Neanderthal Lifeways, Subsistence and Technology

Vertebrate Paleobiology and Paleoanthropology Series

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Neanderthal Lifeways, Subsistence and Technology

One Hundred Fifty Years of Neanderthal Study

Proceedings of the international congress to commemorate "150 years of Neanderthal discoveries, 1856–2006", organized by Silvana Condemi, Wighart von Koenigswald, Thomas Litt and Friedemann Schrenk, held at Bonn, 2006, Volume II

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Preface

The year 2006 was declared *Jahr des Neanderthalers* by the state of Nordrhein-Westfalen to commemorate the 150th anniversary of Johan Carl Fuhlrott's discovery of the famous human fossils in a small cave in the Neander Valley near Düsseldorf. Two major exhibitions were devoted to the jubilee, one "Roots//Wurzeln der Menschheit" at the Rheinisches Landesmuseum Bonn and the other one "Leben in Extremen" at the Westfälisches Landesmuseum in Herne.

The scientific community celebrated the jubilee from 21–26 July 2006 in Bonn with the international congress "150 Years of Neanderthal Discovery", organized by Wighart von Koenigswald (paleontologist at the University of Bonn) jointly with paleoanthropologists Friedemann Schrenck (Senckenberg Institute and University of Frankfurt) and Silvana Condemi (CNRS, Paris). More than 200 colleagues from all over the world came to Bonn, representing all relevant scientific disciplines, such as paleontology, biological anthropology, archaeology, geology, physical geography and genetics.

The results of the talks presented are published in two volumes in the Vertebrate Paleobiology and Paleoanthropology series, one devoted to Neanderthals and related aspects of paleontology and the evolutionary relationship between Neanderthals and modern humans and this volume about the archaeology of Neanderthals, chronology and paleoenvironments.

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Andreas Maier, Stefan Heidenreich and Götz Ossendorf (all from Cologne) arranged the contributions and helped in communicating with authors and reviewers.

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July 2010

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Chapter 1
Introduction

Nicholas J. Conard and Jürgen Richter

The present volume resulted from papers presented at the Neanderthal anniversary conference held in Bonn in 2006, 150 years after the discovery of the famous human fossils by Johann Carl Fuhlrott. The editors arranged the papers in five groups according to major research topics concerning Neanderthal lifeways.

The first group is devoted to the chronology of Neanderthal culture which is practically the same as the Middle Paleolithic. The introductory chapter of this section, by J. *Richter*, evaluates the consequences of recent corrections of the Middle Pleistocene chronology. It has turned out that mere counts of soils represented in loess sections no longer produce reliable correlations with Quaternary interglacials and that the post-Holsteinian time span has shrunk by 100 kyr or so since the Holsteinian interglacial was re-dated to around 300 ka instead of 400 ka as previously thought. Nevertheless, there is still some evidence for early Middle Paleolithic assemblages up to 300 ka old though the number of candidates has decreased. The paper provokes revisions of matching chronologies all over Western and Eastern Europe.

Another chronological turnover comes from Quaternary paleontology, since W. *Rosendahl* et al. made new radiometric dating available for the important archaeological and paleontological sequence of Hunas (Northern Bavaria), which is well-known not only for its Neanderthal remains but also for its monkeys, indicating very moderate climatic conditions at the time of sedimentation. This time range has now been re-dated to be only 100 ka old instead of the much older age formerly estimated. How can the Hunas fauna, including its Wurmian monkeys, be contemporaneous to the nearby lower layers of the important sequence from Sesselfelsgrotte in the Altmühl Valley, only 80 km to the south? If this is true, we have to account for considerable regional variation within the glacial period.

This is also indicated by recent loess research, as *Uthmeier* et al. carried out in the Quaternary sediment cover of the Rhineland lignite mines west of Cologne. It turns out that Middle Paleolithic humans were not only present during phases of moderate climate, but obviously visited the area even under the cold and dry OIS 4 climate (around 50 ka) when dust darkened the sky and loess accumulation was at its maximum.

By contrast, rock shelters in the southwestern Alps-Maritime region close to the Cote d'Azur have only been occupied during severe climates, interglacial occupations being totally missing from the Baume Bonne cave and the neighboring sites of Sainte Maxime and Abri Breuil, as reported by *Gagnepain* and *Gaillard*. Baume Bonne is of special interest because it yields one of the longest chronological sequences ever observed in European rock shelters, stretching over 300,000 years according to radiometric dating.

Because absolute dating is still critical in settings older than those accessible by the radiocarbon technique, alternative approaches are most welcome. D. *Richter*, who is now able to date individual, small, heated artifacts of siliceous materials, solves an old problem of the thermoluminescence dating method that previously required samples of considerable size. This improved method now makes it much easier to find adequate samples for dating.

The second group of chapters elucidates the relationship of the Neanderthals to their environment, producing nutrition and raw material for workmanship. *Gaudzinski-Windheuser* and *Roebroeks* focus particularly on the nutritional behavior of Eemian (last interglacial) Neanderthals who preferably exploited large animals, as prey were more dispersed and large meat portions were desired. This contrasts with glacial nutritional patterns focused on medium sized ungulates occurring in large herds.

Bocherens' paper summarizes direct evidence for preferred Neanderthal prey derived from stable isotope analysis

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of fossil human bone. He found that mammoth and woolly rhino served as major sources of protein during the middle Weichselian (OIS 3) in what is now Belgium. Compared to Gaudzinski and Roebroeks´ paper, we are facing an unexpected result, only partially mirrored by the usual ratio of faunal remnants found in glacial assemblages, which tend to be dominated by ungulates. This might either indicate considerable regional variation or suggest that the OIS 3 nutritional patterns fit the interglacial model proposed by Gaudzinski and Roebroeks.

A detailed case study of Neanderthal environmental management comes from central Italy, presented by *Boscato* et al. The Oscurosciuto case attests for the classic glacial pattern of predominant medium and large sized ungulate exploitation, as illustrated by abundant *Bos primigenius* and some horse remains. The associated lithic industries are differentially of either Levallois or discoid character. The study displays behavioral patterns of very late Neanderthals, around 40 ka.

The third group of papers is devoted to technology. Research of the last two decades has focused on the *chaînes opératoires* recipes involved in artifact production and in economical evaluation of raw material management, as summarized by *Kuhn* in the introductory paper of this section. On the other hand, intra-assemblage variation has widely been neglected, thus excluding from our knowledge, ideas about intra-group variability among Neanderthals.

At Bapaume, near Amiens in Northern France, *chaînes opératoires* re-analysis of the technological features of this 195 ka old assemblage yielded clear proof for blade technology applied along with Levallois concepts. This is of some importance, as Middle Paleolithic blade technology has often been seen as a later feature, connected with early Weichselian assemblages. Bapaume being much earlier, it still resembles Weichselian examples in many aspects. Consequently, *Koehler* argues, the evolutionary hypothesis that blade technology mirrors technological progress in the Middle Paleolithic is no longer valid. This matches the new dating from the Rheindahlen B1 assemblage from the German Rhineland, where blades were produced approximately at the same time (see Uthmeier et al).

At Le Fond des Blanchards near Sens, Northern France, *Lhomme* et al. have found the only example of late Middle Paleolithic usage of Quina *chaînes opératoires* in northern France, along with Levallois concepts. Reindeer and horse hunters discarded these assemblages under harsh climatic conditions of the first Weichselian glacial maximum of OIS 4 to the interplenial glacial of OIS 3. This is exactly the time span when the Quina concept is best documented in southwestern France.

Along with Levallois, discoid, Quina and blade concepts, the bifacial concept is an important aspect of Middle Paleolithic technology. In her technological and typological re-analysis of the famous layer 6 of La Micoque, G. *Rosendahl* ends up with a pessimistic view of the Micoquian. To her, the term appears ambiguous, because some authors have used it as a huge cultural dump, and, by contrast, others restricted it to particular Central European occurrences connected with the last glacial and the *Keilmessergruppen*.

Were all those technological tricks carried out by the left or the right hand? *Uomini* asks this question, discussing mainly data about asymmetry and lateralization in Middle Paleolithic tools. As a result, it turns out that Neanderthals were right handed just like us.

The fourth group of papers is about the usage of space and connected social structure of Neanderthals. In his introductory paper, *Gamble* argues for Neanderthal social patterns distinctively different from modern humans. The idea of social containers, material and virtual, plays a central role in this paper, explaining Neanderthal behavior by bottom-up social processes rather than by top-down processes of growing social stratification, usually understood as evolutionary progress.

A social container, as proposed by Gamble, may constitute territorial behavior, as thoroughly analyzed by *Lourdeau* in his study about technology, site function and spatial behavior among Neanderthals of central Syria. At Umm-el-Tlel, people repeatedly settled on the banks of a spring, yielding archaeological evidence from an early Weichselian wet phase around 70 ka. In his contribution, Lourdeau combines technological and spatial approaches to argue for relative stability in the use of space by Neanderthals within this case study.

Relative stability is also presumed by *Fernández-Laso* et al. for Iberian Neanderthals at approximately the same time. The long stratigraphic sequence from Abric Romani, 50 km from Barcelona, delivered abundant archaeological and environmental data for the time range between 70–40 ka, indicating that Neanderthal land use was restricted to an area of only 20 km around the site.

At the southern fringes of the Pyrenees, the late Middle Paleolithic site of San Cristobal (ca. 50 ka) delivered comparable results, as reported by *García-Antón* et al. Again, the spatial range did not extend much more than 20 km from the site, land use having been restricted mainly to the neighborhood of two adjacent river valleys.

These examples, taken from Syria and Northern Spain, seem to illustrate extraordinary restricted land use, focused on very small areas in contrasting with the evidence from Central and Eastern Europe, where Féblot-Augustins (1997) has documented raw material procurement from sources as far away as 200 km and spatial ranges that were probably larger. Do such differences reflect higher carrying capacities for the reported case studies from Syria and Spain, allowing for smaller mobility ranges?

The *fifth group* of papers is devoted to cultural adaptation of the last Neanderthals, thus approaching the question of why they were replaced by modern humans.

This may have proceeded rapidly as indicated by the Swabian evidence, reported by *Conard*. While essentially the same set of resources had been exploited by both Neanderthals and modern humans, their technologies and artifacts argue for a radical break rather than evolutionary transition. This paper argues that the conservative cultural niche of Neanderthals may have played a greater role in their demise than biological differences between them and modern humans.

Such a replacement might also have proceeded step by step, reaching some areas at a very late time. One of these refuge areas could have been the Malaga coast, since thermoluminescence dates level 14 of Bajondillo Cave may indicate (*Cortés Sánchez* et al.). Here, dates of 28 ka come from the uppermost Middle Paleolithic levels, covered by an Aurignacian occupation dated to 33 ka (uncal. ^{14}C) or 28 ka (TL), this being the only Aurignacian south of Joao Zilhão´s Ebro frontier (Zilhão 2000).

Just the opposite, early replacement by modern humans, is attested for the southern fringe of the Alps, where Fumane Cave delivered one of the earliest examples of an Upper Paleolithic (Proto-Aurignacian or Fumanian) occupation. *Peresani*'s analysis of late Neanderthal behavior in this neighborhood, immediately preceding the Upper Paleolithic period, reveals a differential settlement system with low residential mobility and a high degree of technological variability. Interestingly, Levallois production seems to focus on the production of elongated blanks during the last phase of the local Middle Paleolithic.

While the Italian Neanderthals were behaving progressively, their southern French neighbors saw no reason for any kind of revolution. The central Rhône Valley, described by *Moncel*'s contribution, has always been a favorable place to live. Neanderthals continuously occupied the area between OIS 9 and OIS 3, without much technological change. Residential mobility was always high and restricted within small territories. At the end of the Middle Paleolithic, continuity remained a more significant feature than change within the local Neanderthal society, thus very strongly contrasting with the situation in northern France.

With this volume the reader will see many innovative and exciting aspects of contemporary research on Neanderthals. 150 years after their discovery, research about our closest evolutionary relatives continues to provide insights into the behavioral patterns that for many tens of thousands of years characterized the human condition in western Eurasia. By extension, this kind of research provides us essential information on the evolution of the genus *Homo* and makes a major contribution to defining who we are today.

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Part I
The Chronological Framework: Long Time Sequences

Chapter 2
When Did the Middle Paleolithic Begin?

Jürgen Richter

Abstract The Middle Paleolithic has widely been understood as the epoch of the Neanderthals, including early (Pre-Neanderthals) and classic Neanderthals. The onset of the Middle Paleolithic has conventionally been defined as the time when the Levallois concept of flake production became a dominant and regular feature in stone artifact assemblages. The same "Levallois generalization" seems to have started after the Holsteinian interglacial and before the Drenthe ice advance. New radiometric dating for the Holsteinian (now around 300 ka) and Drenthe (now around 150 ka) indicates the ages for some early Middle Paleolithic assemblages to be much younger than previously thought. Regional chronologies need re-evaluation based on the new, shorter chronological model.

Keywords Middle Paleolithic • Chronology • Levallois • Discoid • Quina • Drenthe ice advance • Holsteinian interglacial

Introduction

The Middle Paleolithic began around 300 ka (Delagnes et al. 2007) and is generally looked upon as the cultural stage of Pre-Neanderthal and Neanderthal man, classic Neanderthal humans having only occurred after 130 ka. This means, classic Neanderthals were only responsible for the second half of the Middle Paleolithic. Moreover, the extinction of Neanderthal man around 30 ka coincides with the end of the Middle Paleolithic.

The term Middle Paleolithic is of quite recent origin: In 1836, C.J. Thomsen defined the Stone Age, the Bronze Age and the Iron Age as the three principal ages of prehistory. In 1865, J. Lubbock introduced the terms Paleolithic and Neolithic (the time when polished stone artifacts came into use), thus subdividing the Stone Age. In 1897, G. de Mortillet subdivided the Paleolithic into the stages *Chelléen*, *Acheuléen*, *Moustérien*, *Solutréen*, *Magdalénien* and *Tourassien* (the last one later omitted). A further subdivision into *Paléolithique inferieur* (including Acheulean and Mousterian) and *Paléolithique superieur* (Upper Paleolithic) was made available by 1912 (Breuil 1912). Several decades later, the term *Paléolithique moyen* came into use for the last stage of what was earlier called *Paléolithique inferieur*. Only after the 1950s, the term "Middle Paleolithic" became widely accepted as indicating the period between Lower Paleolithic and Upper Paleolithic.

Definition of "Middle Paleolithic"

Nowadays, we understand the Middle Paleolithic as the time when lithic assemblages came into use which were characterized by the predominance of tools made on flakes from standardized flake production such as the Levallois concept, the discoid concept or the Quina concept of flake production. Occasionally, Middle Paleolithic lithic industries may also display bifacial tools (Bosinski 1967; Richter 1997) and blades (Conard 1992), sometimes as a dominating component.

