reduction in human populations or a population hiatus in the region (see Peterson and Putnam 1992, and Smith et al. 1998:4 for a more extensive discussion of this issue). This has since been somewhat revised, although Early Archaic sites continue to be rare in the region (Forest 1999; Jones 1994). At the Neville Site in Massachusetts, Dincauze (1976) was able to demonstrate the presence of Middle Archaic components in New England but not the signature corner-notched Kirks and Palmers identified further south.

The Ritchie-Fitting hypothesis has been re-examined from several angles in New England over the past two decades, and a significant change in the focus of settlement patterns was inspired by Nicholas (1988) and his work at Robins Swamp. Nicholas (1988) characterized Early Archaic sites in New England as focusing on "glacial lake mosaic wetlands as capable of supporting a more diverse suite of resources than less heterogeneous upland or valley bottoms." Jones and Forest (2003:86) see glacial lake mosaic wetlands as the center for social, economic, and subsistence activities. In their work at Cedar Swamp in Connecticut, they identified both Late Paleoindian components based on Plano-style projectile points, and Early Archaic components based on radiometric dating. They believe that during both the Paleoindian and the Early Archaic periods, the dietary focus was on plant foods around this swamp. In contrast to the Hidden Creek Paleoindian site, the Early Archaic Sandy Hill site was characterized by the use of bedrock and cobble quartz, fewer bifaces, and "an informal lithic tool kit" (Jones and Forest 2003:85). Further, they argue that at the Younger Dryas/Pre-Boreal change, resources became more predictable. This situation was enhanced by the human clearing of the forest edge, which encouraged the growth of plant foods that were later used by humans. They argued that contrary to the Ritchie/Fitting hypothesis, the region was not abandoned, but Early Archaic subsistence strategies focused on these swamps rather than the river bottoms. Although, Jones and Forest argue for the survey of more areas adjacent to wetlands; they note that, in general, Early Archaic sites are rare (2003:86).

As summarized by Forest (1999), the Early Archaic in New England has been divided into the Atlantic Slope Tradition and the Gulf of Maine Archaic. The latter is mainly found in southern New England and the former is found from Cape Cod to Nova Scotia. The Atlantic Slope Tradition is characterized by Hardaway, Palmer, and Kirk corner-notched biface types, but these "are exceedingly rare in New England and adjacent areas" (Forest 1999:81). Bifurcate-based bifaces are the most widespread evidence for the Early Archaic. These sites contain "numerous expedient tools including a variety of scrapers and other flake tools, choppers, and small numbers of bifurcate projectile points" (Forest 1999:81). This represents a different technology than Paleoindian or the Early Archaic in the Middle Atlantic. A few sites have large numbers of bifurcate points, such as the Taunton River area and Robbins Swamp. These may represent macro-band base camps or "focal points for regional settlement patterns," or "core areas" (ibid). Forest goes on to emphasize cultural continuity between 9,000 and 7,000 BP, stating "that the Atlantic Slope Tradition has no local antecedent." However, the most common sites are like Dill Farm in Connecticut, which Forest (1999:96) states are characterized as being occupied by highly transient foraging groups.

In contrast to New England, there seems to be more support for a revised version of the Ritchie-Fitting hypothesis in the Great Lakes region. Based on environmental reconstructions, Ellis (1991:25) describes the Pine Zone or the Pollen Zone 2 of the Pre-Boreal as dominated by pine but including oak in southern Ontario and oak and hickory in Ohio. Although he characterizes the region during the Pre-Boreal as "resource poor" (ibid), he does not suggest that it was uninhabitable. The major site in the region is the Nettling site located five miles north of Lake Erie in Ontario (Ellis 1991). It is a multi-component plow-zone site and the majority of the artifacts have been collected since the 1950s through surface survey. Based on the horizontal distribution of 158 Kirk corner-notched projectile points, Ellis (1991:2) has been able to differentiate two clusters and attendant tool assemblages. Nineteen percent of Early Archaic lithic material comes from quarries in Ohio (Pipe Creek; 170–200 km) and the more distant Upper Mercer outcrops (at 300 km). The Ontario cherts are probably from secondary (cobble) sources and represent 80% of the lithics at the site. The tool assemblage consists of a wide variety of form tools, bifaces, and retouched flakes. Although Ellis (1991:23, 26) argues that there are many form tool types in this assemblage that are not found in Paleoindian assemblages, the predominance of formal flake tools and bifaces is similar to Paleoindian tool assemblages. The long-distance movement of lithics in the range of 200 km is also similar to Paleoindian and many Early Archaic sites. However, the woodworking and the ground and polished tools are very different from the Paleoindian and the Early Archaic assemblages in the Middle Atlantic.

To summarize, Early Archaic artifact assemblages in the Mid-Atlantic region consist of cherts, jaspers, quartzites, and rhyolites available in massive bedrock formations. They are part of a settlement pattern involving a large seasonal round, but less than 200 km. The tool assemblage continues to include a large number of formal flake tools compared to utilized flakes, and continues to be considered a curated technology, or at least more curated than the subsequent Bifurcate Phase. As with the Paleoindian Period, the majority of sites are small, but there are a few large sites seemingly representing macro-band camps. In the unglaciated region of the Mid-Atlantic, the large sites are located at lithic quarries, whereas in the glaciated region they are located in riverine areas at high biomass ecotones. Although there are adjustments to the adaptive strategy, they continue to use large territories, a curated tool technology, and a probable fission/fusion model of band organization.

In the Great Lakes region and New England of the Northeast, it would seem that the quarry played a less significant role in the Early Archaic settlement pattern, and high biomass ecotones were more important locations for base camps. The ever-changing and patchy nature of the Younger Dryas environment resulted in many small sites that were rarely reused. Lithics were probably exploited in a serial or imbedded pattern. However, distinctive high-quality materials were collected, and their distributions can be used to document long-distance band movements. The frequency of bifaces, bifacial cores, and the lack of other core types suggest a staged biface reduction sequence for both Paleoindian and the Early Archaic. The Paleoindian and Early Archaic assemblages are curated technologies, although there are fewer formal tools during Early Archaic times. Their tool kit includes many nonlocal lithic types, suggesting a relatively large seasonal round. In contrast, the bifurcate components are associated with fewer form tools, and higher frequencies of the tools tend to be in a lithic material that is local in origin. These tool kits are dominated by bifaces and utilized flakes. There are a greater variety of lithic materials, suggesting a greater variety of ecological settings were being used, but their distributions suggest smaller territories than during Early Archaic times. Although the evidence is not extensive, it does not appear that they are using a staged biface reduction system.

In New England, and the Great Lakes, the Early Archaic seems to be different than the Paleoindian Period. Furthermore, although it is still unclear, it would seem that there is not a significant increase in Early Archaic sites compared to Paleoindian sites. This may (or may not) be an issue of not looking in the right place (swamps and bogs), but at this point there appears to be a reduction in population growth during the Early Archaic of the Northeast.

The Early Archaic of New England and the Great Lakes continues to be poorly known. Based on the Nettling site, it continues to use a curated technology and the seasonal round is over 200 km. In New England, the situation is less clear. However, although there is some debate, the technology of the Early Archaic is similar to Paleoindian times and different from the bifurcate tradition.

The Early Holocene Archaeological Database in Pennsylvania

To further examine lithic preferences, the potential size of the seasonal round, and the ecology of settlement patterns, we will use data from the Pennsylvania Archaeological Site Survey (PASS) files. To summarize the early Holocene database for Pennsylvania, the PASS files record 299 Paleoindian period sites based on the presence of one or more fluted projectile points. All of these sites are multicomponent, and all but three are situated in plow-zone contexts and are more or less mixed with artifacts from later time periods. Thirteen of these have been systematically tested, and three of these were stratified: Meadowcroft Rockshelter, 36Pe16, and the Shawnee Minisink site. There are 343 Early Archaic sites recorded in the PASS files (representing a 15% increase over Paleoindian sites) based on the presence of Kirk, Palmer, Charleston, Thebes, Decatur, or St. Charles projectile points. Nine of these are stratified and have been archaeologically tested. There are 808 sites that contain bifurcate-based projectile points (a 136% increase over Early Archaic sites), and 10 of these are stratified and have been tested.

Early Holocene Patterns of Lithic Use in Pennsylvania

Using projectile points in the site files to analyze lithic material preferences, it is clear that the use of jaspers and cherts predominates in the Paleoindian period, with these materials constituting over 91% of the total artifacts recovered. The nonlocal nature of many of these cherts has been noted by many authorities (e.g., Lantz 1984; Carr and Adovasio 2002). However, as is true for much of the Middle Atlantic, there are few sites that demonstrate a cyclical use of these quarries.

High-quality jaspers and cherts continue to dominate Early Archaic projectile point collections with a frequency of at least 72%. Rhyolite and quartz in the Delaware and Susquehanna experience the most significant increases. The Delaware shows the greatest variety of lithic materials during the Early Archaic with quartz, rhyolite, quartzite, and chalcedony being added to the assemblage. Rhyolite artifacts from South Mountain recovered in the Delaware Valley suggest seasonal movements of at least 230 km, demonstrating that territories continued to be large. Overall, a preference for high-quality lithics seems to have been somewhat reduced from Paleoindian times. However, with the possible exception of quartzite (which also occurs in cobble form), the preferred lithic types originate in massive bedrock formations.

Lithic use during the bifurcate phase in the Delaware and Susquehanna drainages illustrates a decrease in chert, an increase in jaspers, and a continued increase in local materials such as quartz and quartzite. Gardner argued that the use of a greater variety of lithic types suggested the use of a greater variety of ecological settings. Rhyolite decreases in the Delaware, suggesting that large seasonal movements were less common, and (presumably) demonstrating that territories were probably becoming smaller.

Site Distributions in Pennsylvania

One of the more interesting characteristics of Gardner’s Paleoindian-Early Archaic cultural continuity model was the overall similarity in settlement patterns. He argued that the Early Archaic pattern also focused on floodplains, and that the bifurcate phase had a significantly greater dependence on nonriverine or upland resources. Using GIS data from Pennsylvania, it is possible to characterize the topography of site locations—specifically riverine and non-riverine settings—in a variety of ways.

Based on numbers of sites in floodplain settings, Paleoindian sites in Pennsylvania cluster in the riverine setting with 66–80% of all such sites being situated near or on the floodplain. However, the situation is not as clear for Early Archaic sites, especially when compared to bifurcate sites. There is a greater preference for riverine site placement by Early Archaic groups on the Piedmont compared to bifurcate sites, less on the Appalachian Plateau, and about the same degree in the Ridge and Valley.

We also examined a number of other calculations that characterize site locations, especially distinguishing between upland and riverine environments such as stream order, site elevation within the watershed, elevation above the nearest stream confluence, and the distance to the nearest perennial stream confluence. Using these parameters, Paleoindian sites show a preference for proximity to water and high-order streams, but Early Archaic sites do not and frequently show less use of these areas than bifurcate sites. When measuring the distance to the nearest stream confluence, Paleoindian sites show a clear pattern, but Early Archaic sites are more similar to bifurcate sites in their uneven distribution. When measuring stream order, again Paleoindian sites are associated with the highest-order streams, but Early Archaic sites are usually associated with smaller streams than are bifurcate sites. Finally, we measured averaged elevation above sea level for sites in the 104 drainage sheds of the state, and again Paleoindian sites are usually situated in the lowest part of the drainage shed, but Early Archaic sites are generally higher in the shed than bifurcate sites.

In Pennsylvania, the preference for riverine settings is clear during Paleoindian times, but not during Early Archaic times, especially compared to bifurcate sites. This may have less to do with cultural continuity than a change in vegetation in Pre-Boreal Pennsylvania compared to Pre-Boreal Virginia. The Pre-Boreal period is characterized as warm and dry, and the deciduous forest may not have penetrated most of Pennsylvania as extensively as it had in Virginia. Considering Gardner's observations in Virginia, the observed pattern in Pennsylvania may reflect the location of high biomass ecological zones in the uplands of Pennsylvania, similar to the bogs and swamps of New England during this period of environmental change.

In New Jersey, Pagoulatos (2003) has examined Early Archaic settlement patterns and has identified differences between floodplain/terrace-focused Kirk components and a more diverse group of upland settings associated with bifurcate components. In an interesting analysis, he tested two hypotheses—one based on cultural continuity between Kirk and bifurcate times, and the second suggesting different cultural traditions. In the latter, he proposes a "major settlement shift from larger (Kirk) population aggregates oriented toward riverine zones to smaller (bifurcate) group dispersals into a greater variety of resource areas, with a focus upon upland locales" (Pagoulatos 2003:15). This is similar to the suggestion by Custer for the change between Kirk populations and bifurcate populations at the West Water Street site. Base camps consisting of macro-bands may not be a characteristic of the Middle Archaic adaptation. In fact, the fluid use of macro- and micro-bands may no longer be the appropriate response to the exploitation of the middle Holocene deciduous forest by a relatively low human population.

Early Archaic Site Densities in Pennsylvania

When graphing the number of sites by time period in Pennsylvania, the sharpest increase in site density occurs not between Paleoindian and Early Archaic times, but rather between 8,900 and 8,200 BP. Between Early Archaic and Middle Archaic or bifurcate times there is more than a 135% increase in bifurcate sites. Furthermore, while 19% of the Paleoindian sites and 27% of the Early Archaic sites were identified by the presence of more than one diagnostic projectile point, 49% of the bifurcate sites yielded more than one bifurcate point. This pattern suggests either multiple uses or a more intensive use of bifurcate phase sites, but in any case, something very different from the Early Archaic or Paleoindian patterns.

A variety of evidence, including the environmental reconstruction for the early Holocene, suggests that population growth in Pennsylvania was slow throughout the Paleoindian and Early Archaic periods, but increased significantly during the Middle Archaic bifurcate phase. This sharp increase in site density and, presumably, human population, likely represents the expansion and "budding off" of groups of people from the south into the region as the high biomass oak/hemlock forest eventually covered Pennsylvania between 9,000 and 8,000 BP.

Overview

All of the foregoing suggests to us that much of the "received wisdom" about Paleoindian and Early Archaic populations and the environmental stage upon which they performed in the Northeast is simply in error. First, it is evident that, just as there was no monolithic late Pleistocene paleoenvironmental setting across the entire Northeast, there was not a completely uniform set of early Holocene habitats. Rather, both sets of habitats were mosaicized to varying degrees, and the transformation of one to another was neither everywhere synchronous nor in any sense cataclysmically abrupt. Perhaps the most significant difference between late Pleistocene and early Holocene environments was the presence of Pleistocene megafauna in the earlier epoch and their gradual extirpation, then complete absence, in the later time frame.

Second, the disappearance of these fauna, while paleontologically significant, is apparently of minor importance to the populations of the time as there is absolutely no convincing evidence that they were ever heavily predated. Indeed, the scant Paleoindian subsistence data from this timeframe from Meadowcroft, Shawnee-Minisink, Cactus Hill, Hiscock, Higgins, and a few other loci suggest not a focal economy based on big-game hunting, but rather a broad spectrum foraging lifeway essentially indistinguishable from the succeeding Early Archaic pattern. Indeed, the closest these Paleoindians seem to get to big-game hunting is on the northern edges of their range, where the seasonal exploitation of caribou is apparently important.

Third, the artifactual signature of the Paleoindian-Early Archaic transition is as hazy and indistinct as the differences between the two socioeconomic lifeways. There are indeed changes evident in the durable technology, such as the disappearance of polyhedral blade cores and small blade technology (though this occurs well before the Paleoindian-Early Archaic transition), the replacement of fluted points by a variety of notched forms, and the proliferation of plant-processing and woodworking tools. However, the basic curated toolkit with its bifaces, bifacial cores, and a mixture of local and exotic raw materials remains essentially the same.

Fourth, while some variations in site density and site location parameters do evidence change during the Paleoindian-Early Archaic transition, these differences are neither universally present nor sharply delineated. Indeed, where apparent, they are incremental and very subtle.

Fifth, while we perceive no startling changes in the Paleoindian-Early Archaic lifeways and attendant toolkits, we do suggest (again) that the Early Archaic-Middle Archaic differences are far more striking in virtually all ways.

Sixth, the foregoing strongly suggests that, despite their hallowed place in North American archaeological literature, the very terms Paleoindian and Early Archaic (or, for that matter, any subdivision of them) need to be reexamined. As classificatory culturally historic constructs with specific sociotechnic behavioral implications, they may have outlived their usefulness. Indeed, retention of these terms seems to obfuscate, mask, or otherwise distort the very transitions in lifestyles they were intended to illuminate.

Terminological issues aside, we reiterate in closing that we view the putatively pivotal Paleoindian-Early Archaic transition not as the beginning of a new set of lifeways in a new and dramatically different environment, but rather as a continuation of an old lifeway in a subtly changing environmental matrix that, as noted by Custer (1989), is different not in fundamental composition but in the structured pattern of its components. Put another way, the Early Archaic is the end of a tradition, not the initiation of a new one. In the long view, the Paleoindian-Early Archaic transition in the Northeast is not, as so-long believed, a case of black inexorably shifting to white, but rather a darker gray passing in nuanced shades to a lighter gray.

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Central Andean Lithic Techno-Typology at the Terminal Pleistocene-Early Holocene Transition

Elmo Leon Canales

Abstract This paper explores the Terminal Pleistocene-Early Holocene transition in the Central Andes as reflected by the stone tool assemblages. Results indicate the isolation of two assemblages each one characterized by particular technological traits. The first one, a Terminal-Pleistocene assemblage composed by non-complex-artifacts, and a second one marked by the occurrence of the well-known leaf-shaped bifacial points on the high Andes, and the stemmed Paijan points on the Coast. Further possible economic implications of this isolation are also made in order to contextualize the lithic production in the Central Andes.

Keywords Central Andes • Terminal Pleistocene • Early Holocene • Leaf-shaped stone points • Paijan points

Although transitional palaeolithic assemblages are a focus of research, this seems not to be the case for Paleoamerican transitions. This paper focuses on Terminal Pleistocene-Early Holocene lithic techno-typologies of the Andes. Recent research provides new data from different parts throughout the central Andean area. Thereafter, we are able to isolate the possible changes within this transition and explore the reasons why these occurred.

E. Leon Canales (✉)
Alexander von Humboldt Foundation, Institute for Ancient America and Ethnology, University of Bonn, Bonn, Germany

The Early Settling of the Andes

America was settled relatively late in comparison to other regions of the world. Most scholars assume that the earliest occupation occurred either around the LGM (18 kyr), or during the Younger Dryas (12 kyr).[1] A similar picture emerges from the Andes in South America, although the earliest central Andean occupation is still a matter of discussion. In fact, at a glance, one can perceive that whereas Terminal Pleistocene remains are scarce, Early Holocene evidence is more documented. To update and assess the state of the question, we need to review new contributions to the issue of entering and peopling of the Central Andes, as well as developments during the Early Holocene time-span. Now, before we discuss this topic, there are two precisions to be made. The first one is that the sites discussed below have at least one radiometric date to avoid including dubious data. The second one is that Central Andes mean mostly modern-day Peru (Bennett, 1948).

The very earliest evidence of the peopling of the Central Andes remains just as "obscure issue." There are only two references, recorded some 40 years ago. Possible modified bones from the cave of Huargo in Huanuco, Peru (Cardich, 1973) are believed to date around 14,000 cal BC, and some thirty stone and bone artifacts from the "Ayacucho level" found in the cave of Pikimachay (Peru) could also be the same

[1] Except for these two uses of the acronym "kyr," we will use cal BC (calibrated years before Christ) because the Andean chronology is based in BC, not BP or kyr. All radiocarbon dates are presented rounded, yet calibrated after OxCal 3.10.

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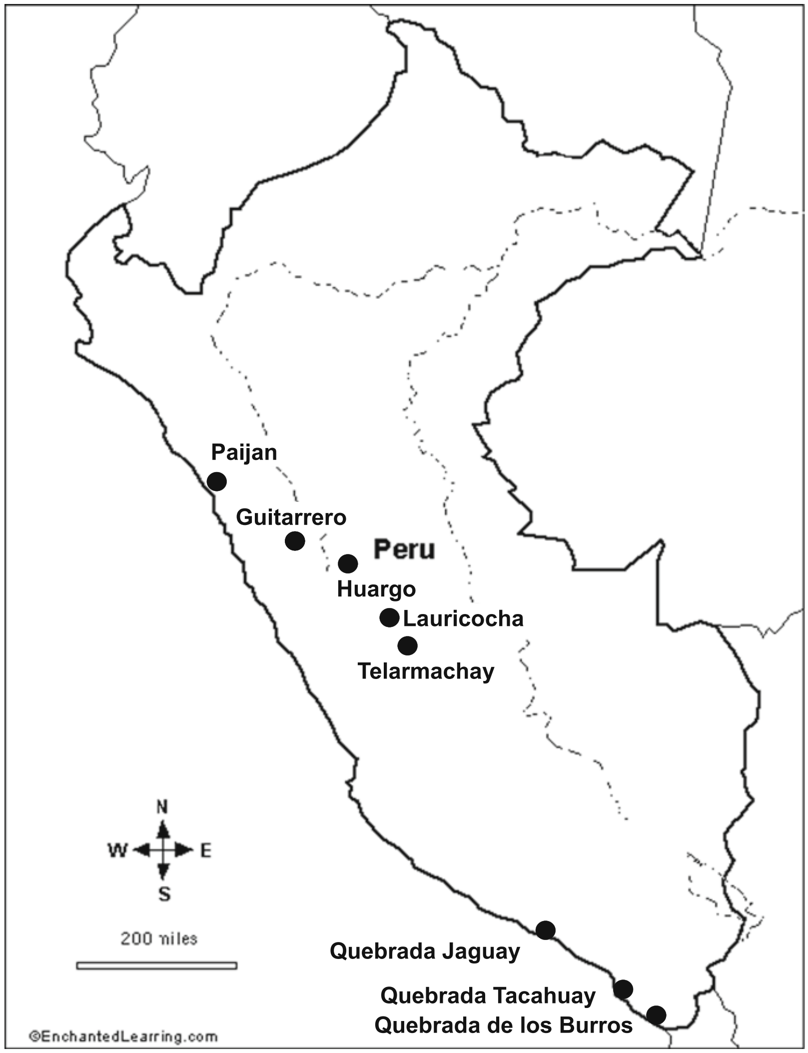

Fig. 1 Terminal Pleistocene/ Early Holocene sites discussed in the text

age (León Canales, 2007; MacNeish, 1979). We will discuss both data further (Fig. 1).

More recently, there have been some findings revealing that later Terminal Pleistocene occupations also occurred on the Peruvian coast, even just a few meters from the current shore. In the south zone, sites like Quebrada Jaguay-280 or Quebrada Tacahuay have yielded dates from 12,000 to 6,000 cal BC (cf. Sandweiss et al., 1998; Keefer et al., 1998). Now if we look at the north coast, we will realize that archaeologists conducting current field research have found remains also dating to the Younger Dryas. Even more important is that this new data is probably related to the origins of the well-known Paijan-Complex (Dillehay, 2000), characterized by a standardized elongated stemmed point—i.e., the "Paijan point" (Chauchat et al., 1992).

In sum, from both coastal and highland records, we can state that human beings were moving across the land and already occupying high altitudinal zones, probably looking for water and animal sources to survive. What remains unclear is the theme of the possible paths and ways followed by the early settlers of the Central Andes—an issue that could be explored by new research projects.

Now let us just summarize very briefly the stand of the question related to the paleoclimate data in the Central Andes before we examine the lithic data.

Changing Andean Paleoclimates and Paleoshores

Multiproxi data coming from a number of sources indicate that, despite some variability, the Andean Younger Dryas dates to 12-9.2 kyr. By that time, the snowline was from 400 to 1,000 m below the current one, and the climate was probably approximately from 1 to 2°C colder than the contemporary conditions in these zones because of the cooling of the Pacific Ocean (e.g., Clapperton, 1993; Dornbusch, 2002; Markgraf, 1993; Metivier 1998; Rodbell and Seltzer, 2000). In contrast, around 15.7 kyr there seems to have been a temperate climate in the central coast of Perú (e.g., Ortlieb and Macharé, 1989). This could virtually have been the climate that the first Andean settlers found when entering Perú.

By the end of the Younger Dryas, O18 isotopic analysis from ice cores sampled from the Huascaran glacier revealed a Terminal Pleistocene last cold episode around 9.2 cal BC, followed immediately by an abrupt elevation of the temperature at the beginning of the Holocene (Thompson et al., 1995) when human groups were adapting to the difficult rugged topography of the Andes. This change also led to the rise of the ocean level by the time from around 11,000 to 9,500 cal BC, which has been well recorded in Barbados (cf. Fairbanks, 1989). By that time, the sea level was approximately 50–60 m below the current shore line (León Canales, 2007).

While these isotopic data are clear, glacial proxy data differ in timing the end of the Younger Dryas episode. Moraines and snowlines show that this last ice age could have finished between 10,900 and 9,200 cal BC. Therefore, to establish the chronological limits of the Central Andes in this paper, we can propose that the Terminal Pleistocene covers a time span from the LGM and 9,200 cal BC, while the Early Holocene is chronologically located between 9,200 and 7,000 cal BC (cf. León Canales, 2007).

Terminal Pleistocene Sites

Between the LGM and 9.2 cal BC, there are at least a half dozen of sites to be reviewed. The two oldest ones are located in the high Andes and yielded dates between around 15 and 14.5 cal BC. In fact, the cave of Pikimachay in Ayacucho contained the indisputable very first remains from Perú. Although those artifacts were not well reported in a final volume (cf. MacNeish et al., 1980), there have been efforts made by Juan Yataco[2] and myself in recording again the collection from this important complex (León Canales, 2007: 220–223). Interesting data, such as the selection of high-quality flint as raw material, the occurrence of bladelike flakes, the knowledge of bifacial technology, the manufacture of knifes, drills, and bifacial points, and a bony point made from a fossil horse with use traces come from the "zone h" that yielded just one radiocarbon date resulting in between 15.2 and 14.6 cal BC.

The next site to examine, in chronological order, is Huargo—also on the high mountains of the Andes in a locality called Huanuco. Although research conducted in this cave has been rather restricted, Cardich unearthed faunal remains from Level 8 believed to date between 15 and 13 cal BC. From the same level, he obtained a bone of scelidoterium that shows some traces of use but that remains somewhat unclear due to the weakness of the original report and the lack of further analyses (Cardich, 1973).

A further Terminal Pleistocene date has been obtained from a site called Pan-12-58 of the Callejón de Huaylas in the central Andes. Excavations provided human bones from a mixed context dated between 11.9 and 11.1 cal BC. Unfortunately there is no report on this issue (cf. Lynch, 1980), however the age indicates a very old occurrence of human groups in the Callejón de Huaylas.

More recently, archaeologists found also Terminal Pleistocene sites on the coast. In Quebrada Jaguay-280, just 40 m above sea level, Sandweiss and his team discovered a level dating to 11,200 cal BC. Lithic artifacts from this layer were mostly apparently simple utilized flakes and debitage, showing a "nonsophisticated" technology. A similar

[2] Curator of Lithics. Museo de Arqueología y Antropología de la Universidad Nacional Mayor de San Marcos, Lima.

assemblage has been found in Quebrada Tacahuay, about 24 m above sea level, in Tacna—the southernmost department of Perú (DeFrance and Umire, 2004). Earliest dates obtained from samples from this site indicate a human occupation at around 11 cal BC. Both sites provided remains that could be interpreted as high, small, human groups depending on sea resources—mostly fish and birds.

Terminal Pleistocene dates also within the Younger Dryas have been obtained from current research on the North Coast. Dillehay and his collaborators have uncovered remains in the El Palto site in the Zaña valley, probably related to the origins of the Paijan Complex with an age between 11.7 and 11.3 cal BC. Other sites from the same zone are also from similar ages, just slightly younger within the 11 millennia BC. Stone tools recovered from El Palto seem to be simple and made by percussion. These artifacts are mostly unifacial and made of basalt and quartzite (Dillehay et al., 2003).

In the same zone, new sites discovered by Dillehay, Maggard, and Stackelbeck yielded Younger Dryas dates around 11,000 und 10,000 cal BC. It is noteworthy that Paijan and fishtail points have been found in context in Quebrada de Talambo, which is interpreted by some scholars as the origins of the Paijan point. Fishtail points are virtually a Terminal-Pleistocene/Early Holocene Horizon with a relative chronological value for the whole South and Middle America subcontinent. However, although fishtail points are found in different topographic locations, they lack absolute dates in the central Andes.

A few kilometers to the south, a new date obtained from a charcoal sample of the classic Paijan zone in Pampa de los Fósiles resulted in 10.9–10.2 cal BC. In this workshop, typical Paijan points were manufactured. Paijan points were made of local raw material and the high performance of these results mean that they were made by masters that knew all isotropic properties of rhyolite—the local raw material—furthermore, the associations indicate that both fishtail and stemmed Paijan points were coeval.