As one possibility, the first occurrence of assemblages dominated by the Levallois concept (the Levallois Generalization) has often served as a chronological marker for the onset of the Middle Paleolithic (Bosinski 1967). The disappearance of the Levallois concept (Boëda 1994) and its substitution by blade production as the predominant or exclusive production concept (accompanied by a whole range of other Upper Paleolithic innovations) indicates the end of the Middle Paleolithic.

As a second and third possibility, the first appearance of the discoid concept (Boëda 1995) and of the Quina concept (Bourguignon 1997) of flake production may be taken as a common feature of the Middle Paleolithic age, although there are also some rare examples of those technological

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concepts to be of much earlier age (Delagnes and Meignen 2006). The emphasis is on the predominance, not on the first occurrence of complex, standardized flake production. Although somewhat vague, this seems the best practical way to separate the Middle Paleolithic from the earlier Paleolithic, because it prevents multiple claims for particular early occurrences of the Middle Paleolithic which would then be based on unique pieces of Levallois (or discoid etc.) character. Such unique Levallois occurrences have been attested at Cagny la Garenne, Orgnac 3 and at Atelier Comment in the Somme Valley, for example (cf. Soriano 2000).

The Time Range of the Middle Paleolithic

According to the mentioned definition, the Central European Middle Paleolithic lasted from 300 to 30 ka and spanned over three major glacials and two intersecting interglacials (Fig. 2.1): MIS 8 (Early Saalian glacial, *sensu lato*), MIS 7 (interglacial), MIS 6 (Saalian glacial, *sensu stricto*, including the Drenthe and Warthe stages), MIS 5e (Eemian Interglacial) and a part of the Weichselian Glacial, including MIS 5d, 5c, 5b, 5a, 4 (Early Weichselian Glacial including the first maximum of the Weichselian glaciation) and finally the first half of MIS 3 (Interpleniglacial between MIS 4 and MIS 2). Within the time range of the Middle Paleolithic, Pre-Neanderthal and Neanderthal man emerged (cf. Serangeli and Bolus 2008); Modern Man appeared in the Near East (around 90 ka) and in Europe (around 40 ka) and Neanderthals were extinct (around 30 ka).

Early sites from the very beginning of the Middle Paleolithic are scarce, if compared with the number of sites known from the younger part of the Middle Paleolithic.

New Chronological Insights

The question when the Levallois Generalization (as preferred indicator for the onset of the Middle Paleolithic) took place is closely connected with problems of the Middle Pleistocene chronology. Here, the correlation between the global climatic calendar on the one hand, as represented by the oxygen isotope stages from deep sea and ice cores, and corresponding terrestrial evidence on the other hand has been subject to permanent debate. Three major issues have resulted from the debate of the last years which essentially changed the chronological scheme of the Middle Pleistocene:

1. The Holsteinian is only 300 ka old, not 400 ka (Geyh and Müller 2005).
2. The Drenthe glacial advance took place only 150 ka, not 250 ka (Litt et al. 2007).
3. The correlation one interglacial soil – one MIS interglacial warm phase has been rejected as a general rule (Schirmer 2002).

Recent datations of the Holsteinian type site at Bostel, near Hamburg in Northern Germany, proved the "Holstein" botanical sequence to be around 300 ka old, thus coinciding with MIS 9 (Geyh and Müller 2005). The Holsteinian displays the most favorable interglacial climate during the Middle Pleistocene. Bilzingsleben (Central Germany), with its late *Homo heidelbergensis* fossils, and the lower horizons of Schöningen date to the Holsteinian period. All over Europe, Holsteinian and/or MIS 9 assemblages clearly belong to the Lower Paleolithic, characterized by Acheulean handaxes or/and simple flake technologies ("Clactonian") in Western Europe and by simple flake technologies ("Clactonian") in Central Europe.

The subsequent period, the interface from the MIS 9 Holsteinian interglacial to the MIS 8 glacial, is well documented at the Schöningen site. The find horizon of the famous wooden spears has been dated to the very beginning of the post-Holsteinian glacial (MIS 8), although still controversially debated (Thieme 2007; Litt et al. 2007; Voormolen 2008). The lithic assemblage still demands for proper evaluation. At the present time it is not entirely clear whether Lower or Middle Paleolithic attributes prevail in the assemblage.

In Europe, the earliest truly Middle Paleolithic assemblages, dominated by the Levallois concept, seem to occur during MIS 8, the cold phase after the MIS 9 interglacial. The climatic deterioration of MIS 8 has recently been identified with the Fuhne glaciation, newly defined by (Eissmann 1994) as the major glaciation preceding the Saale *sensu stricto* (Drenthe and Warthe) glaciation which is now argued to be of MIS 6 age. Matching evidence comes from new radiometric measurements that date the principal Drenthe (Lower Saale *sensu stricto*) continental ice advance, the largest continental Europe ever saw, at around 150 ka (Litt et al. 2007).

Impact of the New Chronology on the Possible Onset of the Middle Paleolithic

The new chronological framework has caused serious uncertainty about the age of some well-known reference sites, which are usually looked upon as examples of the earliest Middle Paleolithic. All sites which are connected with the datation of the Holsteinian or the Drenthe maximum extension of the Scandinavian ice shield need re-evaluation. Moreover, dating based on counts of losses and soil horizons appears to be doubtful now.

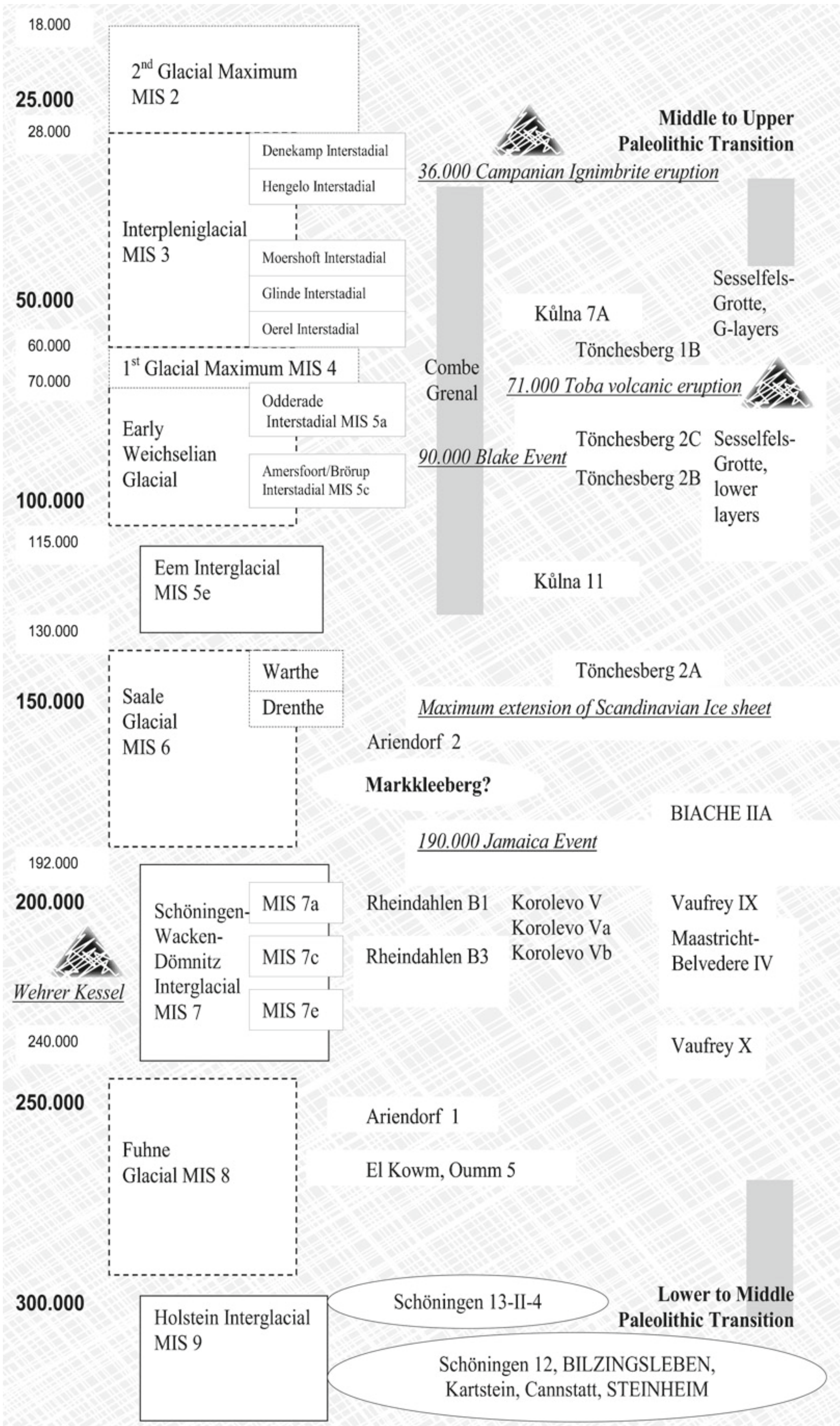

Fig. 2.1 Chronological scheme of the European Middle Paleolithic according to the tentative new correlations of the Drenthe ice advance with MIS 6 and the Holsteinian interglacial with MIS 9. Triangles indicate important volcanic eruptions attested in European sequences. Human fossils in CAPITALS

This applies, for example, to the Markkleeberg site near Leipzig, Germany (see Schäfer et al. 2003). Here, the Middle Paleolithic archeological horizon is securely stratified, underlying the Drenthe gravels, which previously gave reason to date the archaeological find horizon to early MIS 8, but might now be either MIS 8 or as young as MIS 6. The Markkleeberg assemblage combines bifacial tools (handaxes and bifacial scrapers) with highly developed Levallois products of various kinds (Mania 1997). Markkleeberg was formerly accepted as one of the earliest Middle Paleolithic sites in Europe, attributed to the *Jungacheuléen* (Upper Acheulean). Accidentally, Markkleeberg was also attributed to the *Lebenstedter Gruppe* (Bosinski 1967), which term had been synonymously used along with *Jungacheuléen*. As the eponymous site, Lebenstedt, has since been proved to be middle Weichselian and part of the Central European Micoquian (Richter 1997), Markkleeberg must be removed from the *Lebenstedter Gruppe* (Bosinski 2008), if this term should any be used, because Markkleeberg is more than 100 ka earlier than Lebenstedt.

Another problem arose when double and triple interglacial soil formations were recognized, as has recently been done in the Rheindahlen Loess sequence by W. Schirmer. It turns out that three subsequent Loess and soil formations do not represent a full glacial/interglacial cycle each (cf. Bosinski et al. 1966; Klostermann and Thissen 1995), but two of them belong to the younger part of (triple) interglacial MIS 7 and one of them belongs to MIS 5e, but mixed with the Holocene soil (Schirmer 2002). Whereas the soil sequence had previously been dated by simply counting the soil formations (last soil – MIS 5e, second-last soil – MIS 7, third-last soil – MIS 9), it now appears to represent a much shorter period from MIS 7 to MIS 5e, the Rheindahlen B3 assemblage of Mousterian-Ferrassie type dating to the middle MIS 7 interglacial and the Rheindahlen B1 Middle Paleolithic blade assemblage (*Rheindahlien*) to the last warm phase of MIS 7 (Ikinger 2002; Richter 2006).

Further re-evaluation is needed for two most important loess sequences in Europe: Achenheim (Heim et al. 1982; Junkmanns 1991; Bosinski and Richter 1997; Bosinski 2008) and Korolevo (Haesaerts and Koulakovskaya 2006), which both seem to display the interface between Lower and Middle Paleolithic.

At Achenheim (Fig. 2.2) the interface appears between the layer 20 complex (Lower Paleolithic with some Middle Paleolithic components, such as limaces) and layers 19, 18 and 17 which show similarities with the Mousterian of Ferrassie type. In the same stratigraphic portion, mammoth and woolly rhino occur for the first time. Dating of the Achenheim sequence has always been based on the count of Loess accumulation stages, given that one Loess horizon equals one glaciation. Thus, the Lower to Middle Paleolithic interface occurred in the third loess accumulation phase from top. The loess accumulation phases were stratigraphically distinct by intersecting humic horizons or soil formation processes. According to the count of loess accumulation phases, the lower to middle Paleolithic interface at Achenheim would date to MIS 8, formerly identified as the lower Rissian (Saalian) glaciation. Of course, we presently know that MIS 7 can contain up to three soil horizons. If more than one soil complex would belong to stage 7 at Achenheim, then layer 18 would represent stage 7.1 (cf. Fig. 2.1) and layers 20c to 29 would become much younger, being possibly of an Intra-MIS 7 or MIS 8 age, and the whole transitional portion (layers 20 to 17) of the stratigraphy would date to the second half of the long MIS 7 interglacial.

At Korolevo (Fig. 2.3), the Lower to Middle Paleolithic interface appears between the archaeological horizons VIe and Vb. The first occurrence of the fully developed Levallois concept in layer Vb has usually been dated into MIS 9, around 300 ka. Recently; Paul Haesaerts has corrected this estimation. He would place all early Middle Paleolithic horizons present at Korolevo (V, Va and Vb) now into MIS 7 (Haesaerts and Koulakovskaya 2006). The Korolevo sequence is, as a whole, most important for the discussion about the evolution of the Levallois concept, because the lower horizons, such as VIe (formerly dated to an inter-Mindel, MIS 11 interglacial) displays all attributes of a kind of proto-Levallois concept. This is characterized by roughly prepared cores wider than long, thus comparing to the Victoria West cores in eastern Africa. The particular technological features found at Korolevo might indicate a very early local invention and evolution of the Levallois concept.

With the new chronological results in mind, it becomes clear that tracing earliest Middle Paleolithic sites can neither rely on counts of subsequent soil formations/subsequent Loesses nor on simple one-to-one correlations of MIS interglacials and terrestrial loess or soil formations. Additional evidence is needed, such as for example radiometric dates, paleoenvironmental and mineralogical (such as chemical finger-print) correlations. Tephra markers, windblown ashes from volcanic eruptions, yield excellent chronological evidence, because they allow for firm stratigraphic correlation (if two or more sequences display the same tephra marker), and they are themselves datable by particular radiometric methods.