Further sites like the cave of Guitarrero and the shelter of Pachamachay in the central high plateau have yielded other Terminal Pleistocene dates, but because of the method employed and the anomalies we can only consider them as references that human beings were occupying both sites by the 11th millennium BC. In their oldest layers, both sites contained samples that have been dated to the 12 millennia BC. Nevertheless, the C14 dates related to this finds come from disturbed stratigraphies and occasionally yielded anomalous extended sigma. All in all, radiocarbon reviews indicate that the very earliest occupations in these shelters date back to between 9,000 and 8,000 cal years BC. This is the reason why we examine them in the next section. The same could be said for the shelter of Telarmachay (high plateau, central Perú), where radiocarbon data indicate that this site was occupied starting around 7,900 cal BC.

Early Holocene Sites

Two notorious changes appear at the earliest Early Holocene (around 9,000 B.C.) in the Central Andes. First, the number of early sites—also in different environments—increased. Second, the series of lithic artifacts became standard. In the high Andes, small end-scrapers made of flakes and foliate points are present in almost all techno-typological lists. Neither kinds of artifacts occur on the coast during this very earliest Holocene time, where they did arrive in the Middle Holocene.

First, let us take a look the coastal sites. Now, for the first time, after so many years of research (Chauchat et al., 1992, 2004), we are finally able to consider a Paijan complex (*Paijanien*), as a number of sites reveal a series of cultural traits of these early inhabitants of the north Peruvian Coast. However, recent data apparently shows surprisingly different ways of life, instead of just one, as described below.

There are two geographical sources to define the Paijan complex—the first one coming from the classical zone of Pampa de los Fósiles-Cupisnique, where Chauchat is believed to have found high mobile hunter-gatherers, who were always looking for ideal food and water sources and were especially attached to the sea and the seashore; and some floral communities surviving in the desert because of the moist conditions (*lomas*). Flint-knappers became highly skilled in manufacturing the well-know Paijan stemmed points, mostly made of local raw material. The time invested in producing these bifacial points was prolonged, while the first step consisted of a few minutes to outline the bifacial with simple hard percussion. The pressure to finish the point was the hardest work, usually taking some hours to finish the piece. Rose and yellow rhyolites were often selected to achieve a high-quality bifacial work. Conversely, local basaltic rocks, andesites, and quartzites were selected to make unifacial tools (*limaces*). In general, there is a sharp contrast between the highly accurate bifacial technology and the simple unifacial one. Even the increased effort in making a Paijan point remains an unsolved question. On the one hand, Pelegrin and Chauchat (1993) have posited that Paijan points were used primary as a harpoon to catch fish (Fig. 2). On the other, there are scholars that believe that such a delicate distal extreme—i.e., the tip—cannot penetrate the skin of fish (Credou, 2006). Chauchat himself believes that we could be facing a case of demonstration of high qualified and skilled workers—i.e., flintknappers (Chauchat et al., 2004).

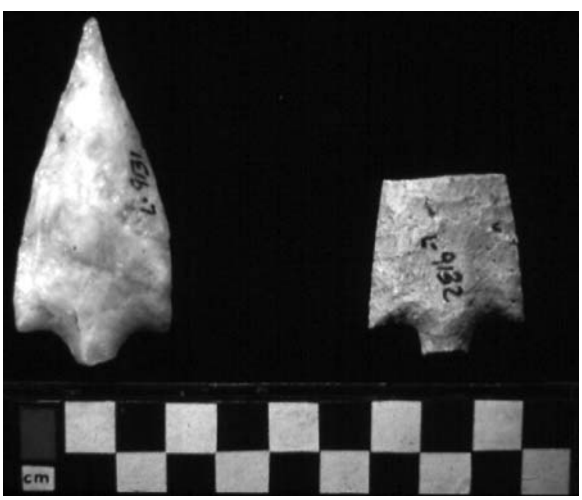

Fig. 2 Typical Paijan stemmed points from the North Coast of Peru (ca. 11,000–6,000 cal. BC.)

The second one comes from current research conducted by an American team in the valleys of Zaña and Jequetepeque. The data obtained indicate rather that there could be an evolutionary process within the same Early Holocene time span from hunter-gatherer populations towards "low" mobile people, living on local resources and becoming quasi-sedentary communities without any other complex traits. Although we do not know much about the lithic technology of these sites, there seems to be more or less the same assemblage of the classical Paijan complex, with the exception of the occurrence of some stemmed fishtail points in association with the stemmed Paijan points. Precisely in those sites, archaeologists found square-like structures that are atypical of early societies.

The problem is how to interpret these different results—not only within the same area, but also belonging, supposedly to the same cultural complex—or are we dealing with different ones? This is one further reason why a debate on the preceramic issue is so urgent to actualize, compare the data, and try to achieve general conclusions.

We now need to leave the North Coast to look at the South Coast, where, as already mentioned, some sites like Quebrada Jaguay 280 (Arequipa), the Ring site (Moquegua), and Quebrada Tacahuay (Tacna) show Early Holocene lithic tools, yet in a scarce amount in comparison with the Paijan series. While the number of tools is low and excavations are not extensive, there is a clear association between Early Holocene dates and an apparently expedient technology, composed by simple used flakes and debitage, with a minimal bifacial component. Besides, bone artifacts could have had a significant role within the different activities carried out by these early populations.

Probably the best site analyzed in depth is the one called Quebrada de los Burros (Lavallée et al., 1999). The principal researcher and her collaborators found that the lithic assemblage was in direct relationship with the marine resource exploitation. Apparently, an expedient technology was the choice by the flint-knappers during this very early Holocene time, and bifacial points were made slightly later. As shown previously, most used raw materials were local.

Sites recorded in the high Andes are abundant, and therefore we are able to make a better assessment because of the classical data and the new information obtained during the last several decades. From the beginning, with the discovery of the cave of Lauricocha (Huanuco), techno-typology showed a standardized *repertoire*. Two omnipresent artifacts are the well-known foliate points and

Fig. 3 Early Holocene leaf-shaped Andean points (ca. 11,000–3,000 cal. BC)

typical end-scrapers made of little secondary flakes (Fig. 3). Perhaps the best data come from the outstanding analyses of lithic artifacts of the Telarmachay rock shelter (Junin) at about 4,000 m above sea level (Lavallée et al., 1985). The typology developed for this site is classical and more or less the same as for the other coeval settlements of the high Andes. This assemblage is characterized by the absence of blade technology, and mostly by orthogonal core reduction, to remove little flakes to make end-scrapers, side-scrapers, perforators, knifes, and even simple debitage used without retouching. Bifacial points and scrapers were made of high-quality raw material (usually flint), while other artifacts were manufactured with different rocks like andesite, quartzite, basalt, and so on. As already mentioned, it was usual that the flint-knappers moved just a few kilometers away for sourcing stones, and only exceptionally further away when they were looking for obsidian. Bifacial points, as well as end-scrapers, are associated with hunter-gatherer economy, where the intensive use of camelids and deer were the principal sources of food. Microwear analyses have proven that points were made not only to hunt animals, and also that end-scrapers were mostly used to work skins.

Now, blade technology is unusual, but there is evidence of the production of intentional blades in some sites located in the high Andes. This is the case, for instance in the Guitarrero cave. Lynch published blade-like flakes and veritable blades—i.e., bladelets and little blades—in comparison with the impressive blades of the Old World Upper Palaeolithic, or even those found in the Clovis culture in North America. A closer approach to this material reveals, first of all, that most of these pieces are little primary blades, and that the cores from which they were removed were just slightly prepared. In these cases, just one flake was removed from the platform to regularize it and obtain elongated products. A similar assemblage has been documented in Quishqui Puncu, not far away from the Guitarrero cave. We also need to put emphasis on the fact that this kind of technology occurs in association with the oldest practice of cultigens in South America (Lynch, 1980). Therefore, this Early Holocene population of the Callejón de Huaylas deserves more attention and further research (Duccio Bonavia, personal communication, February 2006).

Back to blade technology, we expect some interesting data when research is done on the blade issue in the Central Andes, especially because of key data from El Inga (not far away from the central Andes), and also within the same Early Holocene period (Mayer-Oakes, 1986). In this site, there seems to be a clear association of blade technology and fish-tail points. Thereafter, one can ask if the owners of this technology are the same people spreading over the Andes at those times.

Back to the classical assemblages—i.e., the tradition of the foliate points—there is little research on the reconstruction of the *chaine operatoire*. But when looking at this material as a whole, there are obvious analogies, so one can presume that early Holocene central Andean people managed some regular traits regarding lithic technology. As said before, in fact, the best effort in trying to reproduce the whole sequence from the raw material until the discard of the used artifact comes from the study of the shelter of Telarmachay. Andean flint-knappers used mostly percussion but also pressure techniques. Some artifacts have been finished just by percussion—even bifacial points. From Guitarrero Cave, for example, there are a number of unifacial nondiagnostic artifacts that should be explained by the "industrial role in processing raw materials" of the site (Lynch, 1980). Instead, the highly standardized bifacial points from the shelter of Pachamachay should be regarded as a response from the principal activity of the inhabitants of this site—i.e., the hunting of vicuñas (camelids) (Rick, 1980). Nevertheless, the lack of microwear studies is a handicap to further comments.

Exploring the High Andes and Looking for Resources

To date, there is no study of the settlement patterns for the Terminal Pleistocene, nor for the Early Holocene of the Central Andes. It is true that from the very beginning there is some evidence that the Central Andean people were occupying the area from the shore of the Pacific Ocean to the high mountains above 3,000 m above sea level. Even sites like El Palto (north Highland Perú) or Pikimachay (Ayacucho, south Highland Perú), which are not far away from the east tropics, support the idea of a Terminal Pleistocene/Early Holocene peopling covering different topographic landscapes of the Central Andes. Even the scarcity of sites belonging to this period makes getting an objective picture of the issue difficult.

This amazing early coverage of diverse zones is also reflected in the archaeological record related to diet and procured food. Sites are located almost always near water sources (ocean, river, and even near *lomas*, (i.e., a sort of temporary "foggy oasis" in the Peruvian desert), and near food sources like inter-valley areas, the high plateau, and the sea. Paijan sites depended mostly on fish and (secondarily) small fauna like lizards and snails. There is interesting evidence that shows the transport of fish in good conditions from the shore up to altitudes of more than 1,000 m above sea level. On the south coast, during the interval of the Terminal Pleistocene-Early Holocene, humans not only captured fish but also (and sometimes, especially) shells, snails, and crustaceans—like in the Quebrada de los Burros site (Lavallée et al., 1999).

In the high Central Andes, data recorded from different sites indicate that, at the beginning, there could have been hunting or scavenging of megafauna—mostly of the order of the *Probocideae*—but we need more data in this regard. Further, once the Holocene environmental conditions began, first the hunting of deer and then of camelids was the rule. These changes were encompassed with the appearance of the first experimentation with cultigens that has been recorded in the Guitarrero cave (cf. Lynch, 1980). Once the camelids began to be hunted, humans were able to examine their traits, and in this way the domestication process began about 6,000 years BC (Bonavia, 1996).

Concluding Remarks

The current state of knowledge of the earliest human occupation in the Central area is still weak in comparison with other parts of the world, especially during the Palaeolithic. Evidence shows that this territory could have been occupied from the Dryas II period onwards—around 15,000 cal BC. The only two sites dated to this time-span are located in the highlands, but it does not mean that the coast had not been settled by this early time. Undoubtedly, more research is required to achieve a categorical opinion.

Aldenderfer has already pointed out that Terminal Pleistocene-Early Holocene changes in the paleoshore resulted from the rise of the sea level; changes among the floral communities, and from megafauna to camelids and deer as the principal food sources in the Andes, played a relevant role in the new adaptive techniques of these early groups (Aldenderfer, 1999).

By that time, it is possible that flint-knappers were able to manufacture bifacial artifacts, like points and unifacial pieces. It should not be excluded that they already knew about blade technology. It is also probable that they controlled and assessed raw material quality, and therefore selected fine-grained material to perform bifacial pieces, whereas unifacial pieces were made by other volcanic and metamorphic materials. Bony artifacts were also important, but this assemblage remains little known because of a lack of serious research.

Some later occupations (until the advent of the Younger Dryas) show that the shore and coast between 0 and 200 m above sea level were occupied at this time, too. It is probable that from that period, people were moving from the shore to around 3,000 m above sea level because of the later Early Holocene interchanges of materials like obsidian or marine shells (León Canales, 2007). Later Coastal assemblages display just "simple" technologies, because those materials were utilized and slightly retouched flakes were the rule. Occasionally they performed bifacial points. This technology should be assessed within a coastal marine landscape, where fish and birds were the main sources of food.

After the Younger Dryas, transitional changes occurred in the assemblages, both in the high Andes and the North Coast. The first one was the production of a highly standardized industry—composed especially of small bifacial points and end-scrapers, surely in relationship with camelids and deer hunting. Yet, the passage from this way of life to early farming is still obscure. What seems to be clear is that this way of life was established during the 10-9 Millennia BC—a time span to be compared, for instance, with the early Natufian in the near East (León Canales, 2007). Therefore, one of the interesting changes during this transitional period was probably the emergence of a sort of incipient agriculture in the Andes.

The second transition concerns the Paijan Complex and its relationship with the fishtail points. Both bifacial technologies were already known at the end of the Younger Dryas. The extreme difficulty of making a Paijan point makes it singular, and therefore a hallmark in contrast to the high Andes lithic technology. Nevertheless, there is enough evidence that there were several contacts between these two populations, as mentioned above.

The resources used by these groups were mostly local, and one can suggest the opportunistic character of the humans of the Central Andes. Lacking microwear analyses, we can just suppose some uses of some key artifacts. Many stone artifacts from the shelter of Telarmachay were used in an array of tasks. Even bifacial points were not only used for hunting purposes. In Zaña, middle Holocene sites contained tools often utilized in gardening and cutting plants. This kind of artifact is rather "simple" and not sophisticated, lacking the application of bifacial techniques. The use of the stemmed Paiján point remains a mystery. Whereas Chauchat and his collaborators believe they could be used either as harpoons to catch big fish, or as symbols of prestige (2004), there is also the opinion that these points were not able to perforate the hard skin of fish from this time period (Credou, 2006). Therefore, we need more studies in this direction to enrich the discussion.

In summary, the Terminal Pleistocene-Early Holocene transition in the central Andes is characterized by the passage from a hunter-gatherer way of life to two types of economies. On one side, there was one that produced standard assemblages and was based on a marine economy. On the other, one was derived of ancient farmers and therefore initiated one of the greatest revolutions ever: agriculture in the Andes during the Early Holocene.

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The Paleolithic-Mesolithic Transition

Marcel Otte

Abstract An historical approach to the study of Paleolithic cultural evolution considers it a long sequence linking universally relevant events that lead to change in human behavior. However, a more general approach reflects the role of human awareness—an ongoing and increasingly intensive factor for behavioral change—as shown, for example, by the independent invention of agriculture in different parts of the world.