An Early Middle Paleolithic Site Preceding the "Wehrer Kessel Tephra": Ariendorf 1

In the Middle Rhine area, the best early Middle Paleolithic stratigraphy comes from the Ariendorf gravel pit (Bosinski et al. 1983; Turner 1997). Here, 150 m² of the Ariendorf 1 site were excavated in 1982/1983 from the lowest level of Loess LD I (Fig. 2.4). Ariendorf 1 has been dated to MIS 8, because the site must be older than the overlying soil horizon, followed by another Loess layer (LD II) and by the "Wehrer Kessel" tephra layer (ARI-BT1) dated to around

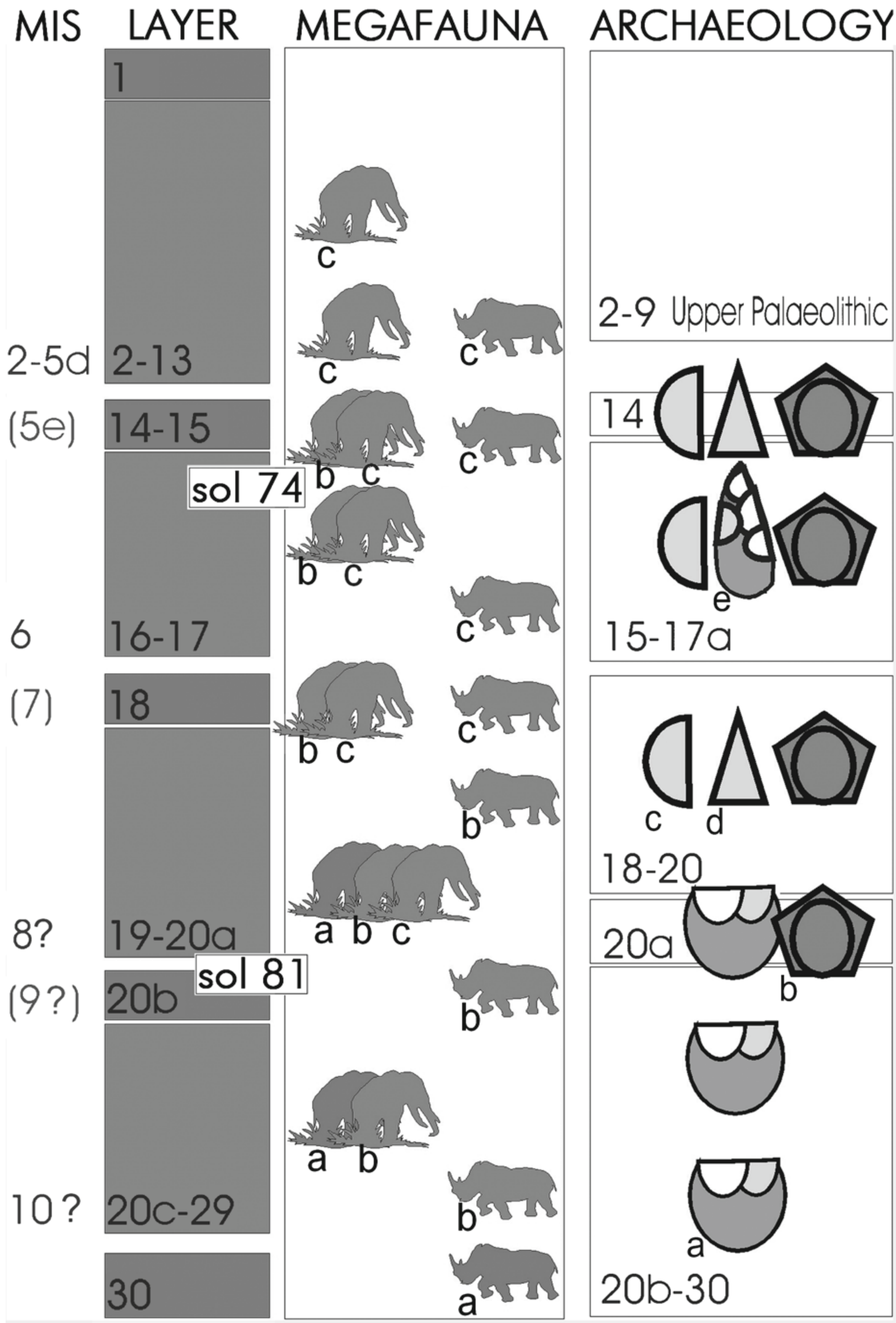

Fig. 2.2 Loess sequence at Achenheim (Compiled from Junkmanns 1991; Bosinski and Richter 1997). Layers 1–30 (After Wernert in Junkmanns 1991) combined with sol 74 and sol 81 (After Heim et al. 1982). Faunal remains from elephants (a: *Elephas antiquus*; b: *Elephas trogontheri*; c: *Mammuthus primigenius*) and rhinos (a: *Dicerorhinus mercki*; b: *Stephanorhinus hemitoechus*; c: *Rhinocerus tichorhinus*). Archaeological occurences (a: Lower Paleolithic pebble tools; b: Levallois technology; c: Middle Paleolithic sidescrapers; d: Middle Paleolithic convergent scrapers; e: bifacial tools)

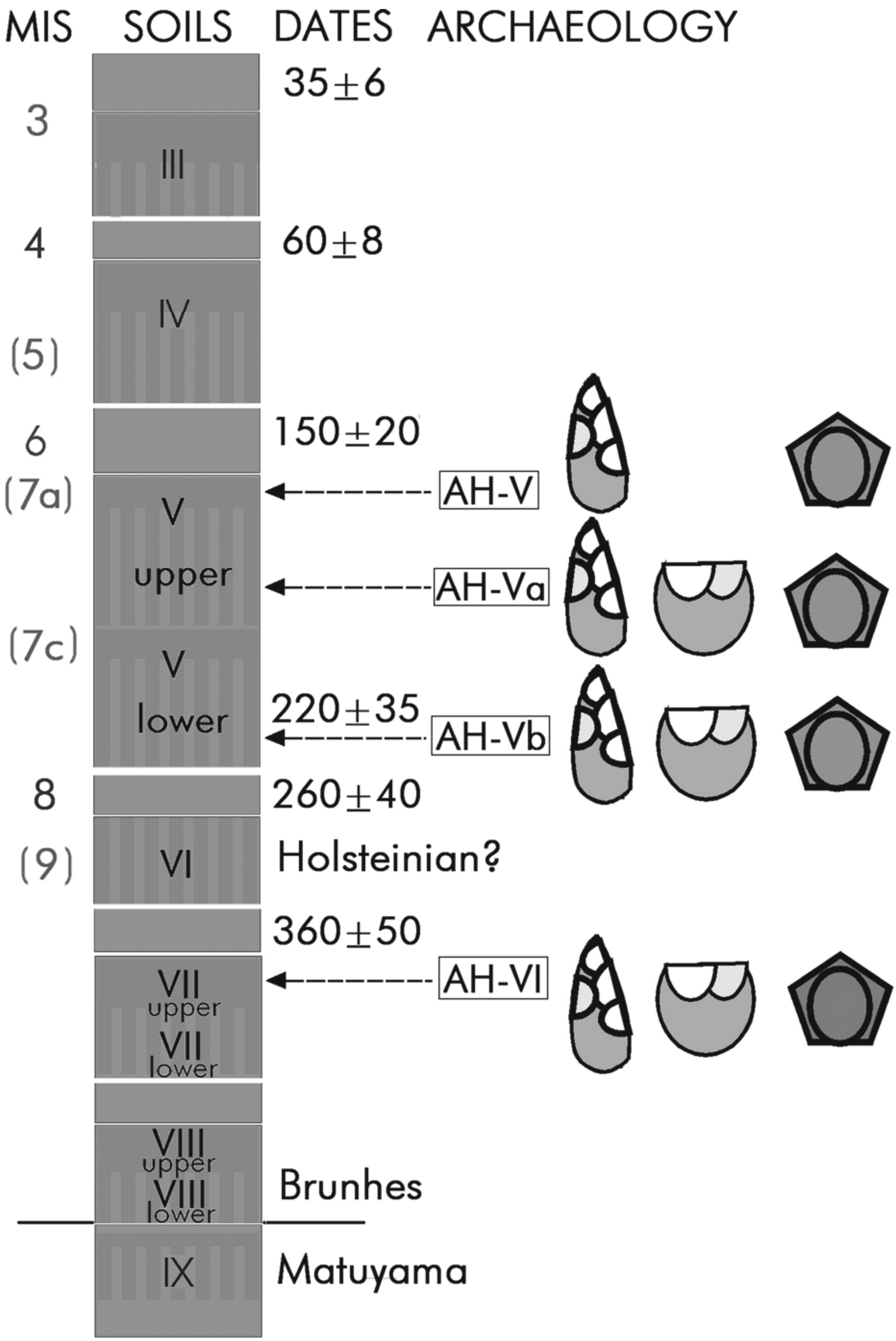

Fig. 2.3 Loess sequence at Korolevo, revised chronology (Compiled from Haesaerts and Koulakovskaya 2006). Arrows indicate the stratigraphic position of archaeological horizons (AH). Sediments are: hatched: soils; plain: Loess. Symbols see Fig. 2.2

220 ka. Around 250 ka (MIS 8; Bosinski and Richter 1997: 10), humans were present at the site situated close to a small brook. One hundred and twenty-six stone artifacts have been found, made of quartz, quartzite and lydite coming from river gravels. Refittings of artifacts not only demonstrate core reduction at the site, but at the same time point to an *in situ* preservation of the assemblage that includes prepared cores of Levallois character. Scrapers and denticulated pieces were found among the retouched tools, and horse, mammoth, woolly rhino, red deer, bovid and wolf were among the faunal remains. The 1982 excavations uncovered a second, younger archeological site (above the "Wehrer Kessel" tephra) within the MIS 6 Loess of the Ariendorf sequence. Only one retouched tool was found among 37 stone artifacts, comprising some cores, but mostly flakes made of lydite, quartz and quartzite along with bones of mammoth, woolly rhino, horse, red deer, bovid and wolf. The find scatter has formerly been interpreted as a dwelling structure, but has since been demonstrated to be a natural pit which may have attracted human activities (Turner 1997).

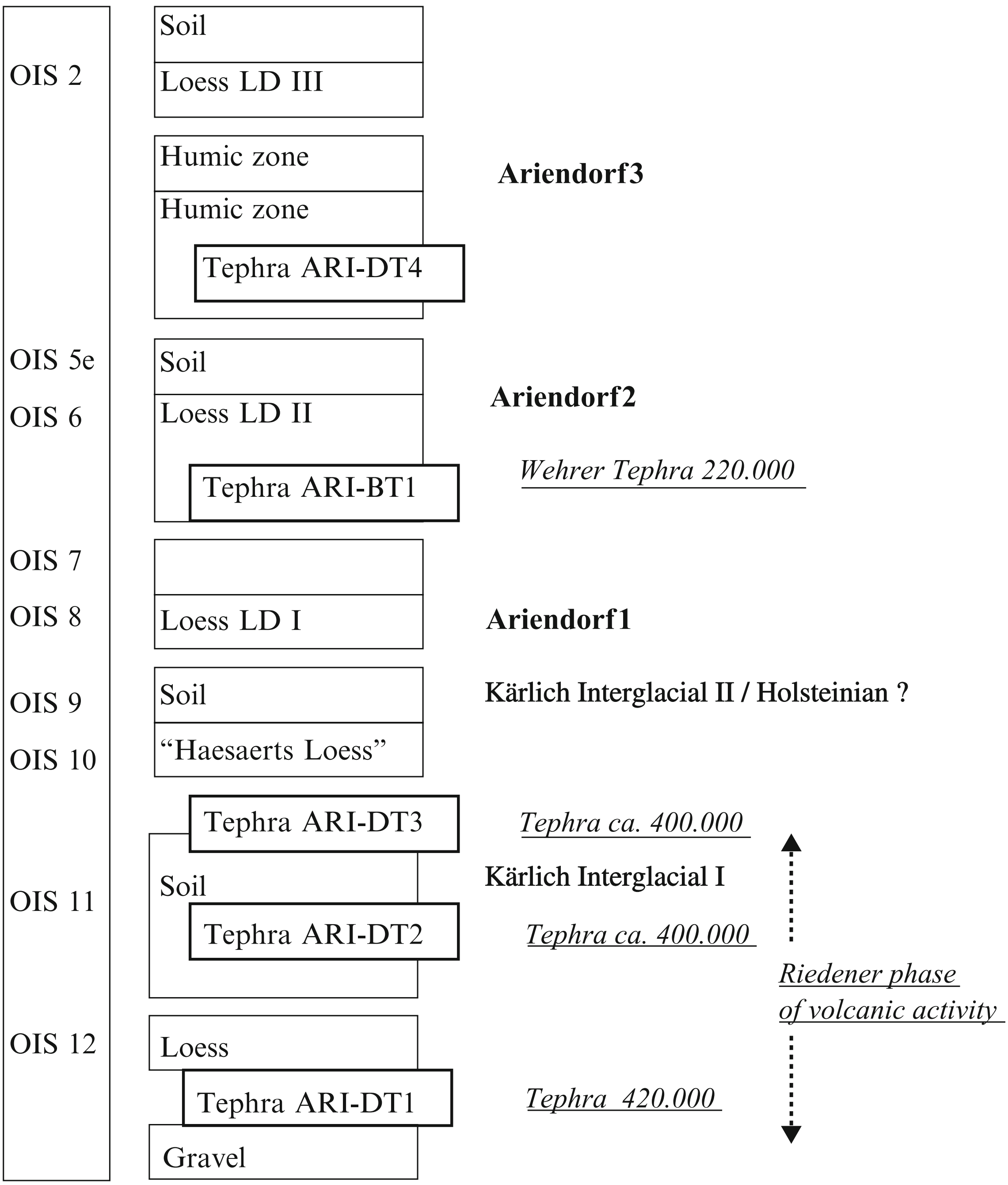

Fig. 2.4 Loess sequence at Ariendorf. The "Wehrer Kessel" tephra gives a *terminus ante quem* of 220 ka for the early Middle Paleolithic assemblage Ariendorf 1

Conclusion

The last two decades of research saw major corrections in the middle Pleistocene chronology of Europe. When the oxygen isotope chronology was initially correlated to terrestrial archives, this was often done in a very simplistic way underestimating specific problems connected with different kinds of archives, different kinds of dating and regional differences. Moreover, new radiometric data from the Holsteinian type site and from the Drenthe ice advance along with the detection of multiple interglacial soils (namely within MIS 7) have led to a shorter chronology for the first half of the Middle Paleolithic. In some cases, early Middle Paleolithic assemblages, who had previously been dated to MIS 8, have skipped now to MIS 7 and MIS 6. This means, assemblages like Markkleeberg, Rheindahlen B3 or Korolevo Vb might rather represent more advanced stages of the Middle Paleolithic rather than its initial stage.