The most important of these "developmental phases" concerns what has been considered by some archaeologists to have been the "optimal" adaptation of hunter-gatherers to their environments (see Sahlins, 1972 and subsequent debate). In Europe, Asia, and North America, this is particularly evident during the Late Glacial period, but other examples exist elsewhere in the world and from both earlier prehistoric periods and modern hunter-gatherer groups (e.g., the Khoi San, Amazon, and Polynesian tribes) (Cziesla, 1992; Conte, 2000; Deacon and Deacon, 1999). In this developmental phase at the end of the Paleolithic, technological culture is characterized by the geometrization of microliths made on bladelet segments, and the generalized use of the bow and arrow. Yet, on a metaphysical plane, the transformation is much stronger: human representations show man in narrative scenes and in action, dominating animals and nature, well before domestication (e.g., in British Columbia). With respect to subsistence economy, the range of fauna hunted is much broader than during the Paleolithic, and plant food resources broaden as well, making it possible to lead to sedentism prior to the adoption of agriculture (e.g., Natufian, Capsian).

Keywords Settlers • Hunters • Sociology • Religion • Evolution

Introduction

There are only a limited number of processes proposed by archaeologists to account for or explain the forms of transformation during the Paleolithic. The first makes reference to the evaluation of the degree of cognitive *capacity*, as has been applied to the Lower to Middle Paleolithic transition. The second concerns the *accomplishment* or *realization of capacities* applied to comparison of the expression of different Upper Paleolithic cultures (Gravettian-Solutrean in Europe, Clovis in North America, or Wilton in Africa). The third category combines these two types of processes applied to the Middle to Upper Paleolithic transition. All three kinds of processes take place within environmental contexts that permitted the choices that were made, without being deterministic: cultures vary much more than climates and biotopes.

The transition from the Paleolithic to the Mesolithic belongs to the third category. In our view, this is the most significant transition that occurred in human history; not only was it universal in scope (as if it were "contained" within the human spirit), but it was also the basis for the subsequent Neolithic food producers (Bar-Yosef, 1983, Cauvin,

M. Otte (✉)
Service de Préhistoire, Université de Liège, Liège, Belgium

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Fig. 1 Introduction. *Left*: Lepenski Vir head (Serbia) (after Gimbutas, 1991). *Right*: divinity statuette (Polynesia) (after Collective, 1972)

1978; Valla, 1988). Moreover, this transition can be observed, even today, in different parts of the world. It combines both changes in cultural aptitudes and adaptation to dramatically changing climatic conditions. We consider that this phase more particularly corresponds to a radical change in the structure of thinking, in which humans developed an entirely different view of their relationship to nature. Some examples presented here will illustrate this phenomenon (Fig. 1).

Chronology

The dating of this transition begins with the chronological patterning in which the Paleolithic always precedes the Mesolithic, as if the Mesolithic in each area of the world developed from the Paleolithic. We also note the much shorter duration of the Mesolithic period in comparison with the Paleolithic—also apparently in all regions of the world. In consequence, the evaluative *rhythm* followed by the succession of cultural traditions appears to be much more elevated during the Mesolithic than during the Paleolithic; even during the Epi-Paleolithic—its final phase. This phenomenon may be due to a demographic increase—itself caused by new ways of life—or the development of denser exchange networks during the Mesolithic than previously. Because the developmental phases of the Mesolithic are both more rapid and more clearly separated, it is thus possible to distinguish them with greater facility than for those of the Paleolithic.

This chronological uniqueness, in relation to Paleolithic traditions often lasting several thousands of years, did not take place everywhere at the same time, but the approximate equivalents can be observed. For example, in Europe, a chronological gradient is observed from southeast to northwest, in which this transition took place from the 8th millennium BC (in the southeast) to the 4th millennium BC (in the northwest), depending on the adaptation rates of the food-producing ways of life that followed. In the Near East, this transition begins earlier, during the 12th millennium BC (the "Natufian"), and is quickly replaced by the Early Neolithic which developed directly from the preceding Natufian (in contrast to Europe). The schema is fairly similar in North Africa, with the Capsian. But, in our view, in the modern world, entire regions still practiced what could be considered to be "Mesolithic" ways of life until the first European contacts: British Columbia, South Africa, Amazonia (Lavallée, 1995; Deacon and Deacon, 1999) (Figs. 2 and 3).

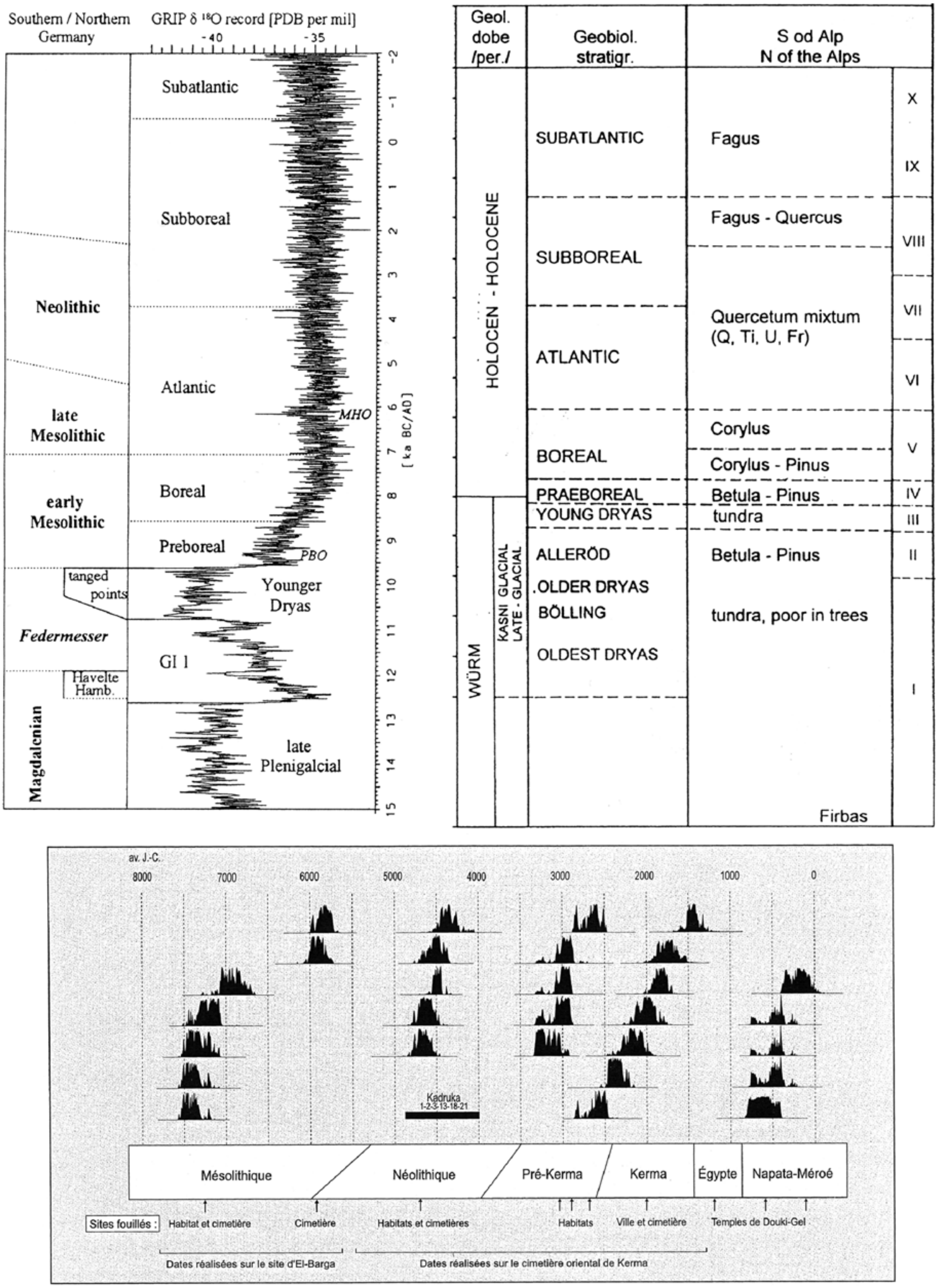

Fig. 2 Chronology. *Top left*: (after Johnsen et al., 1997 and Jöris and Weninger, 2000, in Street et al., 2001). *Top right*: (after Alojz Sercelj, 1996). *Bottom*: (after Honegger, 2005)

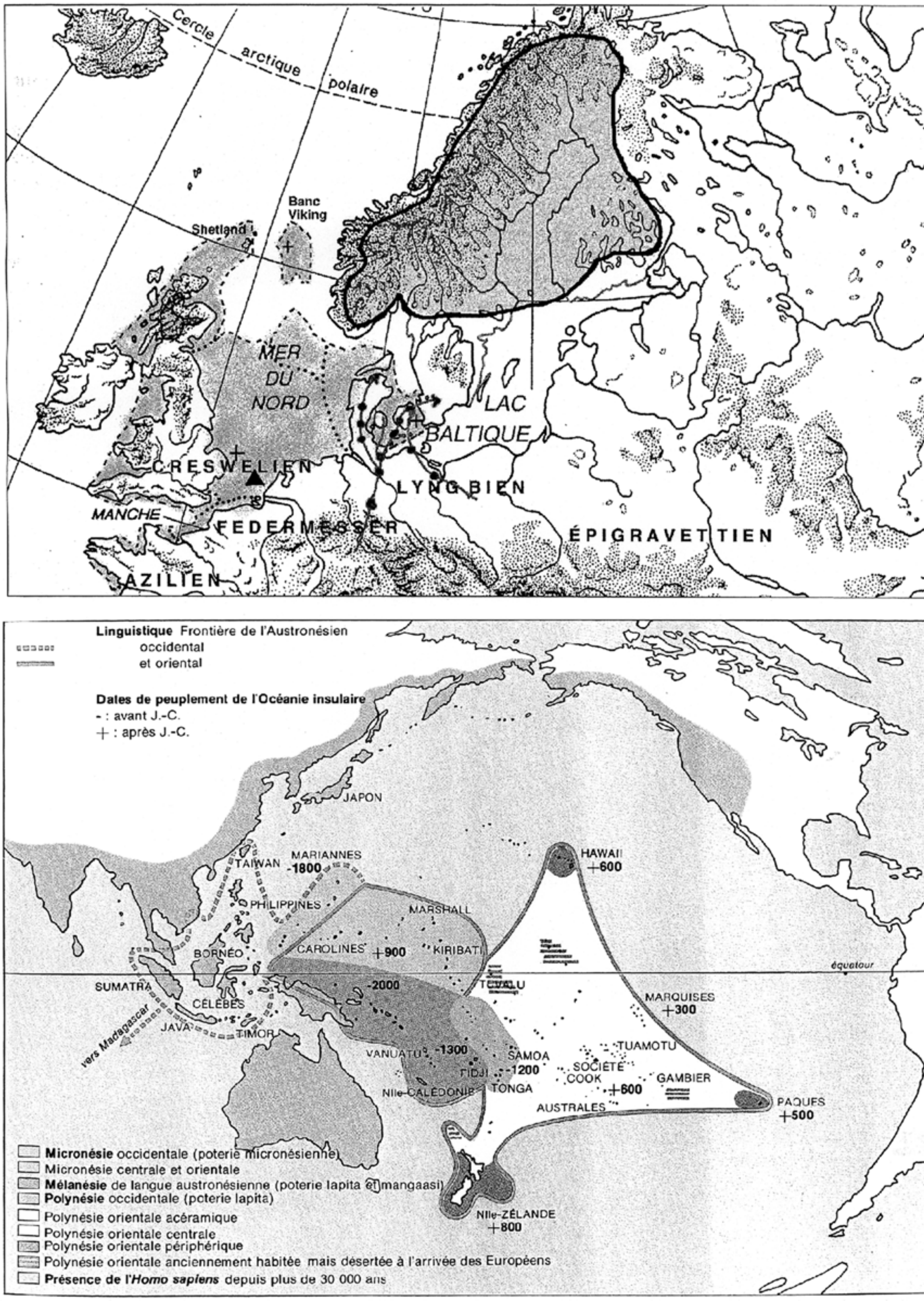

Fig. 3 Extension. *Top*: European population distribution (after Plumet, 2004). *Bottom*: Oceanic population distribution (after Conte, 2000)

Environment

In a general manner, the Paleolithic-Mesolithic transition also corresponds to significant changes in climate—the transition from dry and cold conditions to more temperate and humid environments that were more variable. It is difficult to determine a cause-effect relationship between cultural factors and ecological conditions, even less so since certain populations seem to have preserved their Paleolithic values and ways of life nearly until modern times (e.g., Australian Aborigines, Pygmies, Inuits). Even in the archaeological record, we observe this Paleolithic persistence, continuing in parallel with Mesolithic innovations (Central Africa, South America, China). Thus, we can argue that the ecological context of the Late Glacial and Post-Glacial *permitted* the transition to the Mesolithic, but was not deterministic—an argument that can be applied to all of human history. In addition, these climatic changes occurred innumerable times during the Paleolithic without significant cultural changes comparable to the development of the Mesolithic. With R. Braidwood, who alluded to the emergence of the Neolithic, we have to accept, although fairly vaguely, that humanity "was ready" and that climatic change served only to accentuate a trend that was, in any case, inevitable.

The transition was also dramatic on a geographic scale. The global rise in sea level led to the alteration of coasts that now penetrated deep into formerly terrestrial territories (Fischer, 1995). New aquatic resources became available and new settlements were thus installed near coasts and along rivers. This, in turn, led to considerable demographic change because, apart from seacoasts, the rise in precipitation also created lakes, increased the size of estuaries, and led to the compartmentalization of landscapes by the expansion of hydrological networks. The human-nature relationship was thus profoundly marked by aquatic environments.

Techniques

For the archaeologist, the most easily accessible data are relevant to technology. This indirectly evidences the universality of changes in thought processes, oriented in the same sense across the globe regardless of context—the transition was simultaneously, global, fundamental, and irreversible. The general tendency is toward the diminution in blank size, which changes from Paleolithic blade or flake to bladelets and microlithic tools. This increased the quantity of blanks from a single raw block, fist-sized, which could itself be exported where needed, depending on hunting demands. Once at a hunting site, the core could then be knapped to produce fine bladelets that would be systematically broken into segments that were directly retouched into microliths. The lightness of lithic products worked well with the propulsion method generally adopted during the Mesolithic, although sporadically present during the Paleolithic. The bow and arrow was much better adapted to the denser forest cover: it was precise, rapid, and silent. But more significantly, it corresponded to an entirely new metaphysical relationship to nature—the bow overcame the constraints of speed, distance, and precision. Humans who mastered this technique came close to being natural gods by borrowing part of nature's power. It is this that defines the veritable transition to the Mesolithic—a more advanced level of human dominance, due to the ability to think over the forces of nature (Fig. 4).

This "amplification of mechanical powers" is identical not only across the world, but also in all material categories. Vegetal materials were abundantly exploited in conjunction with stone: arrowheads, lamps, and bows, as well as woven fishing baskets, canoes, and containers. Bone materials continued to be exploited, especially as axes to work wood, but had less importance than before the transition (Fig. 5).

The most spectacular change in the technical domain lies in the shaping of terra cotta containers (e.g., the ceramics of Limburg, La Huguette, and Ertebölle). These exist from Normandy to Kamchatka to the Americas, in the same cultural contexts. The mobility of the groups supports their limited structure and highly fragmentary state: the main containers were made of vegetal material.

Resources

With respect to diet, the transition to the Mesolithic is characterized by broadening the range of resources made possible by the more clemental

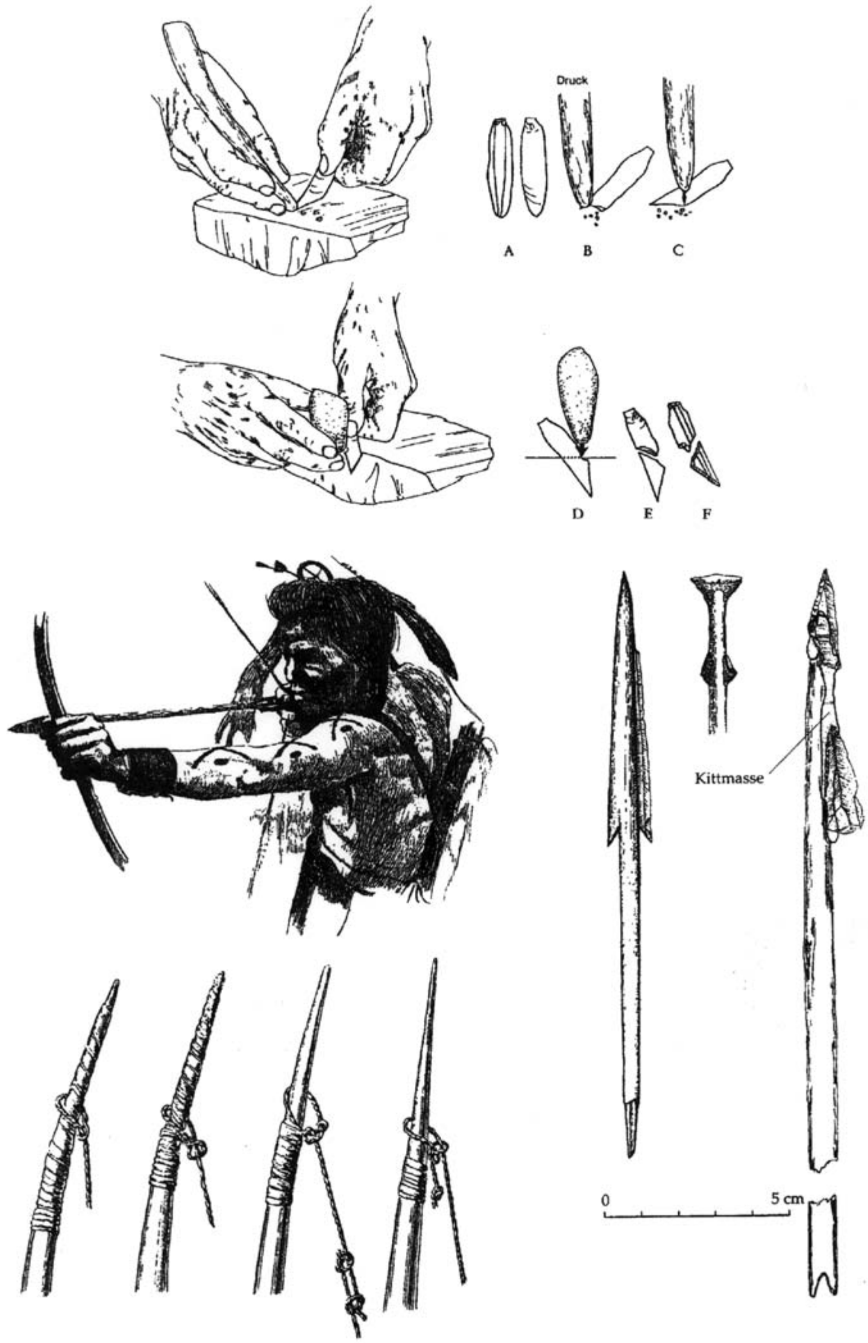

Fig. 4 Lithic technology (after Cziesla, 1992)

climatic conditions, a better adaptation of techniques to new environments (e.g., fishing baskets), and the crucial contribution of proteins from aquatic contexts (from mollusks to whales). Dietary diversity was staggered throughout the different seasons and included a significant vegetal component: leaves, fruits and roots that were nearly inaccessible during the Paleolithic. Hunting is specialized and a social aspect is added to the search for subsistence, serving to give an individual a specific role within the group. Astuteness, courage, and ability are recognized in a selective hunting strategy

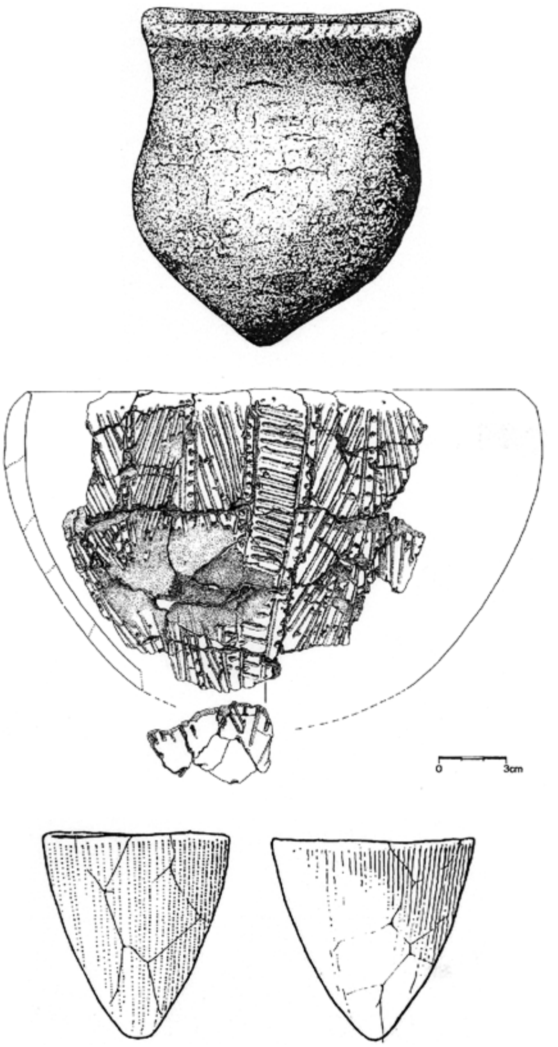

Fig. 5 Ceramics. *Top*: Ertebölle (Denmark, 5th mill. BC) (after Fischer, 1995). *Center*: Limburg pottery (Mesolithic, 6th mill. BC) (after Jadin et al., 1991). *Bottom*: Pottery of northern Eurasian hunters (after Groot, Sugihara and Serizawa)

of single animals more than a strategy oriented towards herds, as was practiced during the Paleolithic.

Resource-gathering was thus varied and abundant, implying the existence of a greater diversity of tasks, and included the participation of women and children, with large-game hunting being limited to young adult males. The guarantee of resources, and thus survival, became a largely collective task, reinforcing social links as can be seen in artistic and religious domains, for which the basis became man himself and (less clearly) nature.

The varying access to different resources throughout the years has a symmetrical counterpart: seasonal migrations following herds (e.g., reindeer, horses, and bison) lost their economic importance and were limited to the sphere of traditional customs. The ethnic landscape of the Mesolithic was more parceled out, with a greater degree of regional differences, than during the Paleolithic. The Paleolithic-Mesolithic transition thus has a social value (Fig. 6).

Habitations

Associated with such new ways of life, the greater ethnic division of the landscape, and the broadening of the resource base, settlements accentuate more permanent aspects—in particular, by the concentration of tasks. More "durable" structures appear, for long-term use and to protect a wide range of activities—crushing and grinding of materials included. Remaining circular, like transportable tents, such structures were permanent. Circular and vertical postholes show evidence of posts to support walls made of clay and stone. The traditional heritage is thus one of nomads, living in portable tents, but the definitive transition is marked by their fixity that would be later given to the orthogonal houses of the Neolithic.

This change from mobile to fixed led to a completely different relationship to the landscape. Although it remained exploited in its wild and natural state, land was from then on "owned" by the clan, family or lineage, because it was already the main source of life and reproduction. This perpetuity can also be observed by the grouping of burials in cemeteries close to semipermanent "villages" of the living; this would be further developed by the complete integration of burial places and habitations. Isolated skulls, and at other times entire bodies, were sometimes physically interred into the habitation floors, as if to mark the permanence of this dominance over the obstacles from life to death. The Mesolithic habitation forms a symbol of this new idea, like the use of the bow is for prey. The possession of such powers, symbolic and technical, evidence both a spiritual conquest of man over biological constraints and a will to be freed relative to caloric procurement (Fig. 7).

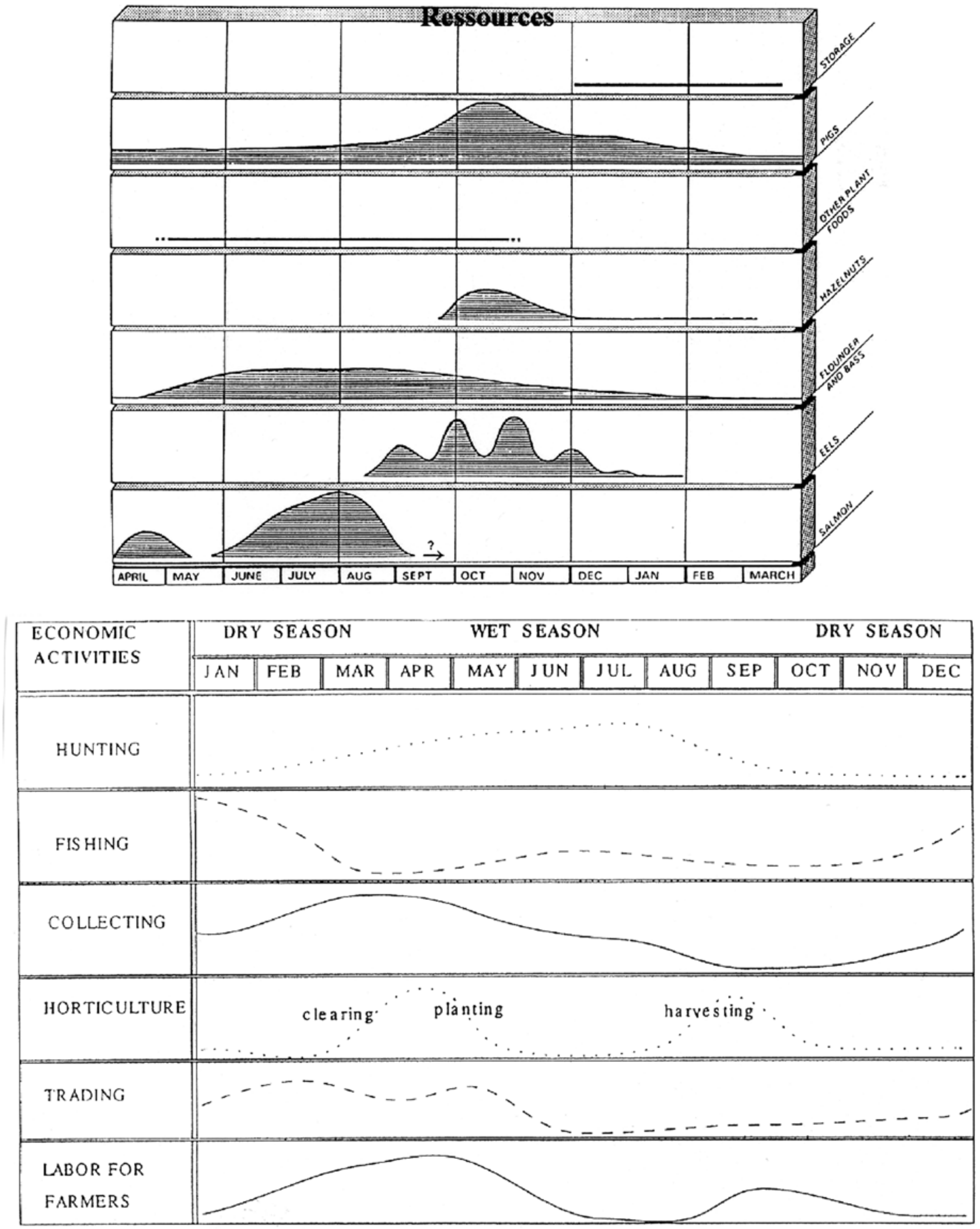

Fig. 6 Resources. *Top*: (after J. Woodman). *Bottom*: (after Lee Junker, 2002)