Consequently, the question arises whether MIS 8 belonged rather to the late Lower Paleolithic than to the early Middle Paleolithic age. This would place the lower to middle Paleolithic transition around 250 ka. On the other hand, there are Middle Paleolithic assemblages which are resistant to the mentioned chronological corrections, because their dating relies on independent arguments, as, for example, stratigraphic linkage to tephra chronologies.

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Chapter 3
Neanderthals and Monkeys in the Würmian of Central Europe: The Middle Paleolithic Site of Hunas, Southern Germany

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Abstract The site of Hunas is a cave ruin, filled with bedded sediments up to the roof. About 20 m sediments from the top down were excavated and yielded Middle Paleolithic artifacts as well as numerous faunal remains, including *Macaca*. With a single human molar, the site is one of the rare Neanderthalian localities in Germany. New TIMS-U/Th dating of speleothems at the base of the profile indicate that the whole sequence was not deposited during the late Middle Pleistocene as previously thought, but during the last glacial. According to the new chronological results, Hunas is the only place which shows the coexistence of man and monkey in the Würmian of Central Europe. The *Macaca* remains are the most recent evidence of magots in Central Europe so far.

Keywords *Homo neanderthalensis* • *Macaca* • Late Pleistocene • TIMS/U-Th • Enviromagnetism • Bavaria • Cave

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Introduction

The site of Hunas is located 40 km east from Nuremberg/Bavaria (Fig. 3.1) and lies in a limestone quarry on the eastern slope of a hill, 520 m above sea level. The limestone is a dolostone of Middle Kimmeridgian (Malm Delta) age. The karstification of the Franconian Jura dates back to the Neogene. In the limestone quarry of Hunas no other caves or karstic fissures with archaeological or paleontological finds are known.

The cave ruin was discovered in 1956 by Florian Heller from Erlangen University, Institute for Paleontology and was investigated in the following years up to 1964 (Heller 1983). From the top of the hill, the excavation opened just the upper part of a stratigraphic sequence which comprises altogether 20 m thick sediments and included abundant faunal remains as well as several archeological levels. In anticipation of the complete destruction of the site – the quarry has been reactivated in 1982 – new excavations have been started in 1983 (Reisch and Weissmüller 1984) and are still going on (Groiss et al. 1998; Kaulich et al. 2006).

Stratigraphy

The cave ruin is filled with bedded sediments up to the roof. The roof is collapsed, covering the sediment-filling and obstructing the cave entrance. The extent of the room and the dimensions of the entrance are unknown. The sediment filling has been opened vertically by the blasting-front of the quarry. About 12 m sediment from the top down were investigated (Fig. 3.2) with modern methods in the recent excavation since 1983 (Ambros et al. 2005). The sequence shows a series of sediments of various compositions (Table 3.1). The sediments are mainly built by fine grained sand and silt, sometimes mixed with dolostone blocks (roof falls) of different size. The sediment colors vary between different brown, grey and yellowish color shades.

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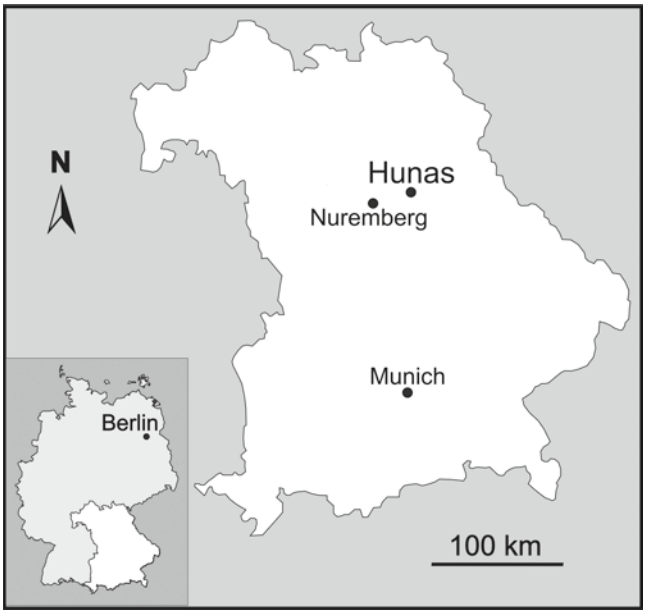

Fig. 3.1 Geographical position of the Hunas site (Graphic by W. Rosendahl)

Paleontology and Environment

About 140 different taxa have been found in Hunas (Ambros et al. 2005). More than 50% are mammals, nearly 30% birds, 10% mollusks and 5% reptiles and amphibians. The majority belongs to living species. The macrofauna is dominated by the family of the bears (Hilpert 2006). The most important paleontological finds belong to primates. The macrofauna known up to now is listed in Table 3.2.

Most of the mammals are micromammals, including Chiroptera, Insectivora, Lagomorpha, as well as the rodent families Sciuridae, Castoridae, Dipodidae, Muridae, Criceti-dae and Microtidae, the most abundant family with 18 species (Heller 1983; Carls et al. 1988). Due to the distribution of each species, multiple changes of climate are reflected in the Hunas stratigraphy. It begins, from bottom to top, with a phase showing temperate to warm climate and vegetation in the layers P-L with *Muscardinus avellanarius, Apodemus maastrichtensis, Clethrionomys glareolus, Pitymys subterraneus* and other forms of mixed deciduous woodland. The lack of these forms indicates a significant colder climate in the following layer (K_{unt}) but their reappearance in the next layers (K_{mitte} – H) testifies again favorable moderate humid and warmer climatic conditions. In the layers G2 and G1 – G3 is represented very poorly in the excavation since 1983 – a clear and rapid change to colder and dryer conditions turns up, indicated by *Lemmus lemmus, Dicrostonyx gulielmi, Microtus gregalis* or *Microtus oeconomus*. G1 with coarse, sharp-bordered rock debris portrays the coldest climatic phase within the whole stratigraphy. The covering layers – only small remains of Hellers layer F and nothing of layers A – D are left – indicate an improvement of the climate.

Altogether we are facing a gradual development from an ending warm phase to a significant cold climate. Investigations in pollen and charcoal confirm this opinion. Less pollen are conservated in the detrital layers of Hunas. A small series from layer F with spruce (*Picea abies*), pine (*Pinus silvestris*) and birch (*Betula* sp.) represents open woodland vegetation with many herbs showing a cold to cool climate. Charcoal out of layer L results from a piece of yew (*Taxus baccata*) which was often used for spears or other weapons in prehistory. Pollen from layer P, a speleothem, indicates a warm and wet climate with mixed deciduous forests.

Paleoanthropology

As mentioned above, the most important paleontological finds belong to primates, i.e. *Macaca* and *Homo neanderthalensis*. Five remains of *Macaca sylvanus* ssp., the Pleistocene subspecies of Recent magot (*Macaca sylvanus*), were found in the cave ruin Hunas till the end of the excavation campaign 2006 (Groiss 1986; Ambros 2003; Ambros et al. 2005). The first evidence of *Macaca* in Hunas, a right M3, was found in 1985 in layer H (Groiss 1986). The second find, made in 1987 in layer H, was a left M3 (Fig. 3.3), probably of the same individual. Other finds from a much lower stratigraphic level (layer K) are a fragment of a M2 (in 2000) and a dp3 (in 2001). Checking undetermined material of layer H from the excavation of Heller (1956–1964) in winter 2000/2001, a fragmentary right third metatarsal could be determined as a *Macaca* remain. These five remains belong to at least two, probably three individuals. Three of the teeth and the metatarsal represent adults; only one tooth is from a very young individual. This deciduous premolar was not broken through the maxillary bone and therefore belongs to an animal younger than 3 months (Starck 1990).

Magots or Barbary Macaques (*Macaca sylvanus*) belong to the genus *Macaca* (macaques). The genus includes nearly 20 species with numerous subspecies, e.g. *Macaca mulatta* (Rhesus Macaque) and *Macaca fuscata* (Japanese Macaque). All members of the genus live in Asia with exception for *Macaca sylvanus*. These species today has a patch-like distribution in Northwestern Africa; in the Atlas range of Morocco and Algeria. In modern Europe there are some semi-domesticated populations of the magot, e.g. the colony at the rock of Gibraltar.

The oldest known macaques belong to the species *Macaca libyca* living in the Miocene of Egypt. Macaques have existed in Europe since the Late Miocene (Rook et al. 2001). In the

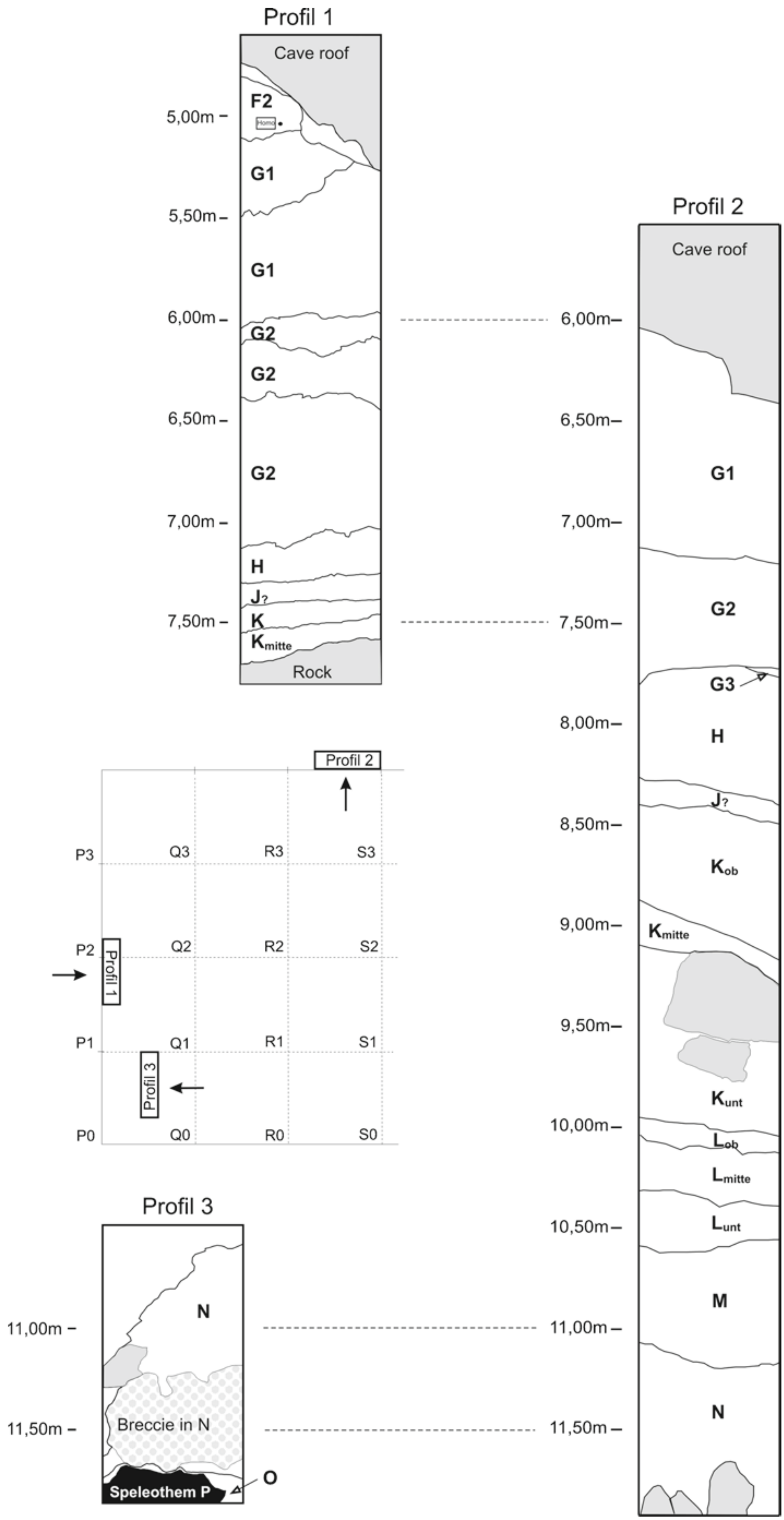

Fig. 3.2 Compiled stratigraphy of the Hunas site (state 2005). The lowermost level shown is *P*, the dated speleothem layer (Graphic by C. Gropp)

Table 3.1 Detailed sediment description of the actual profile (state 8/2004)

Layer	Sediment description
Cave roof	Partly strongly corroded
E	– Coarse-medium scree, to some extent heavily weathered, with light reddish-brown, silty, fine sand
Distinct boundary	Abrupt change of sediment
F2	– Medium-fine, heavily abraded and weathered scree with reddish-brown, loamy, fine sand and Mn and Fe incrustations
Distinct boundary	Abrupt change of sediment
G1	– Coarse-medium angular scree with small amounts of light brown to yellow fine sand – Mainly angular, coarse scree with light reddish-brown to red fine sand (earthy dolomite), comprising several large blocks and a layer of slab-shaped stones at the base
Distinct boundary	
G2	– Coarse-medium, slightly abraded scree comprising horizontally-bedded stones with large amounts of pale greyish-brown, silty fine sand – Medium-fine, heavily abraded scree with light brown fine sand – Medium-fine, abraded scree with reddish-brown fine sand – Coarse-medium, heavily abraded scree with bright reddish-brown fine sand
Distinct boundary	
H	– Intermediate layer, only preserved in places: medium-fine scree in varying stages of abrasion with pale reddish-brown, slightly silty, fine sand – Medium-fine scree in varying stages of abrasion comprising large amounts of grey fine sand; numerous remains of charcoal on the surface – Medium-fine, abraded and partly heavily weathered scree with isolated large blocks and pale grayish-brown, silty, fine sand, becoming reddish-brown towards the base – Medium-fine scree in varying stages of abrasion with slightly silty reddish-brown fine sand, numerous particles of charcoal
Distinct boundary	
J	– Medium-fine scree with yellowish-grey, slightly silty, medium-fine sand
Distinct boundary	
K_{ob}	– Medium-fine, heavily abraded and weathered scree with dark-grey fine sand
K_{mitte}	– Large block of rock respectively scree deposit
K_{unt}	– Loosely bedded, mainly weakly abraded, coarse-medium scree with light greyish yellow, slightly silty, medium-fine sand – Loosely bedded, mainly weakly abraded medium-sized coarse scree with light ochre, slightly silty, medium-fine sand
Distinct boundary	
L	– Thin zone with heavily weathered, medium-sized scree comprising isolated pieces of coarse scree and a high proportion of brownish-grey, weakly silty, medium-fine sand – Mainly heavily weathered, medium-sized scree with isolated, larger scree pieces and a large proportion of grey, partly yellowish-light brown, slightly silty, fine-medium sand, numerous charcoal remains – Heavily weathered, coarse-medium scree with many voids and some light grey, silty, medium-fine sand and tiny pieces of charcoal
Irregular boundary	
M	– Medium-fine scree with isolated larger components and yellowish-grey, slightly silty, medium-fine sand, compact sediment without voids, Manganese flecks – More heavily abraded, medium-fine scree with large amounts of ochre colored, slightly silty, medium-fine sand, increasing percent of detritus towards the base, isolated larger stones covered with thick manganese deposits, isolated weakly-developed sinter incrustation – Partly heavily abraded, medium-fine scree with ochre coloured, slightly silty, medium-fine sand with some voids
Distinct boundary	
N	– Thick, chaotically deposited coarse scree deposit, in places breccia-like, high proportion of medium-fine sand in the upper part, on the upper and lower surfaces multiple sinter incrustations, already displaying weathering, deposits of grey to ochre coloured, silty, medium-fine sand stratified above larger blocks, abundant traces of manganese, increasingly larger blocks (up to more than 1 m in size) towards the bottom of the layer, which form locally a massive, thick and hard breccia at the base
Distinct boundary	
O	– Thin deposit of distinctly ochre-colored, slightly silty, medium-fine sand, not visible throughout
Sharp boundary	
P	– Extensive, in places more than 15 cm thick, speleothem with thick stalagmites on top forms, in places, a hard breccia together with sediment from the upper part of the deposits currently forms the base of the excavated sequence, exposed only in one part of the site

Table 3.2 Macrofauna of Hunas (state 2004); (Compiled by B. Hilpert)

Carnivora	D	E	F	G1	G2	G3	H	I	Kob	Km	Ku	L	M	N	Höh	So
Canis lupus																
Vulpes sp.																
Alopex sp.																
Ursus spelaeus																
Ursus arctos																
Mustela aff. *praenivalis*																
Mustela aff. *palerminea*																
Putorius cf. *stromeri*																
Martes sp./*Martes martes*																
Meles sp.																
Lutra lutra groissii																
Gulo gulo																
Crocuta crocuta spelaea																
Panthera leo fossilis/P. spelaea																
Perissodactyla	D	E	F	G1	G2	G3	H	I	Kob	Km	Ku	L	M	N	Höh	So
Dicerorhinus kirchbergensis																
Equus aff. *mosbachensis*																
Artiodactyla	D	E	F	G1	G2	G3	H	I	Kob	Km	Ku	L	M	N	Höh	So
Sus scrofa																
Alces sp.																
Megaloceros sp.																
Cervus elaphus																
Rangifer sp.																
Capreolus capreolus																
Bison priscus																
Bos primigenius																
Lagomorpha, Rodentia	D	E	F	G1	G2	G3	H	I	Kob	Km	Ku	L	M	N	Höh	So
Lepus *sp.*																
Ochotona pusilla																
Ochotona sp.																
Sciurus sp.																
Marmota marmota primigenia																
Castor fiber																
Primates	D	E	F	G1	G2	G3	H	I	Kob	Km	Ku	L	M	N	Höh	So
Macaca sylvanus pliocena																
Homo neanderthalensis																

Coarsely shaded: From new excavation, not directly correlated to layers of the Heller excavation (Höh.: cave). Heller 1983 mentioned 3 "caves". These are small cavities among big blocks, an assignment to layers is impossible. So: without assignment to a layer (from detritus)

Early Pliocene, *Macaca sylvanus prisca* appeared. It resembled the modern magots except for its smaller size, so it was described as subspecies of *Macaca sylvanus*. *M. sylvanus prisca* is known from numerous Pliocene sites in Southern, Western and Central Europe. In the Latest Pliocene and Early Pleistocene, *Macaca sylvanus florentina* lived in Southern, South-eastern, Western and Central Europe. It was nearly like the modern magot in size and morphology.

During the Early and Late Pleistocene, *Macaca sylvanus* (*pliocena*) subsp. showed a wide geographical distribution (Szalay and Delson 1979). It colonized large parts of Europe, the Caucasus and Israel. In comparison to the modern magot the fossil subspecies had slightly broader and more powerful teeth. In the past it was believed that magots became extinct in Central Europe at the end of the Middle Pleistocene. Only a single premolar from the Kugelsteinhöhle in Austria was discussed as a Late Pleistocene (MIS 5e) find (Fladerer 1991). According to new speleothem dates (Rosendahl et al. 2006) the *Macaca* remains from Hunas provide the most recent evidence of magots in Central Europe so far (Fig. 3.4).

During the excavation campaign of 1986, the author B. K. found an isolated human tooth *in situ* by cleaning the sediment profile at the base of layer F2. The tooth could be identified as a right, possibly third, mandibular molar (Figs. 3.5 and 3.6). Characteristic parameters such as crown and root morphology, fissure pattern, enamel thickness, occlusal and interproximal wear, dental dimensions and indices indicate that the Hunas molar represents the tooth of a Neanderthal (Alt et al. 2006). This is corroborated by the archeological findings (Mousterian) of layer F2.

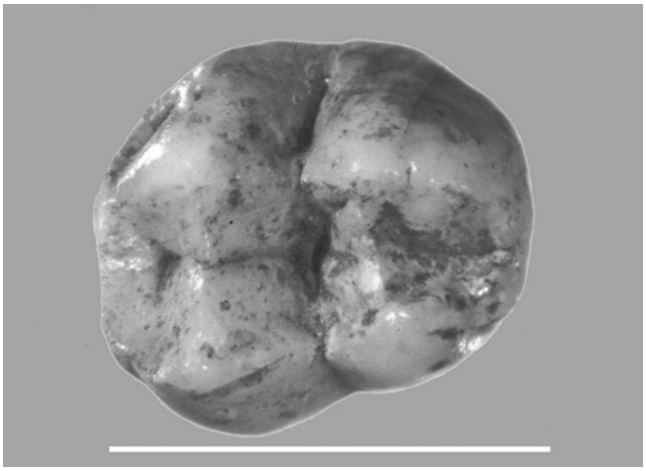

Fig. 3.3 Occlusal view of the upper right M3 of *Macaca sylvanus* ssp. from layer H, scale bar=9 mm (Photo Institut für Paläontologie, Erlangen)

Archeology

Artifacts (mainly flakes, backed bifaces and sidescrapers) were discovered in all layers except A, B and G1 of the Heller excavation and layer O and P of the recent excavation. Small series from the levels G2 and G3 have been considered to belong to a *Charentien* of Proto-Quina type (Freund 1983). New finds from layers H to N cannot be assigned to an industry because of their scarcity.

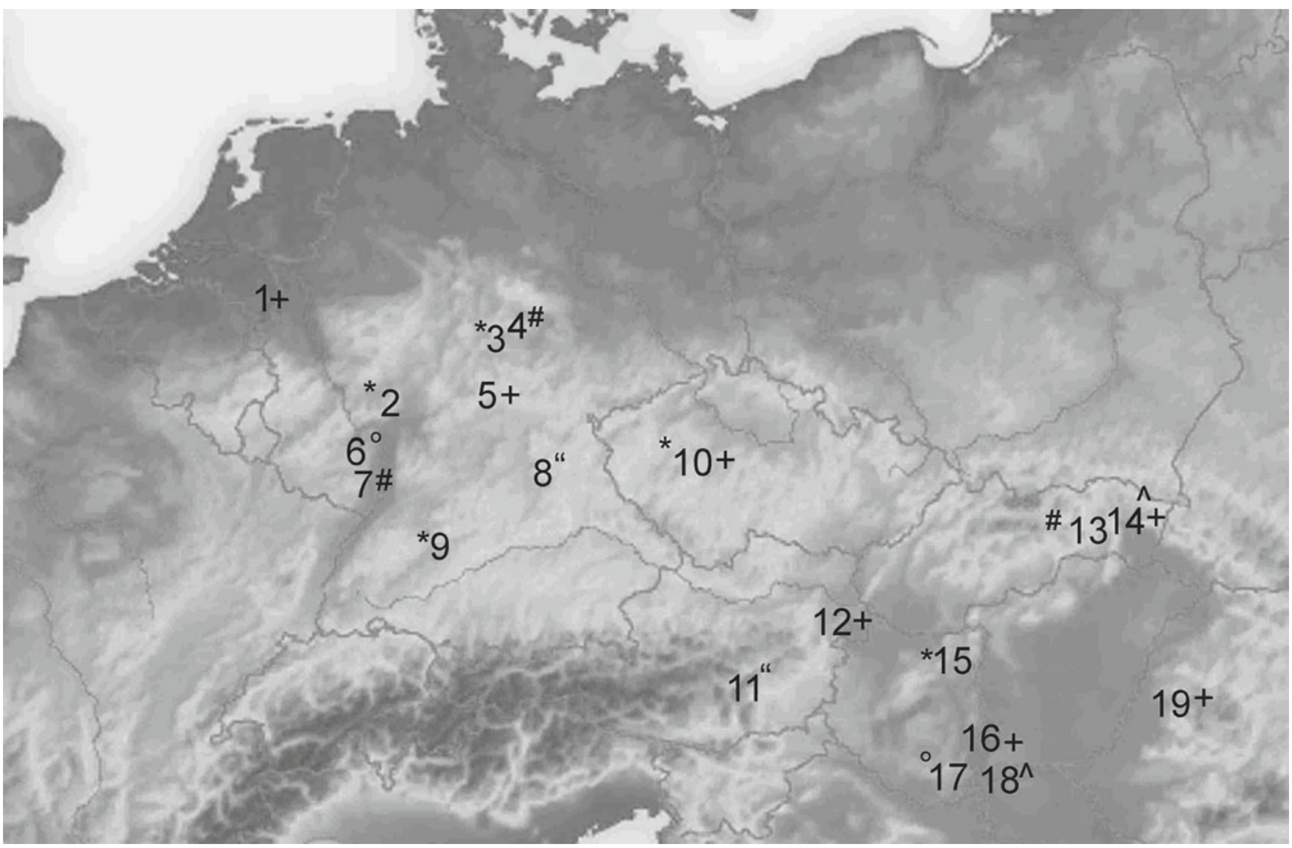

Fig. 3.4 Pliocene and Pleistocene macaques' sites in Central Europe (graphic by W. Rosendahl). Pliocene (°), Pliocene or Early Pleistocene (^), Early Pleistocene (+), Early or Middle Pleistocene (#), Middle Pleistocene (*), Late Pleistocene (“). *1* Tegelen/Netherlands, *2* Mosbach/Germany, *3* Bilzingsleben/Germany, *4* Voigtstedt/Germany, *5* Untermaßfeld/Germany, *6* Gundersheim/Germany, *7* Hohensülzen/Germany, *8* Hunas/Germany, *9* Heppenloch/Germany, *10* Zlatý Kůň/Czech Republic, *11* Kugelsteinhöhle/Austria, *12* Deutsch-Altenburg/Austria, *13* Gombasek/Slovak Republic, *14* Včeláre/Slovak Republic, *15* Vertesszölös/Hungary, *16* Somssich-hegy/Hungary, *17* Csarnóta/Hungary, *18* Beremend/Hungary, *19* Betfia/Romania

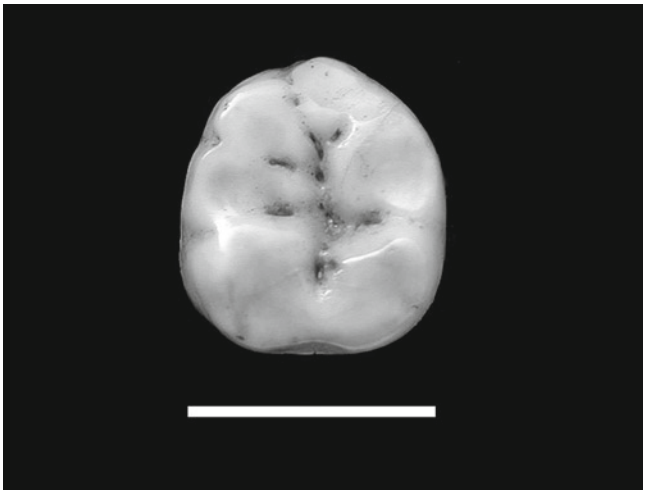

Fig. 3.5 Occlusal view of a lower right (possibly third) Neanderthal molar from layer F2 Hunas, scale bar = 1 cm (Photo by I. Hirsmüller)

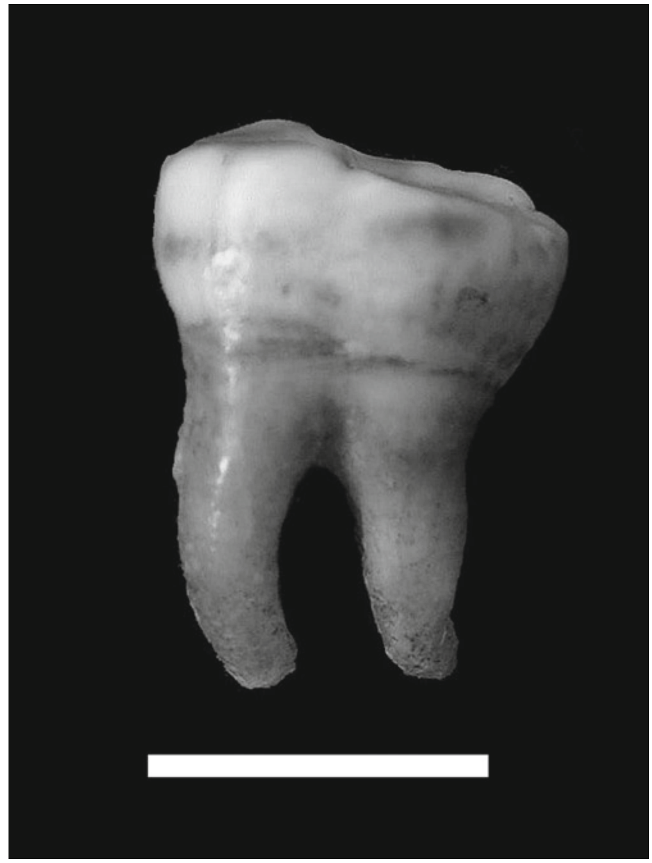

Fig. 3.6 The lower right Neanderthal molar from Hunas in lingual view, scale bar = 1 cm (Photo by I. Hirsmüller)

Chronology

Due to the fact that true index fossils are missing, it was quite difficult to determine the age of the cave filling. The stage of evolution shown by certain species led Heller to place the deposits of Hunas into the final part of the Riss glaciation (Heller 1983). A first dating of a speleothem was carried out in 1979 by (Hennig 1979). The sample originated from a layer below Heller's excavations, but detailed sample documentation does not exist. The age of 260 +60/−40 ka was used as one important argument for a Middle Pleistocene chronostratigraphical position (Brunnacker 1983).