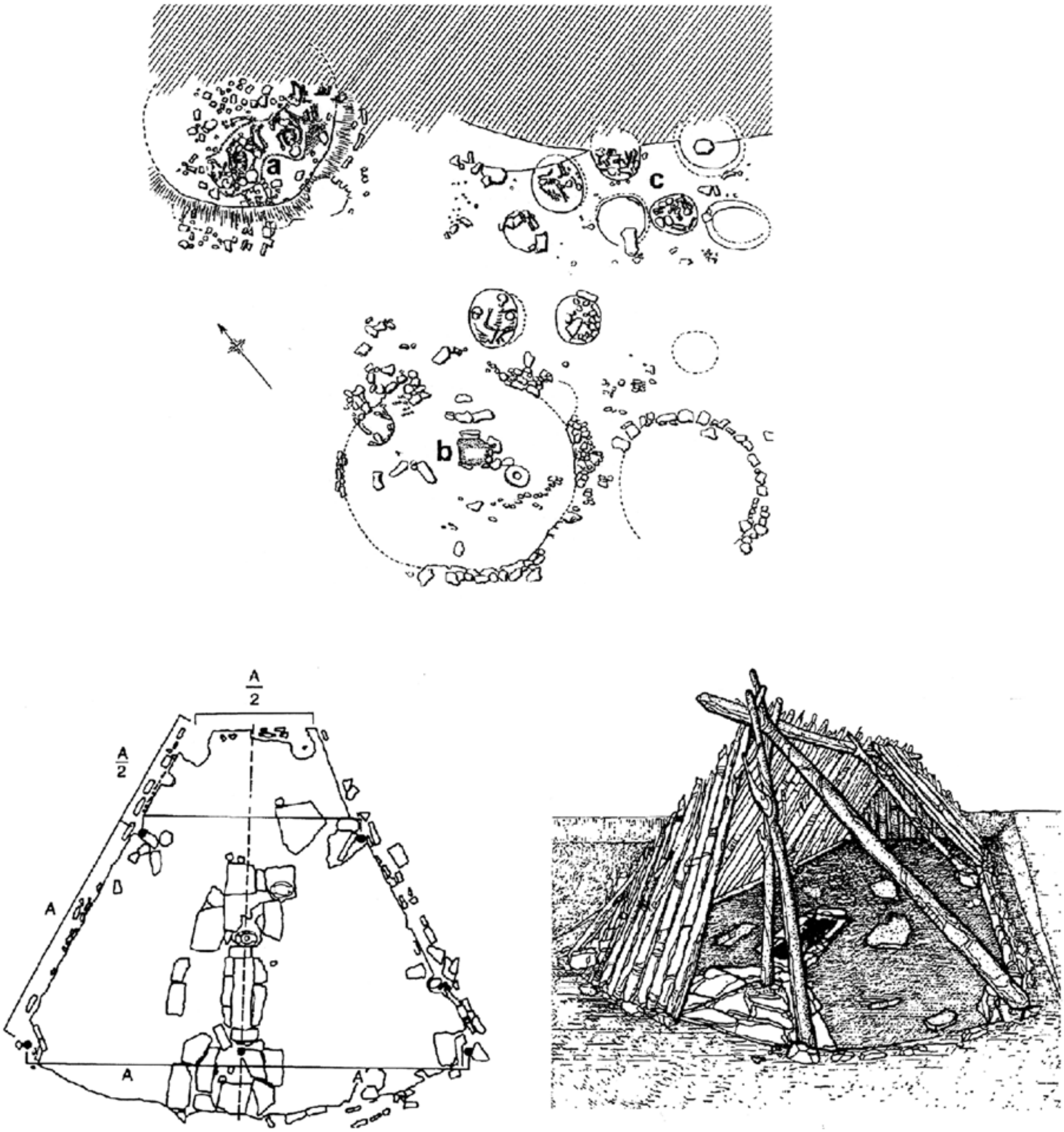

Fig. 7 Habitations. *Top*: Mureybet (Syria) (after Cauvin, 1978). *Bottom*: Lepenski Vir (Serbia) (after Sailer, 1997)

Cultural Traditions

As reflected in technical methods, Mesolithic cultural traditions seem to "explode" across the landscape and through time. Countless groups appeared, defined by stylistic criteria, covering Europe like patchwork during the short climatic phases of the Holocene. Such "regionalism" is clearer than during the Paleolithic, defined on the basis of secondary but permanent criteria (armature types, lateralization, geometric forms, retouch types). Such cultural diversity can be observed outside Europe—for example, in the Capsian of North Africa, the Natufian of the Levant, the cultures of the

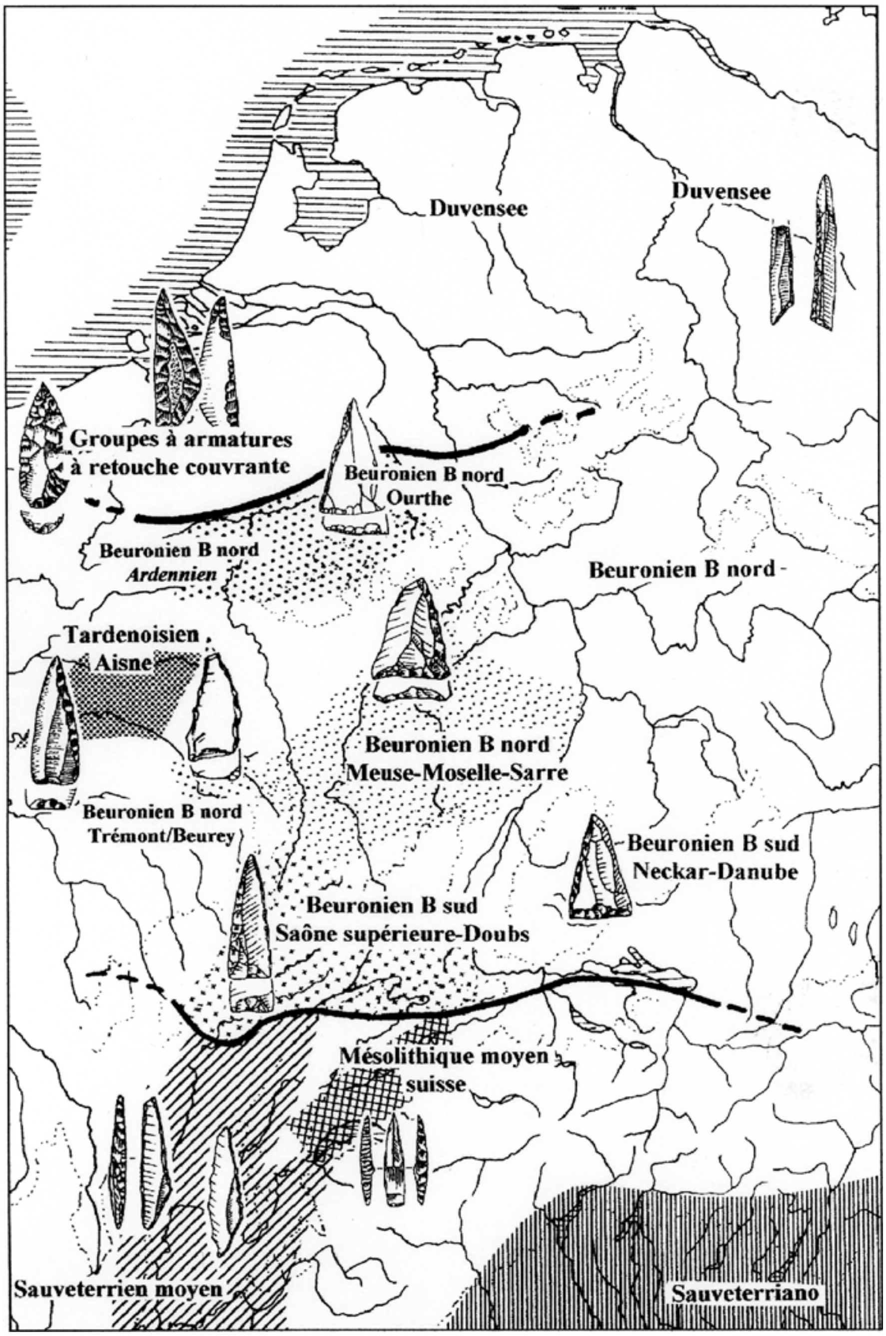

Fig. 8 Northwest European traditions (after Guillot et al., 1997)

Amazon, the north of the Far East, and especially the abounding production of armatures in East and South Africa (to modern times in the case of the latter) (Fig. 8).

For each region in Europe, "vertical" developmental charts have been constructed to demonstrate variation in both time and space. Certain constants can be seen within this diversity, however, such as the geometrization of microliths or expansion of core reduction by the pressure technique. These demonstrate the impact of the circulation of effective technical concepts, despite traditional and geographic barriers (Fig. 9).

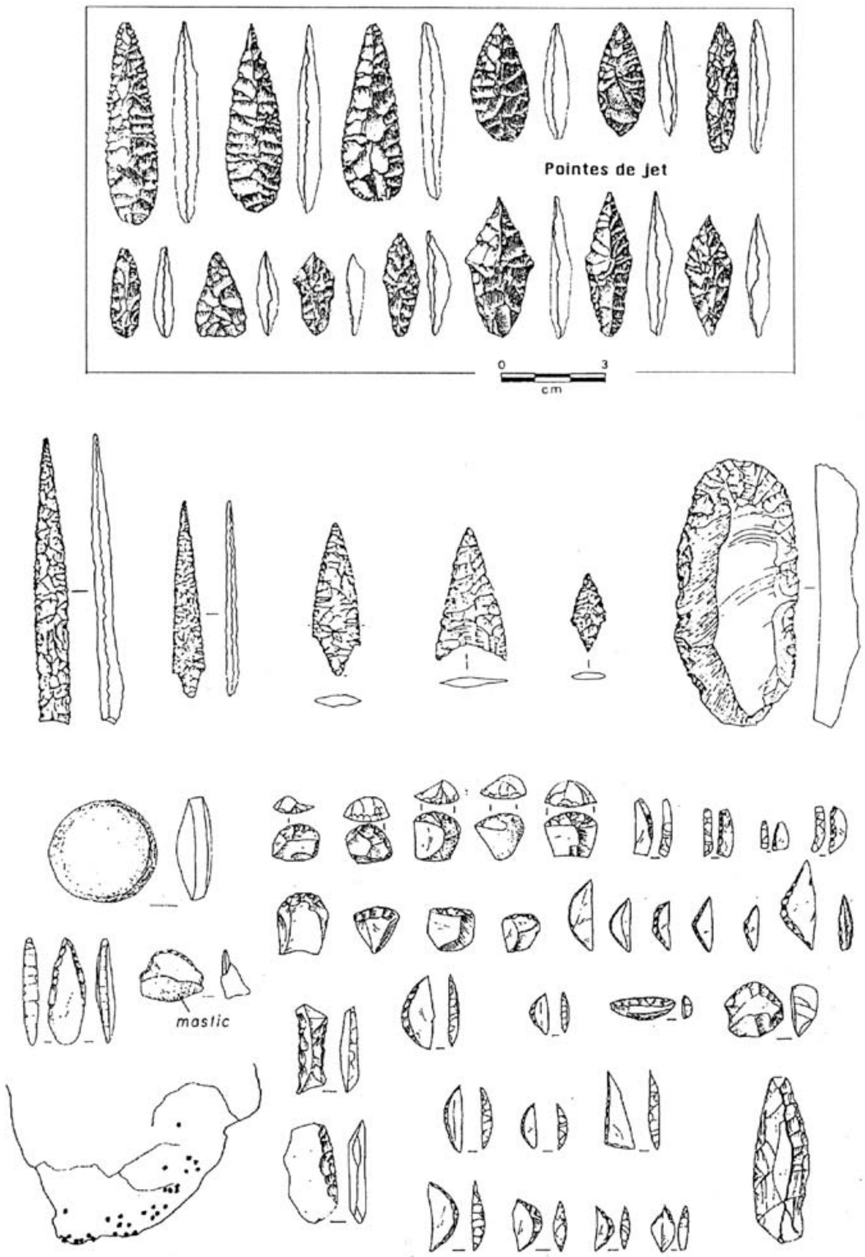

Fig. 9 Traditions. *Top*: Brazil (after Lavallée, 1995). *Center*: Japan (after Inamura, 1996). *Bottom*: South Africa (after Deacon and Deacon, 1999)

The transition is here attached to the decomposition of the large ethnic and cultural units of the Paleolithic, replaced by social boundaries indicated by connections of highly specialized technical practices and, in consequence, intimately linked to the self-identification values of a group (Figs. 10 and 11).

Art

The rupture with the Paleolithic is perhaps strongest in this category of activities. Several major trends appear and emphasize the impact of the new epoch. The first consists in a form of "inertia" from the Paleolithic in which artistic

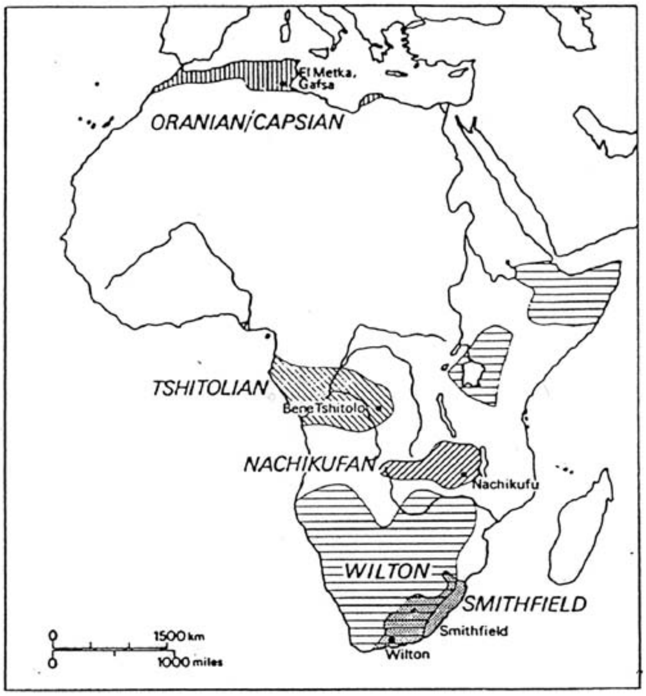

Fig. 10 African traditions (after Clark, 1977)

values slip in their material importance. Animal motifs that dominated Paleolithic mythology descend from monumental walls and are found as harmless objects, such as handle decorations on sickles in the eastern Levant or amber pendants in Scandinavia (Clark, 1975). The savage nature of animals has clearly lost its importance in the symbolism expressed by the image, as if separated from its potency, thus accentuating the demarcation between the natural world and human society. Another trend highlights this transition—the increase in the number of images of humans, in engraved bone in Scandinavia, statuettes in the Levant, and veritable permanent statues sculpted at the entrances of the houses at Lepenski Vir in Serbia (Sailer, 1997). This phenomenon is observed everywhere that has a way of life comparable to the European Mesolithic—the tikis of Oceania and African and Amazonian statuettes. Such art materializes a totally new power given to humanity by the image, as if the nascent gods were comparable to humans and thus gave humans their power and value by their image. Finally, art became "animated" during this transition; we now observe scenes—a network of relationships that unite the figures (men, women, animals) in a significant way (Spanish Levant, Sahara, South Africa). From then on, this became the perceived, recounted, and understandable reality that took its first steps toward a world idealized by the mythological practice of the Paleolithic (Figs. 12 and 13).