In 2002, a flowstone layer has been discovered at the base (layer P) of the section in the recent excavation. This layer gave the opportunity to date the sediment filling of Hunas with a modern method. The layer is in direct contact with the partly cemented sediment series above without showing an obvious hiatus. A 30 cm high stalagmite from this layer was dated by TIMS-U/Th-method at Stanford University. The stalagmite base yielded an age of 79 ± 8 ka and the top an age of 76 ± 9 ka (Rosendahl et al. 2006). This early Würmian age was additionally confirmed by dating a second stalagmite from the same flowstone layer. These new data indicate a maximum age of around 85 ka for the base of the Hunas section. The minimum age of the site is constrained by the presence of typical Middle Paleolithic artifacts within the top layer of the section (Freund 1983). Therefore the whole sediment stack was deposited within a maximum time span of around 45 kyr (OIS 5b till OIS 3). An explanation for the first, Middle Pleistocene numeric age could also be found. The sample, taken in the 1970s, is from an older speleothem generation, only partly covered by the younger generation. Where both generations are present, they are only separated by a 2 mm layer of reddish silt. This could be demonstrated by dating the speleothem layer under the small reddish silt (Rosendahl et al. 2006).

Additionally, enviromagnetic investigations (Evans and Heller 2003; Ellwood et al. 2004) were undertaken on the cave sediments. The results of magnetic measurements were plotted as a function of stratigraphy and correlated to the isotope record from Greenland ice cores (North GRIP Members 2004: Fig. 3.7).

The magnetic volume susceptibility as a simple concentration dependent parameter shows strong variations and enhancement of magnetic compounds in stratigraphic units G2 to J. This fits quite well to the sedimentological results from these units but contrasts the observation of strong weathering in units M and N where no enhancement is observed. The so called S-ratio, however, which provides information about the relative amounts of magnetite and hematite in the sediment, reveals the predominance of magnetite in units G2 to J as well as in units M and N. This finding is interpreted as an indication for intense weathering during the formation of these units. The climate during formation of units G2 to J was probably more humid but not warmer than during formation of units M and N. The higher humidity resulted in higher absolute concentration of ferromagnetic minerals but gave similar ratios of magnetite to hematite.

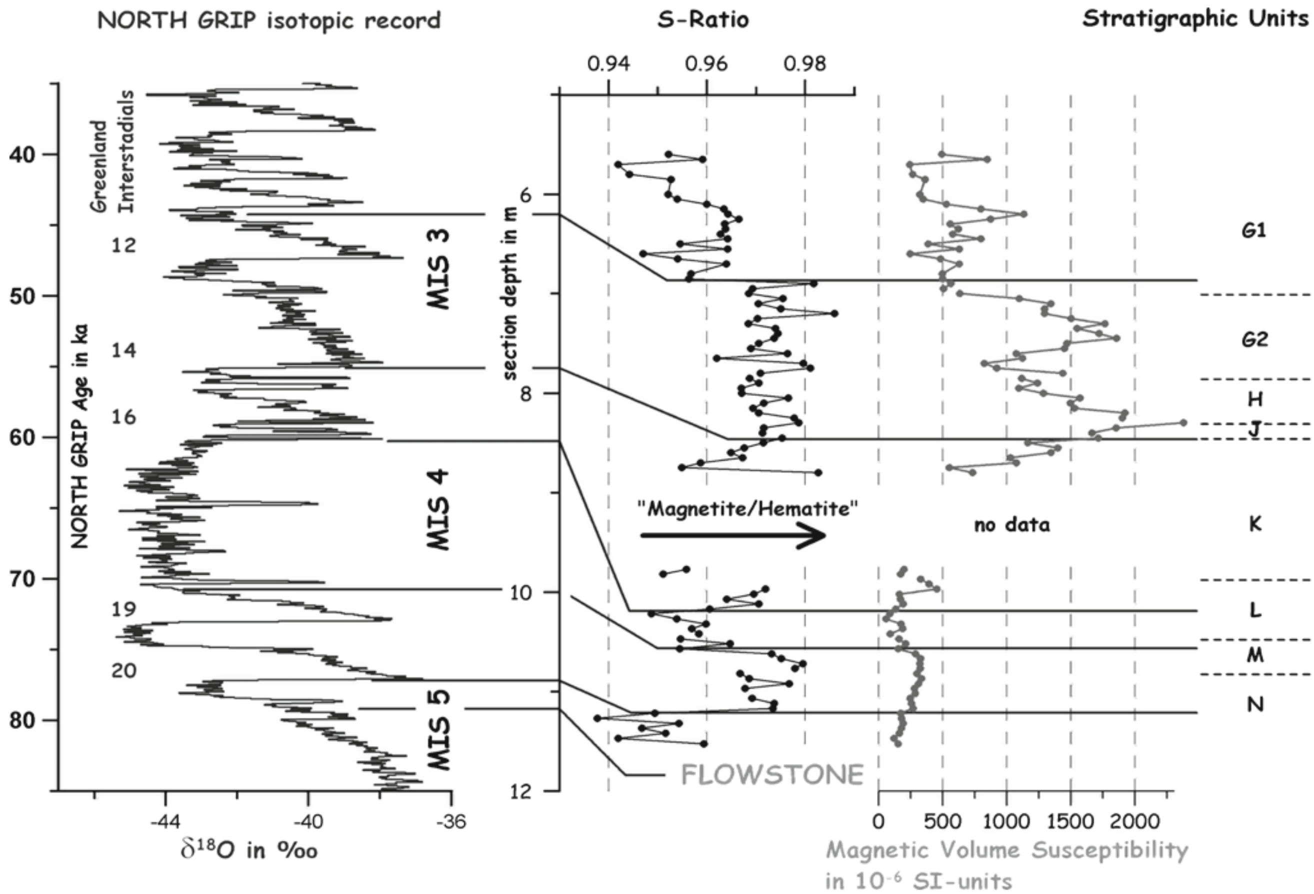

Fig. 3.7 Magnetic volume susceptibility and the S-ratio (proxy for magnetite/hematite) are plotted as a function of stratigraphy and correlated to the isotope record from Greenland ice cores (North GRIP Members 2004). The enhancement of magnetic minerals in the cave sediments causes higher values in magnetic susceptibility and an increase of relative magnetite concentration, reflecting warmer and more humid climatic conditions (Graphic by U. Hambach)

Based on these results and on the TIMS-U/Th-age of the basal flowstones (layer P), we propose the following correlation to the North-Grip isotopic record: Units M and N correspond probably to Greenland Interstadials 20 and 19 and thus to the end of MIS 5. Consequently, units G2 to J may correspond to Greenland Interstadials 12 to 14 which represent the warmest phases in MIS 3. Unit G1 is presumably older than Greenland Interstadial 8. However, the use of only magnetic volume susceptibility as a simple concentration dependent parameter may lead to wrong conclusions. The complexity of the formation of cave sediments requires a magnetic multi-proxy approach as applied here and as recently demonstrated in the Moravian Karst (Sroubek et al. 2001).

Conclusion

According to the new chronological results, the *Macaca* remains from Hunas are the most recent evidences of magots in Central Europe so far. It seems that in this region, *Macaca* did not disappear with the end of the Eemian (Fladerer 1991), but probably at the middle Würmian (OIS 4). Further, Hunas is the only place which shows the coexistence of man and monkey in the Würmian of Central Europe.

Remark Recent studies of the mandibular molar root morphology in Neanderthals and Late Pleistocene and recent *Homo sapiens* strongly suggest that the Hunas molar, which was assigned to a molar of a Neanderthal, is that of a recent *Homo sapiens* (Kupczik & Hublin 2010). This result changes nothing to the general statement of this article.

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Chapter 4
Neanderthals in the Cold: Middle Paleolithic Sites from the Open-Cast Mine of Garzweiler, Nordrhein-Westfalen (Germany)

Thorsten Uthmeier, Holger Kels, Wolfgang Schirmer, and Utz Böhner

Abstract In the years 1999–2001, an area of approximately 150 ha was surveyed by continuous control of the loess walls of the open-cast lignite mine of Garzweiler near Cologne, Germany. A total of 46 Middle Paleolithic sites were located, most of them clustering in connection to small stream positions. Despite the importance of natural factors during the site formation processes, lithic artifacts and skeleton elements preserved well, suggesting high impact of human and non-human agents, followed by low to moderate post-depositional alteration of finds. Altogether, eight sites were dated to the first maximum of the last glaciation (MIS 4). They consist of small assemblages of lithics mainly produced *ad hoc* from raw nodules carried along during hunting and gathering activities, and low frequencies of faunal remains. Traces of human use are restricted to reindeer. Therefore, it is concluded that these sites represent scanty remnants of kill and butchering sites of this species, enriched by additional faunal remains of unknown agency. The local loess stratigraphy as well as a brief survey of the environmental data from contemporaneous sites in Central and Eastern Europe reveals conditions more moderate than previously expected. It is inferred that changing environments after the last Interglacial Complex (MIS 5) had less effect on the dynamics of Neanderthal populations than formerly hypothesized.

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Keywords Open-cast lignite mine • Loess cover beds • Large scale continuous survey • MIS 4 • Off-site archaeology • Middle Paleolithic land use

Introduction

Since 1999 until today, the open-cast lignite mine of Garzweiler near Cologne has been subject to several projects of the University of Cologne that focus on the geo-archaeological investigation of areas of impending digging (Uthmeier 1997; Böhner & Uthmeier 2000). Whereas Holocene sites are prospected on surfaces barely untouched by mining, potential Pleistocene sites are mainly searched within the vertical walls of the open-cast mine itself. In this report we confine to Paleolithic sites that were located and investigated during the first phase of the project between 1999 and 2001.The archaeological work described here was conducted in the frames of the project “Archäologische Prospektion der Abbaukanten” financed by the “Stiftung zur Förderung der Archäologie im Rheinischen Braunkohlenrevier”. In this period, a joined team of archaeologists and geologists from the Institute for Prehistoric Archaeology of the University of Cologne and the Geological Department of the Heinrich Heine-University (Düsseldorf) prospected the loess walls of the open-cast pit in weekly intervals. The excavation front of the pit is 6 km long and is excavated to a depth of approximately 120 m below today’s surface. It offers the opportunity to vertically survey a changing number of ancient landscapes exposed in the walls of the pit. Pleistocene sediments in Garzweiler overlie Tertiary marine sands, which were deposited near to the then beach and alternate with layers of lignite. The Pleistocene part of the sequence is found in the upper 30 m of the walls of the lignite mine. It consists of the Main Terraces (*Hauptterrassen*) of the Meuse and Rhine Rivers at the base, and up to 15 m of loess (Kels 2007). The loess exposed represents large parts of the chronological scheme of the Rhine loess sequence (Fig. 4.1) developed by W. Schirmer (2000a, b, 2002a, b).

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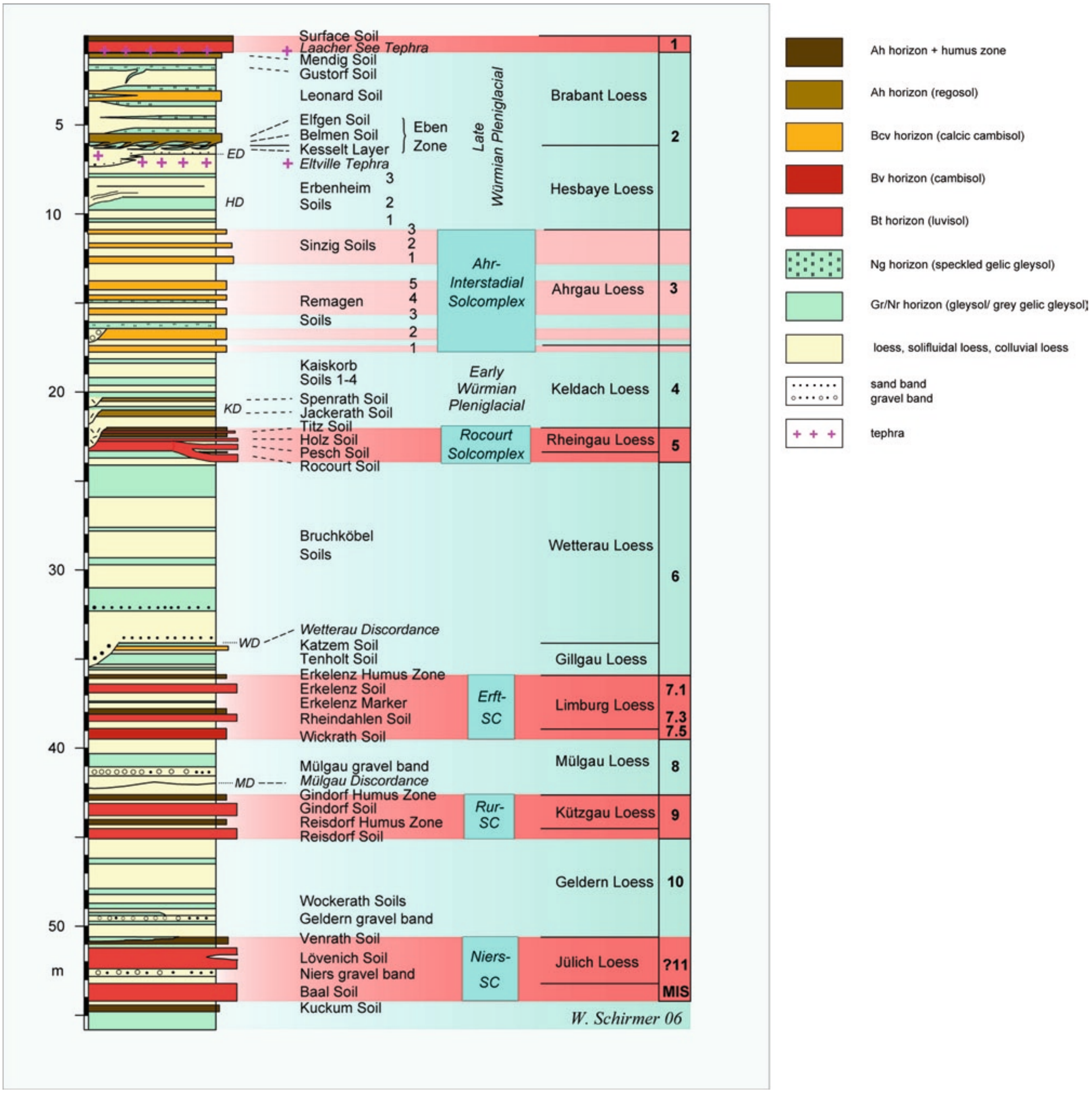

Fig. 4.1 Rhine loess sequence (Slightly modified after Schirmer 2006). *ED* = Eben- , *HD* = Hesbaye-, *KD* = Keldach-,*WD* = Wetterau-, *MD* = Mülgau-Discordance

The lignite open-cast mine Garzweiler is an extension of the former pit Frimmersdorf and lies in the southern part of the Lower Rhine, circa 20 km northwest from Cologne and in linear distance of 25 km to the Kleine Feldhofer Grotte (Fig. 4.2) where in 1856 the eponymous skeleton of the Neanderthal species was discovered (Schmitz 2006). In general, the Lower Rhine is a landscape with little relief. Major rivers drain the even landscape to the north and northwest. During the 1980s, the pit cut through the river valley of the Erft, which is a tributary to the Rhine, and destroyed the Mesolithic wet site of Bedburg-Koenigshoven (Street 1991).

Plateaus with little to gentle slopes prevail in most areas of the Lower Rhine and contrast markedly to the bordering mountain ranges of the Eifel in the West and the Bergisches Land in the East. Both mountain ranges have peaks that reach maximum heights of 750–850 m above sea level, and both are known for the existence of karstic cave systems (e.g., the Dechen cave: Hammerschmidt and Niggemann 1998), some of which yielded rich archaeological sequences (e.g., Kartstein and Balve caves: Bosinski and Richter 1997). Aside from colluvial sedimentation at foothills and floodplains, Pleistocene sites in even territories may be covered by

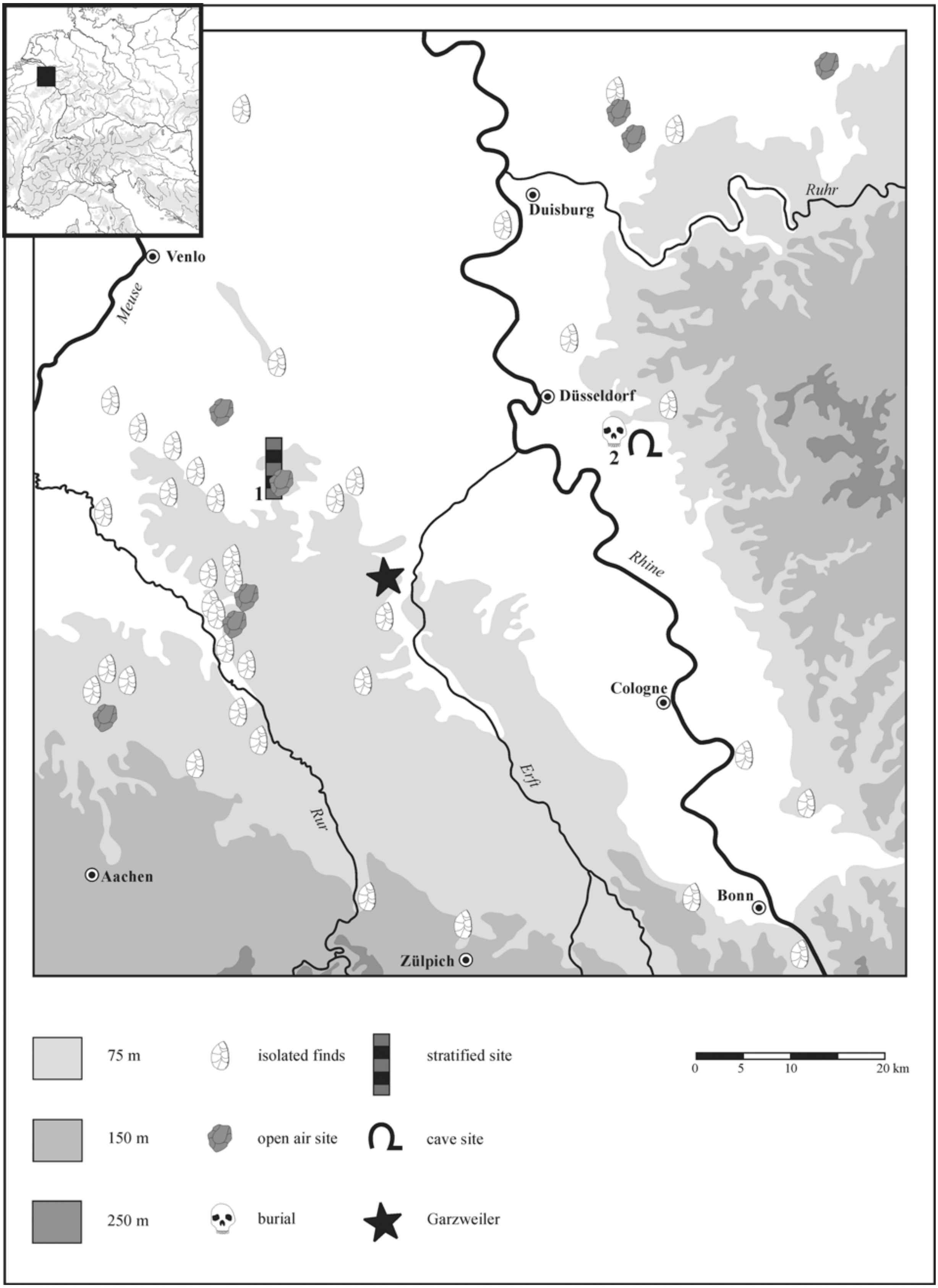

Fig. 4.2 Middle Paleolithic sites in the Lower Rhine. *1*: Rheindahlen; *2*: Kleine Feldhofer Grotte (Modified after Uthmeier 2006a: Fig. 13; database taken from Bosinski and Richter 1997)

vast accumulations of windblown sediments. A detailed geological map of the Lower Rhine displays a widespread Middle and Upper Pleistocene loess cover, sometimes reaching a thickness up to 20 m and more (Kels 2007). At the moment, the lack of caves in the Lower Rhine area, combined with thick sediment coverage, provides the best explanation for the comparably low density of well-preserved Middle Paleolithic sites known from this region before the start of our project (Fig. 4.2; for an overview Bosinski et al. 2000). With the exception of Rheindahlen (Fig. 4.2(1); Schirmer 2002a), which was recovered in a small loess quarry, and the reconstructed sequence of the 1856' extraction of the Kleine Feldhofer Grotte (Fig. 4.2(2); Schmitz 2006), no stratified site is known so far from the Lower Rhine (Bosinski and Richter 1997). Occurrences of artifacts classified as Middle Paleolithic are mainly surface material collected from slopes along river valleys, e.g. from locations indicative of destructive post-depositional processes.

Methods of Survey

Due to dynamics of Holocene landscapes caused by erosion and colluviation (local details see Schulz 2007; Schirmer and Kels 2007), archaeological open-air sites in the Lower Rhine that postdate the end of the Pleistocene are mainly found in sediments near to today's surface. Consequently, they are in reach of traditional surveying techniques, e.g., collections of objects from the ploughing zone of farmed areas, remote sensing, or aerial photography. To the contrary, potential *in situ* Pleistocene artifact sites may be deeply buried – to deep to be located by conventional prospection methods, and often even too deep to be unearthed within the frame of conventional construction projects. In addition, it is difficult to predict characteristic topographical settings, as ancient landscapes may strongly differ from today's surface. Thus, from an archaeological point of view, the potential sediment cover of Pleistocene archaeological sites implies a dilemma: while the chances of more or less *in situ* preservation by rapid windblown sediments are good, sites are difficult to detect. Open-cast mining pits offer a solution for this particular problem, as they expose long, deep-reaching profiles.

In the Garzweiler pit, continuous geo-archaeological survey and documentation of the walls were conducted to establish a local geo-chronological frame, and to locate archaeological sites. In general, archaeological fieldwork in the walls was made possible by the stepped excavation technique applied by the wide-bucket excavators. With a daily displacement rate of 200,000 t, the excavators cut the walls in major sediment levels of approximately 30–50 m. To provide stability, the walls consist of steps of 5–10 m in height. Because the dynamics of the mining procedure requires a periodical cut-back of the front walls, it was possible to survey each year approximately 20 km of the front wall along these steps. The pit is organized in two mining fields, with the extraction fronts moving towards each other (Fig. 4.3). Therefore, time span for more detailed archaeological fieldwork varied between 3 months and a year, depending from the distance to the meeting point of the two axes. The following routine was applied during field work (Böhner and Uthmeier 2000): survey of the whole loess sections of the walls in strips of maximal 100 m along the horizontal steps to locate objects fallen out of the wall, cleaning of the wall in 1 m wide sections every 10 m, and drawing and description of the profile. Geologically informative sections were drawn in large cut-outs (an example is given in Fig. 4.4) comprising a total length of 1.6 km (Schirmer 1999; Schirmer and Kels 2002, 2006; Kels 2007). In cases when surveys resulted in the detection of faunal remains or artifacts, large-scale plateaus were produced with the help of the wide-bucket excavator for further invasive prospection. The latter was realized either by mechanically made test trenches, or by small-scale hand-made soundings with subsequent screening. When promising archaeological sites were found (indicated by the combination of faunal remains and lithics, or archaeological structures), Paleolithic excavation techniques were applied.

Although the scale of the cutting seems large, it is in fact small compared to annual, seasonal, or even logistical territories of hunter-gatherers. The total amount of surface area mined within a year in the Garzweiler open-cast was no more than approximately 50 ha. This disadvantage is compensated by two features: first by the fact that numerous ancient surfaces with a considerable depth in time were exposed in one and the same wall, and second by an approach that aimed at a preferably continuous record, instead of searching large "flagship" sites. It was expected that the combined investigation of medium to large archaeological sites as well as small sites and artifact scatters comprising "off-site-archaeology" (Foley 1981) would enable to reconstruct local to regional subsistence patterns and settlement systems.

Geostratigraphical Position of the Garzweiler Paleolithic Sites and the Relation of Loess Units and Prehistoric Find Density

In the Lower Rhine area a detailed loess-soil stratigraphy was elaborated by Schirmer (2000a, b, 2002a, b, 2006) (Fig. 4.1). As the loess substratum is known for its excellent preservation of prehistoric finds the question arose on the statistical rate of prehistoric finds covered by different loess layers and fossils soils. The walls of the Garzweiler open-cast mine expose sediments up to 6 km in length, and a loess cover with an average height of 8.7 m (Figs. 4.4 and 4.5). Within the years 1999–2001

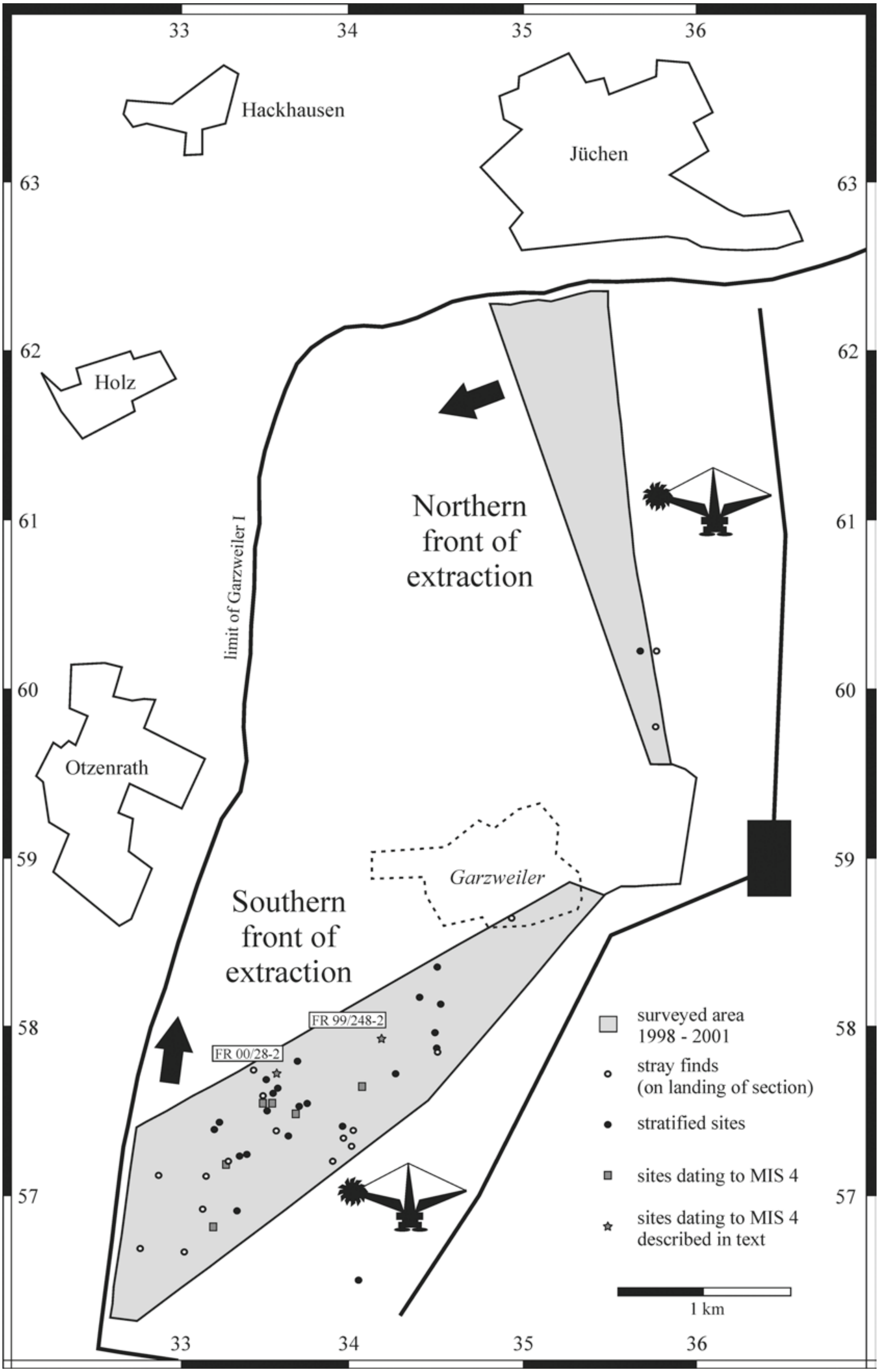

Fig. 4.3 Middle Paleolithic sites located in the open-cast lignite mine of Garzweiler between 1999 and 2001. The mining is organized in two mining fields that move forward towards each other (Modified after Uthmeier 2006a: Fig. 7)