Religion

Man was thus placed at the center of spiritual preoccupations after this fundamental transition. Nature beat a retreat and, by his action transposed in images, man continued to master his natural behavior while still remaining (in part) in the natural world. This is comparable to burials that remind one of the Paleolithic period, and to animal fetishes that were introduced (teeth, antlers). The religion of the Mesolithic did not eliminate nature; many representations evidence this fact and, moreover,

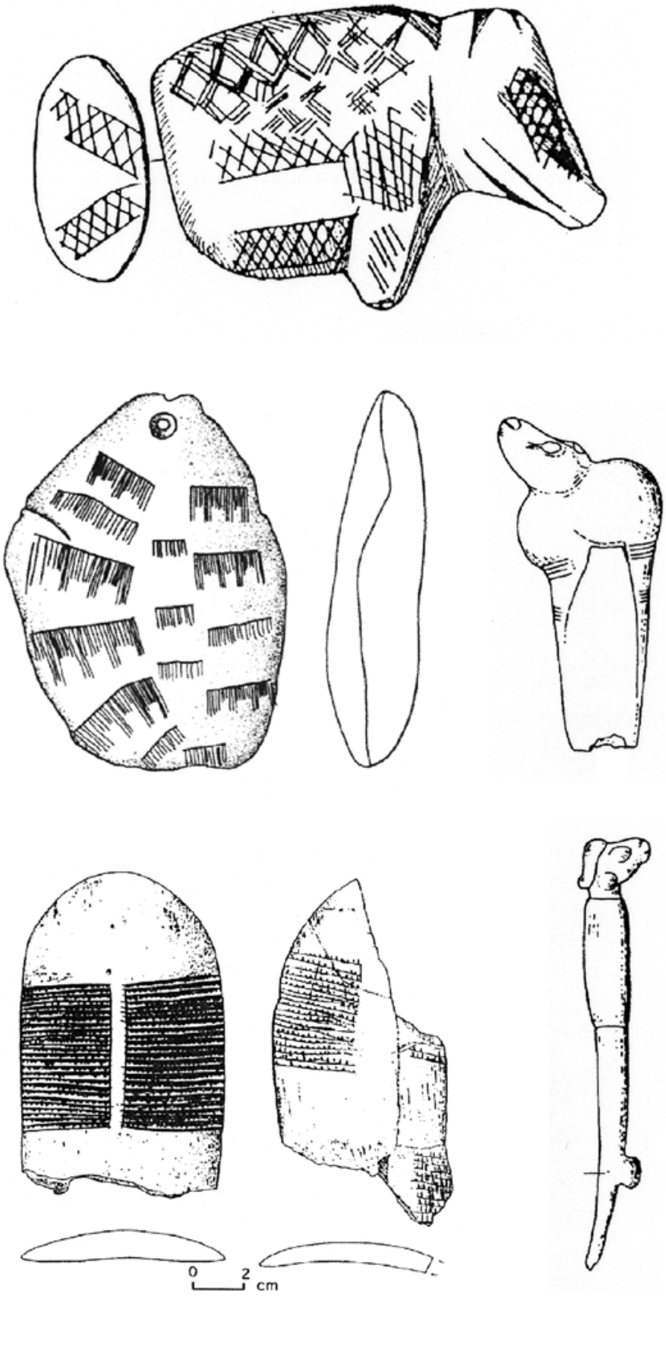

Fig. 11 Mobile art. *Top and center-left*: Denmark (after Clark, 1975). *Center-right*: Kebara (Israel) (after Bar Yosef, 1983). *Bottom-left*: Russia (after Plonka, 2003). *Bottom-right*: Hayonim (Israel) (after Bar Yosef, 1983)

the demographic equilibrium was (and still is) maintained in this societal mode. The Mesolithic is properly "transitional," and in this sense is both fundamental (the Neolithic derives from the Mesolithic) and perfectly balanced (many populations live today with this way of life) (Fig. 14).

By showing humans as dominant in artistic scenes, art restored a religion in which the human conscience is displayed and takes on a new privileged status. Man took on a crucial importance, as much in images as the quite real force obtained by the use of the bow. Aiming long and precisely, he

Fig. 12 Arts. *Top*: Levantine art (Valencia, Spain) (after J. Jelinek, 1978). *Bottom*: Khoi San art (South Africa) (after D. Lewis-Williams)

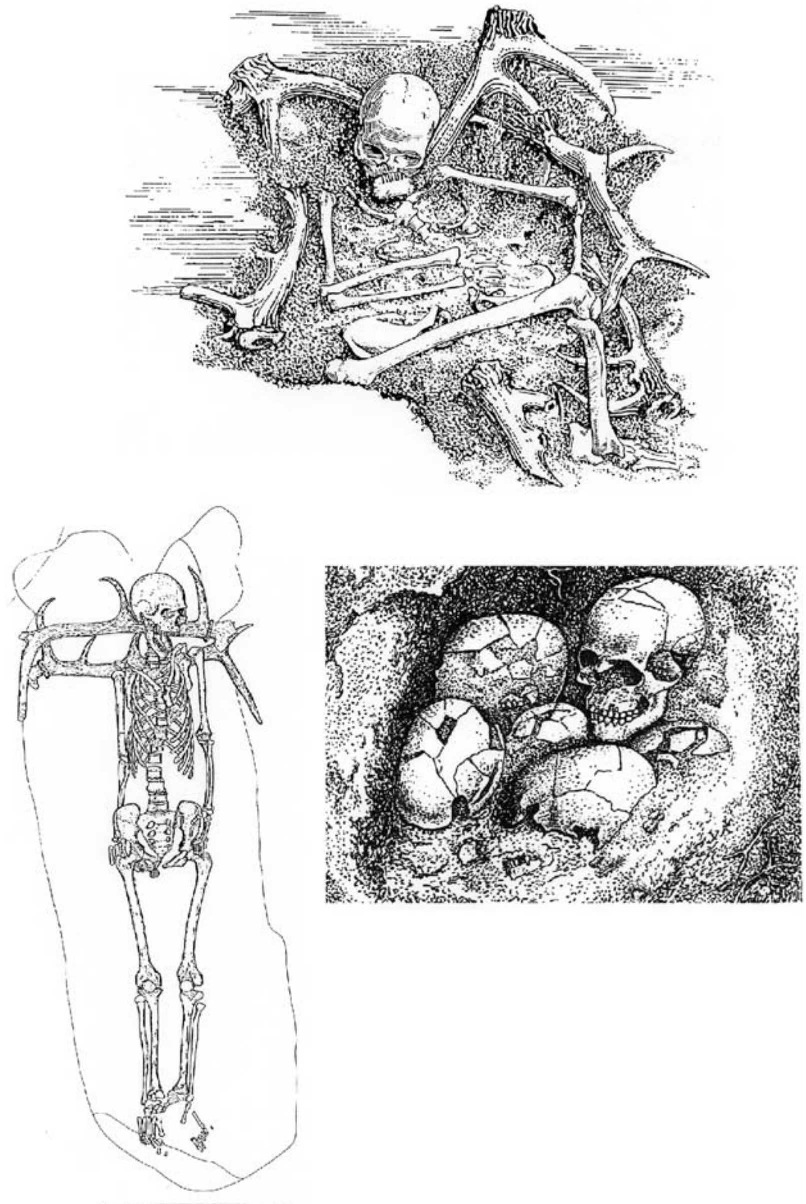

Fig. 13 Religions. *Top*: Teviec (Brittany, France) (after M. and St-J. Péquart, 1954). *Bottom-left*: Denmark (Albrethsen, Petersen, 1976, Excavation of a mesolithic cemetry at Vedbaek, Denmark, Acta Archaeologica, 47). *Bottom-right*: Ofnet (Bavaria, Germany) (after Cziesla, 1992). Burials (PEQUART M. et S.J., Hoedic, deuxieme station-necropole du mesolithique cotier armoricain, Anvers, De Sikkel)

physically extended the power of thought; man developed as a demonstration of this dazzling power accorded to the spirit as to weapons. Man was freed from biological constraints and demonstrates this in religious thought as in his visualized reflections. Classical religions would soon be developed to complete this process, while gods would be in the image of man and animals would be reduced to the rank of attributes. The symbolism of arrows became omnipresent (e.g., Diana the Huntress) and universal because they symbolize not only the deferred power of the human will, but also the spirit of justice, clarity, and messenger remaining in communication with the cosmos.

Conclusion

The transition to the Mesolithic has a critical importance in the human adventure. It corresponds to a very specific period, both fundamental and

Fig. 14 Arts. *Top*: North Africa (after Alonso and Grimal in J.-L. Le Quellec, 1998). *Bottom*: South Africa (after Clottes et Lewis-Williams, 1996, Les chamanes de la prehistoire, Seuil, Paris)

universal. Like all transitions, it has both Paleolithic "souvenirs," Neolithic potentialities, and intermediate particularities that support its autonomous status as a period on its own. Certain populations today have kept the same Mesolithic way of life over the millennia.

Among the principal factors that characterize this "heavenly" epoch, we note the perfect adaptation by predatory paths, in extremely varied environments, across space and through time. This harmony with the savage world evokes that described for Eden in the Old Testament: the Neolithic could only be the subsequent period when humans became farmers and earned their bread by the sweat of their brow. During the Mesolithic, we thus observe the desire to conserve a hunting way of life and to maintain harmony between demographic development and perpetually under-exploited capacities offered by the savage world. In this sense, the Neolithic breaks this "alliance" and we suffer the inconveniences—today more than ever.

The transition to the Mesolithic thus corresponds principally to a phenomenon of change in metaphysical thought. The Upper Paleolithic seems characterized by all-powerful natural laws acting on human destiny. The Mesolithic, in contrast, is a period of definition of this condition, against the control of natural laws, attempting to render man the master of his destiny—but in revenge, conferring on him a terrible responsibility.

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DISCUSSION 5: Transitions in the Later Palaeolithic

Rupert A. Housley

Abstract This paper discusses a number of concepts common to "transitions" in the Later Palaeolithic, whether change should be multifaceted in nature involving more than one cultural or technological attribute to be accepted as a defining point in time; the extent to which rate of change is important, be it gradual, accelerated, punctuated or uniform, and whether duration of change is relevant to the "transitions" debate. The case for refining chronologies is discussed. The paper concludes by drawing on the other papers in this section of the sourcebook to make some general methodological points.

Keywords Later Palaeolithic • Transitions (Abrupt, Incremental, Multi-faceted, Time-transgressive, Stasis)

"Transitions" and the Archaeological Record

Archaeology as a discipline has always had periods—divisions of time—within which material culture is grouped. As one period finishes, another begins and this process of change conveys a sense of dynamics to the subject—the succession of one archaeological body by another producing evolutionary stages where one set of material is replaced by another. Change may occur due to many factors, including (but not limited to) demographics, technological innovation, indigenous evolution, and cultural change. The boundaries that separate periods are the transitions, and because these represent moments in time at which change is concentrated, they have long attracted the attention of scholars (e.g., Adams, 2007; Bar-Yosef, 1996; Carciumaru and Anghelinu, 2000; Kobusiewicz, 2004; Narr, 1984). One only needs to think of the Neolithic Revolution (Childe, 1952; Cole, 1970; Harris, 1996; Maisels, 1993; Redman, 1978; Smith, 1998) to see the effect of a new entity in the archaeological record and the way it attracts attention. As the contributors to this monograph show, transitions in the Palaeolithic are no exception in the interest they engender.

Transitions, whether Palaeolithic or later, typically ask similar questions. Focus is often centered on changes manifested at the point of transition and the study of small incremental steps may elucidate the underlying cause of the transition or the mechanism effecting the change. Studies may be undertaken into a single attribute of a transitional assemblage (e.g., d'Errico and Laroulandie, 2000); alternatively, attention may be focused on the multifaceted nature of the transitional process, examining interconnected changes in many artifact groups within a cultural collection (Gowlett, 1999; Hopkinson, 2007). Complementary to this are approaches that examine the chronology of change, measuring the rapidity by which one cultural entity is replaced by another (e.g., Jöris and Weninger, 2000). Determining whether change was gradual or accelerated, punctuated or uniform, can provide important insights into the process. By definition, transitions involve change, and change requires

R.A. Housley (✉)
Department of Geography, Royal Holloway College, University of London, London, UK

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explanation, thus motives and reasons are sought and discussed. Association with external noncultural stimuli (e.g, climate change) may be investigated. These questions and others (Camps, 2006) are often central to any treatment of transitions in the archaeological record, and are pertinent here.

Archaeology, viewed simplistically, could appear to be no more than a succession of time blocks—periods of cultural "sameness" divided by short intervals within which change is concentrated. The points of change between the stasis blocks are the transitions. Although convenient, this viewpoint has clear methodological shortcomings. Conceptually, it is difficult to endorse this model since, in reality, no period is ever wholly in stasis; a degree of change is always present, however limited. No matter how similar, archaeological assemblages will display a modicum of variation in their attributes. The more appropriate question is how much variability, or degree of difference, is accepted before one archaeological assemblage becomes sufficiently different to be assigned a different period "label" (Hopkinson, 2007). This process will define the number and extent of transitional events in the archaeological record.

In attempting to identify or characterize a "transition" in the archaeological record, it is right to ask whether *duration of change* is important. Specifically, must transitions be appreciably shorter than the adjoining "stasis" periods? Alternatively, is it ever useful to see an entire period, like the Middle Palaeolithic, as "transitional"? (it is certainly transitional in the sense of it "links" or connects the Lower with the Upper Palaeolithic but this could be said of almost all periods). Should we be concerned that the Middle Palaeolithic transition extends over a longer period of time than the Upper Palaeolithic? Equally, is it important that for many Palaeolithic archaeologists, there is probably more cultural change in the later "stasis" Upper Palaeolithic period than in the preceding Middle Palaeolithic transition where change should, at least theoretically, be concentrated. Such considerations suggest that the labeling of complete periods as transitions serves little useful purpose and a more restrictive application is to be preferred.

Do transitions require the change of more than one cultural attribute? Should a transition involve synchronous change in a combination of material components—e.g., artifact typology, lithic/faunal procurement strategies, settlement and/or mobility patterns, biological palaeoanthropological attributes, and others—or is it permissible to have only one manifestation of change? For example, one could argue that while Neanderthal assemblages in Europe display "Mousterian variability" (Binford and Binford, 1966; Binford, 1973; Bordes and de Sonnevilles-Bordes, 1970; Mellars, 1970), typological variation alone is not sufficient to represent a transition. On the other hand, the combination of changes associated with the succession from the Middle Palaeolithic to the Upper Palaeolithic is sufficient for it to be recognized as a transitional event, even though some of the "classic" elements of the Upper Palaeolithic are now recognized as present in the preceding Mousterian and Levallois techno-complexes (Bar-Yosef, 2002). One could conclude that multifaceted change *is* probably a requirement for a true archaeological transition. Clearly there is a problem where limited preservation often means one element of the archaeological record takes precedence over the rest of the cultural package. In the Palaeolithic, emphasis has historically been placed on typological classification of lithics; whether this alone is sufficient for a transitional event to be defined is debatable. Change involving a suite of material culture attributes must surely be preferable.

Later Palaeolithic Transitions

Three of the five contributors to this section of the monograph have chosen to address the transition at the end of the Pleistocene. Drawing on examples from the Old and New Worlds, the authors refer to it in very different ways—in one instance, the transition is from the Paleoindian period to early Archaic, for another it is the Palaeolithic-Mesolithic boundary, while the third discusses the Terminal Pleistocene-Early Holocene transition—but in essence all are concerned with the same subject matter: the archaeology of the Pleistocene-Holocene boundary (Straus et al., 1996). This highlights a general matter that is relevant to all transitions—the influence that terminology may have on our perception of the event. As Adovasio and Carr note, some of the terminology we use as archaeologists has possibly outlived its usefulness, and in the context of discussing transitions, retention of the old constructs is obfuscating—masking or otherwise distorting the transitions that we are studying. In the context of the American Northeast, this point is more comprehensively developed in their paper, but the point is more generally applicable, and will be returned to later in this paper.

The same transition need not take place at the same moment in time. In the case of the Pleistocene-Holocene boundary, the environmental responses to climate change were geographically varied and time-transgressive. Temporal synchronicity of vegetation recolonization stages did not take place because geographical position was important. While a similar succession of "development phases" may have taken place, a geographical and temporal cline is observable. Although time-transgressive and culturally diverse, this transition is a major archaeological marker and some of the insights to be gained are almost certainly applicable in other contexts.

The paper by Otte is pitched deliberately wide-embracing as is the Terminal Palaeolithic-Mesolithic (Pleistocene-early Holocene) transition on many continents. In the context of this volume, the ideas put forward are particularly valuable in relation to the other contributions because the author proposes a series of common cultural manifestations that are believed to be universally applicable: (1) the geometrization of microliths associated with the adoption of the bow and arrow, (2) the adoption of a broad-spectrum hunting and food procurement strategy, (3) the decrease in mobility as semi-sedentism becomes more widespread, and (4) a transformation in the way humans perceive their position in nature as seen in the artistic depictions of the period. The degree that these are represented in the other case studies dealing with the same transitional boundary is revealing, and this interplay between generalized ideas and specific examples assists to unify this section of the monograph.

Many broad issues concerning transitions in general are discussed by the contributors. Otte, for example, is clear that the Palaeolithic-Mesolithic transition is multifaceted in the way it is represented in many components of the archaeological record (lithics, fauna, art, resources, habitations, and so on). He makes the point that transitions can be time-transgressive, with similar transformations occurring in separate regional settings on different continents, but not necessarily at the same moment in time. Indeed, he makes the point that entire regions still practiced what could be characterized as the "Mesolithic" way of life until the first European contacts, suggesting that while a transition may be of short duration in a specific geographical region, the overall transitional event could encompass a considerable length of time—in this instance, *c.*10,000 years. Hence a global age model for a given transition may be very different from that applicable regionally. The time-transgressive nature of the environmental changes in the (North American) "Northeast" are well brought out in the paper by Adovasio and Carr, who show that the later transformation in the Northeast (from an open sparsely wooded landscape to a forested environment) had a much more profound effect on the cultural adaptations of the region's inhabitants than the earlier Late Glacial/Early Holocene boundary (or, in cultural terms, the Palaeoindian-Early Archaic). Their paper successfully shows how historical terminology proposed decades ago may no longer assist the process of understanding certain transitions in the archaeological record. In the context of Late Pleistocene-Early Holocene, it is good to see the recognition that "the Early Archaic-Middle Archaic differences are far more striking in virtually *all* ways" than those at the Palaeoindian-Early Archaic boundary. The fact that the Early Archaic-Middle Archaic boundary coincides with a change in forest composition, where conifers give way to deciduous trees, is worthy of note; clearly in this instance, landscape vegetation structure is more important culturally than climate-induced temperature amelioration.

It would appear that environmental and climatic change has a complex relationship with archaeological transitions. Otte persuasively argues that environmental context is important in *permitting* cultural choice, but he makes the point that some societies seem to have been able to preserve their Palaeolithic ways of life until comparatively recently, in spite of the considerable environmental changes at the end of the Palaeolithic. In his view, environmental change at a transition is important, but its influence is not deterministic. Commenting on the environmental changes at the end of the Early Archaic, Adovasio and Carr make a related point that "the putatively pivotal Palaeoindian-Early Archaic transition [was] *not*… the beginning of a new set of lifeways in a new and dramatically different environment, but rather … a continuation of an old lifeway in a subtly changing environmental matrix." Although initially appearing to coincide with climate change, these Late Palaeolithic-Mesolithic examples show the subtle ways humans may respond to external stimuli.

However, as illustrated by Graf in her examination of the Middle Upper Palaeolithic (MUP) to Late Upper Palaeolithic (LUP) transition in south-central Siberia, determining the cause, nature, and rate of transition in situations where the change is coincident with an *adverse* climatic event is much more difficult. Here, the issue relates to whether there is a gap in the regional settlement record coinciding with the Last Glacial Maximum (LGM) and the implications for the process of transition. The general point needs to be stated that if there is a hiatus in human habitation in this region, then the expectation would be for an *abrupt* change in the archaeology at this transition. This is because sites with intermediate properties (temporally located between the MUP and the LUP) will be lacking if this part of the settlement record is absent from the region. In such a case, cultural contrast rather than similarity will be emphasized; more so if temporal separation between the respective periods of settlement is great. The problem is methodological and is not specific to this case study. Regardless of context, poor temporal resolution is likely to produce erroneous outcomes, suggesting continuity of settlement, whereas the true picture may be otherwise. Better chronological control may show that there was a break in settlement and regional abandonment. The solution is clearly good chronological control, which is precisely what Graf recognizes in her paper. Chronological "weeding" of the ^{14}C record is an essential part of assessing this transition, and the author's conclusion that there is a hiatus from 22 to 19 ka cal BP, which almost inevitably means that the transition will appear abrupt, with major differences between the MUP and the LUP. However, extension of the study to the likely areas of refuge during the LGM (possibly Japan and the coast of the Russian Far East) would probably change the appearance of the transition, demonstrating that the location of a study is likely to affect the form of the transition.

Canales' examination of the transitional Terminal Pleistocene-Early Holocene lithic assemblages from the Andes is valuable by linking with many of the ideas that Otte proposes. The South American evidence supports the model that the transition involved a degree of specialization and standardization in lithic assemblages involving the development of microbifacial points for camelid and deer hunting, a regionalization of techno-typological traditions, and a shift in some societies to a more sedentary lifestyle with an increased role for aquatic resources. The concluding observations concerning the emergence of two lifestyles in this region—one essentially similar to what preceded it but subtlety changed with a simple flake-based typology and a focus on marine resources, and another involving a microlith projectile industry linked to deer/camelid hunting and plant gathering—helps to give the more generalized predictions a firm regional setting.

The final contribution by Steguweit focuses on the evidence for the period of transition between the Aurignacian and the Gravettian techno-complexes in the Bistriţa valley of northeast Rumania. In this contribution, the issue is whether there was cultural continuity of the Aurignacian after *c*. 28,000 uncal ^{14}C years BP in this region of Eastern Europe. The question comes down to the existence of a "late Aurignacian" or "Epi-Aurignacian" industry in northeast Rumania. Again, the questions asked are similar to other studies in this monograph—did the change from Aurignacian to Grevettian take place rapidly, or was there considerable cultural and temporal overlap? How can the observed pattern be explained? Is this transition synchronous with the Aurignacian/Gravettian boundary observed elsewhere in Europe? If it is not synchronous, then did the transition take place earlier or later? Clearly, many of these questions focus on chronology, and this is precisely what this paper pays careful attention to. The conclusion that there is no convincing evidence for cultural overlap of these two techno-complexes in this region suggests the transition was abrupt—there is no late Aurignacian in the Bistriţa valley, and the transition was not time-transgressive in relation to the same event elsewhere in Central and Eastern Europe. In terms of the Palaeolithic of Eastern Europe, the outcome is valuable and complements the work undertaken on both earlier and later transitions (Adams, 2007; Allsworth-Jones, 2000; Carciumaru and Anghelinu, 2000; Kobusiewicz, 2004).

Steguweit makes an important concluding observation concerning the limitations of the ^{14}C record and the effect this has on our study of transitions. In all these examples, ^{14}C has been the basis for our chronologies, and most of the contributors have rightly devoted a good deal of attention to improving the dating. The problem with ^{14}C in this period is the uncertainty concerning atmospheric production of ^{14}C and the effect it has on the calibration process (Hughen et al., 2004). Other forms of chronology, such as tephrostratigraphy and tephrochronology (Lowe, 2001), have the potential to make a valuable contribution if they can be tied to high-resolution environmental sequences (ice-cores, peat bogs, lakes, and marine cores). In the future, if more precise chronology is achievable, and decadal rather than centennial or millennial scales become a reality, then abrupt transitions will possibly feature more in archaeology. Whatever develops in the future, it is likely, however, that "transitions" will remain a focus of Palaeolithic enquiry for many years to come.

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Afterword

There is a dialectic contradiction between the explanatory scope and the descriptive capacity of Prehistoric research. At an intrasite, contextual level—crucial for the description of variables under consideration—archaeology is, in fact, a powerful crossroad of research strategies, since at this level it may approach high levels of accuracy, occasionally enabling the understanding of the relations involving different types of evidences (environmental and cultural). Yet, the mere intrasite description is not powerful enough to properly explain human behavior, since this is often not univocal and to understand it one requires a broader, but much foggier, scale. Various problems arise at this level, the question of synchrony being a crucial one—it is very difficult to ascertain the absolute simultaneousness of two allegedly related sites, and a vast literature on landscape archaeology derives from this. The other path is to focus on cultural change, or changes in general—the approach of the Commission of International Union for Prehistoric and Protohistoric Sciences (UISPP) on Palaeolithic Transitions, established by the Permanent Council of the Union during the XVth World Congress in Lisbon in 2006.

This volume includes the contributions made to a session organized by the volume's editors during that congress (Colloquium C63), and some others that could not attend. The issue of change is, apparently, closer to the explanatory scope of Prehistoric research. In fact, evidence differentiation and stratigraphy are the basic methods of archaeological sciences, and the understanding of changes through time is at the very essence of historical method. But how should we discuss transitions between foggy structures? Which evidences should we consider as the most relevant, and how should we process them? And once perceived, how do we establish causal sequences leading to them and explaining them? Answers require a clarification of concepts (theories)—a terrain where contradictions tend to prevail—and a definition of research tools and procedures (methods), which tends to achieve a greater consensus. Interpretations derive from both of these, and the papers in this volume are an illustration of such.

Several papers in the volume are oriented towards the refinement of methods. This is the case of Stephen Lycett, who revisits the discussion on morphometry in technomorphological analysis of lithics, of Bonnie Blackwell et al. on the explanatory potential of the ESR method (dating and beyond), of E. Leon Canales and D. Stanford on the American Hunter-gatherers, and of the papers focusing on taphonomic considerations (J. Zilhão; I. Karavanić et al.). P. Willoughby stresses the shortcuts of the archaeological record concerning the LSA emergence in Eastern Africa.

Conceptual issues are at the heart of some papers. M. Chazan reviews the concepts of *tendence* and *fait* from Leroï-Gourhan, trying to overcome the finalist paradigm. F. Harrold discusses conceptual issues related to the middle-upper Palaeolithic transition, whereas M. Otte does so concerning the Palaeolithic-Mesolithic transition. O. Soffer questions the genesis of these concepts and what she calls a "normative stereotypical approach to behavior" that we can still recognize in a majority of the approaches to Pleistocene hunter-gatherers. J. Gowlett reasons around the

M. Camps, P. Chauhan (eds.), *Sourcebook of Paleolithic Transitions*, DOI 10.1007/978-0-387-76487-0,

discrepancies involving artifactual and biological sequences. G. Clark questions the usability of historically generated analytical units to organize the archaeological record before the advent of absolute dating.

Papers dealing with the explanation of transitions offer deep—even if less consensual—insights. Environmental change-guided transitions tend to dominate the studies on the earliest cultural changes. M. Rogers et al. discuss the nature of the transition to hominin tool production—a debate that merges with ethology. Sileshi Semaw and M. Rogers summarize the evidences and problems related to the Oldowan-Acheulean transition, but this approach is also structuring the models proposed by P. Chauhan for the Indian subcontinent.

Miriam Belmaker discusses evidence for the human adaptation limits in the Levant circa 1 Ma, suggesting that this is evidence for a new "out of Africa" dispersal. J. M. Burdukiewicz raises the hypothesis of the use of composite tools in Northern Eurasia since 1 Ma ago, explaining it through the abundance of wood in such latitudes (but how can it explain its absence elsewhere, even in interglacial periods?).

The transitions within the middle-upper Paleolithic dominate the volume. These are increasingly unclear, largely (we could argue) due to the dubious content of the term "middle"—a conceptually poor notion—but also to some misleading uses of terminologies (see, for instance, the paper by D. Olszewski). The "cul-de-sac" character of the Iberian Peninsula (evidenced in M. Camps' paper) is increasingly less isolated. The problem of cultural recurrence or convergence is addressed by M. Patou-Mathis after the observation of middle Palaeolithic and transitional industries in Crimea. As the author stresses, similar features may be observed in other latitudes, as in the Iberian Peninsula, and in this case they may even move back to the lower-middle Palaeolithic *transition*. A similar problem is evidenced by C. Norton and X. Gao, but considering the middle-late Pleistocene transition. A critical approach, which denies the existence of a unidirectional evolution, is taken by A. Arrizabalaga and M.J. Iriarte on the Cantabrian area, and by B. Adams when questioning the Szeletian.

A clear theoretical alternative is proposed by R. Bednarik, opposing gradual evolution to the clear-cut changes that seem to dominate most interpretations. A similar perspective is taken by L. Steguweit on the aurignacian-gravettian transition in Romania. But if one takes a step back, one may recognize that clear-cut ruptures are more likely to "occur" in older periods (precisely when the synchronous data is less rigorous). This seems to be the perspective assumed by L. Straus in his paper.

Localism—partially conditioned by environmental specificities—is one of the theoretical responses as sustained by K. Graff or by F. Bernaldo de Quiros and J. M. Maillo for the middle-upper Palaeolithic transition. The papers of these authors follow a theoretical approach converging with J.M. Burdukiewicz for a different transitional problem. They also meet the explanatory model of J. Riel-Salvatore concerning the Uluzian, the interpretation of James and Petraglia on the Southeast Asian transition to the middle Palaeolithic, or the view of J. Adovasio on the transition to the Holocene in SW Pennsylvania.

Covering a wide range of topics, as is the editors' aim, this volume does contribute to an overview of the main debates emerging from contemporary hunter-gatherer archaeological studies. In doing so, it helps define the framework of the "Transitions in the Palaeolithic" commission of U.I.S.P.P., and it also offers the basis for further detailed seminars and publications of this Commission. We look forward to seeing these as well.

Vila Franca da Serra, April 26th, 2008

Tomar, Portugal Luiz Oosterbeek

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