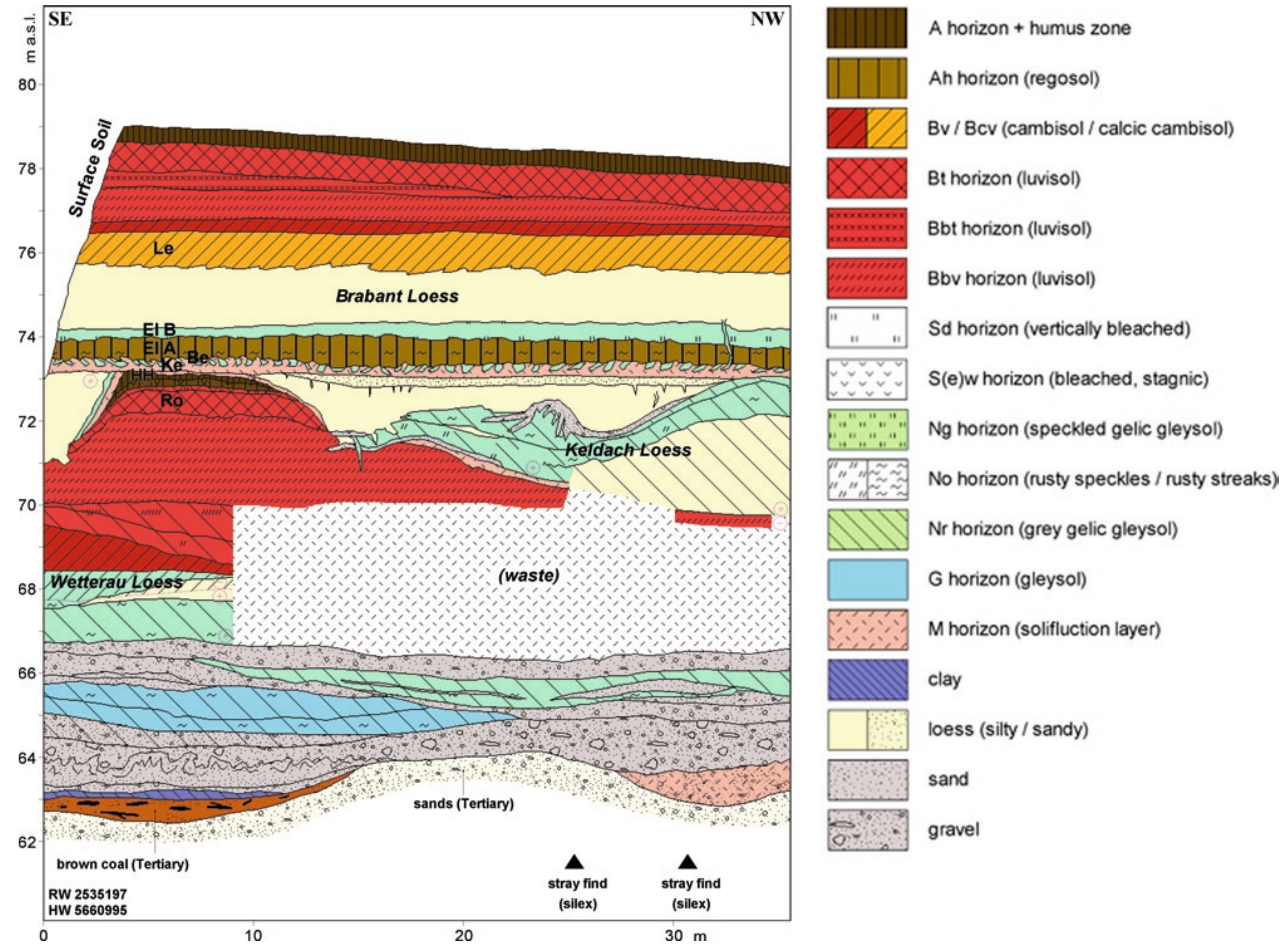

Fig. 4.4 Garzweiler open-cast mine. Loess wall section with the Rocourt-Solcomplex (red and dark brown), there incised colluvial Keldach Loess (*light grey*), and the small Kesselt Layer (Hesbaye Loess) unconformably covering both older units (*yellow brown*), covered by Brabant Loess up to the top. Meter stick is 2 m long (Kels 2007: 140); Ro: Rocourt Soil, HH: Holzer Humus Zone, Ke: Kesselt Layer, Belmen Soil, El A, El B: Elfgen Soils A and B, Le: Leonard Soil

about 130 stratified lithic artifacts could be assigned to the local loess stratigraphy. Surprisingly, the stratigraphical distribution of the finds in the Garzweiler open-cast mine contradicts to that of finds made prior to our study in the Lower Rhine loess plateau where a prevalence of finds from the fossil soil clusters (Fig. 4.1) within the loess pile was observed. However, the statistical inquiry showed quite different results (Table 4.1) (Kels and Schirmer 2006a, b).

Only a few finds are from the Pre-Eemian loess which covers a quarter of the complete loess mass. Likewise the Rhein Interglacial Complex (MIS 5) was devoid of prehistoric finds. The first cold maximum of the Last Glacial (MIS 4) is represented by the Keldach Loess. Surprisingly, half of all finds were embedded here. Within the Keldach Loess the finds appear in all horizons, but with a distinct concentration to its deeper part. The sparsely preserved Ahrgau Loess (MIS 3) was lacking any finds. In contrast, the very thinly preserved uppermost Hesbaye Loess (lower MIS 2), which represents the mature stage of the second cold maximum of the last glaciation, yielded the other half of all finds in Garzweiler. Unlike this, the Brabant Loess (upper MIS 2) deposited since the maximum of the Last Glacial did not deliver one single find.

The lack of Pre-Eemian finds may be due to the lack of the Erft Soil Complex along this wall. In Rheindahlen, this soil complex yielded artifacts (Schirmer 2002a; find a compilation in Ikinger 2002). The Rhine Interglacial Complex (MIS 5) was exposed over longer distances, but delivered no prehistoric finds. This may be due to local conditions. Other localities as Veldwezelt on the Maas river show rich find assemblages therein (Gullentops and Meijs 2002). The Keldach Loess – representing the Early Würmian maximum period – was exposed in a quantity as much as the whole pre-Eemian loess. Its find assemblage is unique for this area. The Keldach Loess at its base is very rich in solifluctional loess. This is a common feature in central Europe. Semmel (1968: 30) called this solifluctional layer Niedereschbach Zone. Schirmer (2003a: 49) stated that this solifluctional layer according to local morphology may comprise a thin time slice at the base of the Keldach Loess as well as a very thick time

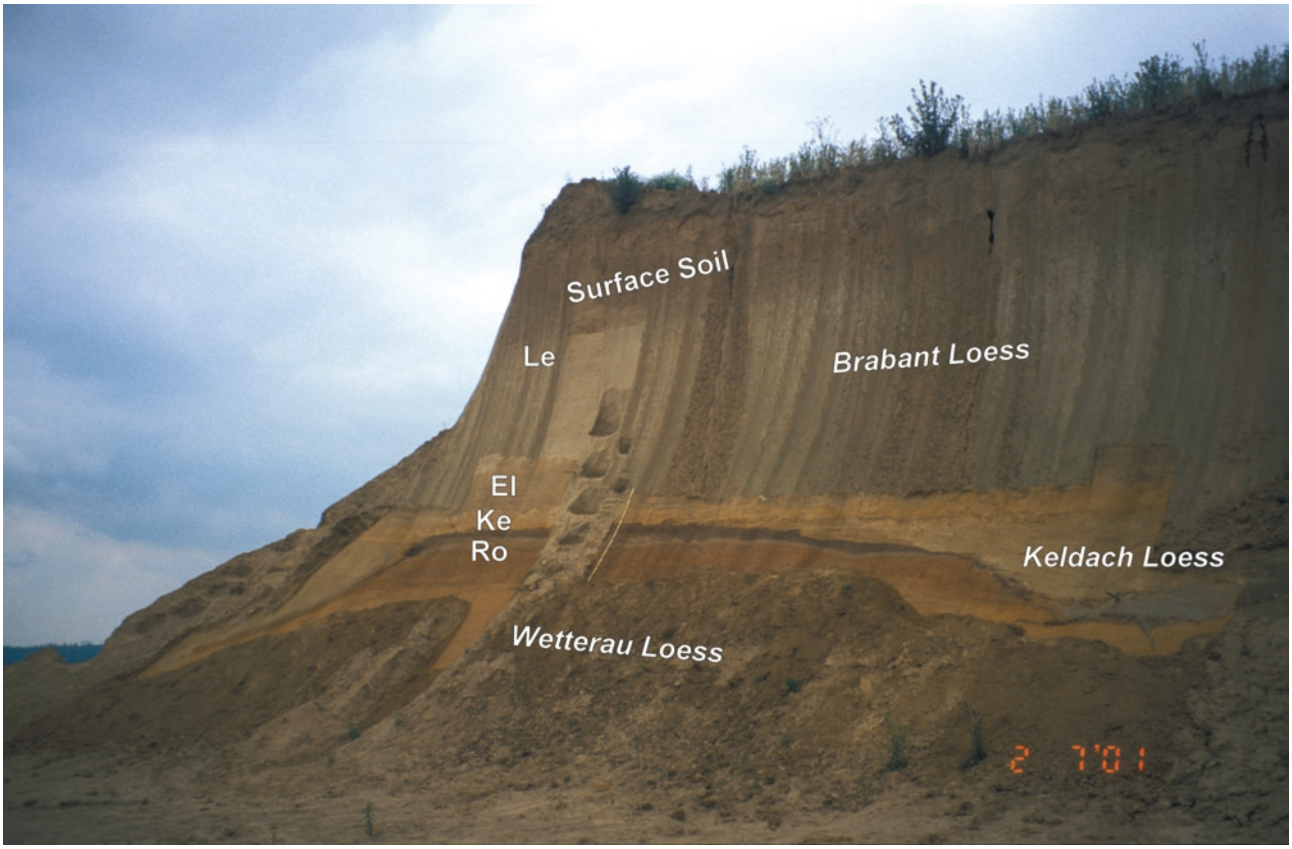

Fig. 4.5 Garzweiler open-cast mine. Loess section. Le: Leonard Soil; El: Elfgen Soil (A/B); Be: Belmen Soil; Ke: Kesselt Layer; Ro: Rocourt Soil (Kels 2007: 200, meter 0–35, slightly modified)

Table 4.1 Shares both of the loess units in the Garzweiler open-cast mine and of Paleolithic finds. (The difference of the values given in former calculations [Kels and Schirmer 2006a; Schirmer and Kels 2006; Kels 2007] are due to an improved planimetry)

Stratigraphy	MIS	Loess unit	Quota of wall area (%)	Number of finds	Quota of finds (%)
Late Würmian maximum 2	MIS 2	Brabant	45	0	0
Late Würmian maximum 1		Hesbaye	4	64	49
Middle Würmian	MIS 3	Ahrgau	0.01	0	0
Early Würmian maximum	MIS 4	Keldach	25.5	66	50
Rhein Interglacial Complex	MIS 5	Rheingau	1.5	0	0
Pre-Eemian	MIS 6 to 11	Pre-Eemian loess	24	1	1
Total	–	–	100	131	100

package comprising the whole Keldach and parts of the overlying Ahrgau Loess. In some cases the Garzweiler finds came from the basal Keldach deposits. In this case it might be possible that some finds are reworked from the underlying Rhein Interglacial Complex. The bulk of finds occurring in different beds of the Keldach loess are nevertheless parautochthonous in space by solifluctional, colluvial and fluvial concentration however autochthonous in time (Schirmer 2005: 32). In any case the finds of the Keldach complex are situated in close connection to small stream positions. Thus, these ecological wet positions within the tundra environment might have attracted both animals and hunters. The Ahrgau Loess was exposed only with its basal part in one small place due to its widespread erosion below the Eben Discordance (*ED* in Fig. 4.1) (Schirmer 2003b). Hence, there was no possibility for preservation of possible relics.

Middle Paleolithic Sites from the Garzweiler Pit

During 3 years of archaeological survey between 1999 and 2001, a total of 60 km of the stepwise advancing front wall of the Garzweiler pit were observed for their Pleistocene parts (Böhner and Uthmeier 2000; Uthmeier 2006a). It is important to underline that the total distance of surveyed walls results from different states of mining of one and the same section along the front end of the pit (Fig. 4.3). The surface excavated by the pit in this period measured 150 ha, which equals 45,000,000 m^3 of Pleistocene sediments (with an average depth of the Pleistocene sediments of 30 m, including gravels and sands of the river terrace at the base). However, if the average thickness the of loess cover of 8.7 m forms the basis of the calculated loss of sediment through mining, it comes to 13,050,000 m^3 of potential *in situ* sediments, respectively. Within this enormous, chronologically diverse volume, 46 Middle Paleolithic sites were observed. Of these, 11 underwent further investigation by test trenches or excavations mainly parallel to the wall of the pit, or on plateaus cut by large excavators. Excavations itself measured between few and 71 m^2. A classification as "Middle Paleolithic" was based on either typological and technological features, or – in cases when artifacts were not diagnostic – a geostratigrahical position between the beginning of MIS 8 and the mid of the Interpleniglacial (MIS 3; in the scheme of Fig. 4.1, the transition between Middle to Upper Paleolithic takes place during the formation of the Remagen Soils 3–5).

Seventeen of 46 Middle Paleolithic sites (Fig. 4.6) contained small assemblages of clustered stray finds, but out of stratigraphical context. Although it is highly probable that these artifacts and faunal remains collected from the steps had been fallen out of the above wall section (which is further strengthened by the fact that the ground surface in the surrounding above was also surveyed), nothing secure can be said about their age. Among the remaining 29 stratified sites those with faunal remains prevail; stratified sites with lithic artifacts alone account for three cases only. The comparably good preservation of the faunal record can be seen as a consequence of the thick, and in parts calciferous loess cover. However, any generalization from this is limited by the few faunal remains preserved in the decalcified Ah and Bt horizons of the last Interglacial Rocourt Solcomplex (MIS 5). Half of the finds come from different stratigraphical positions in the Keldach Loess, which dates to the first maximum of the last glaciation (MIS 4: Fig. 4.1). Fourteen of all in all 26 stratified sites with faunal remains lacked any direct evidence for the presence of humans. In five cases bones showed cut marks or traces of impact directed towards the extraction of marrow and thus were altered by humans, and six sites combined faunal remains and lithic artifacts. In one case, faunal remains were associated with charcoal.

Most Middle Paleolithic sites were detected in the southern mining field (Fig. 4.3). Part of the reason for this must be seen in the relief, as the mining front almost longitudinally cuts through a paleochannel (Kels 2007). The geological documentation of the respective sections of the walls showed that this channel was active since the end of the last interglacial. Several times it served as streambed for small rivers. Judging from the grain size of the sands and the size of the gravels, water volume and stream velocity were low to moderate, which may indicate seasonal water flow only, or braided river systems. Therefore, the linear clustering of Middle Paleolithic visible in the southern mining field does not only result from different stages of mining, but in part reflects the distribution of sites along shallow banks of several almost congruent river valleys that existed during the Upper Pleistocene. In the northern mining field, a comparable situation existed, but was

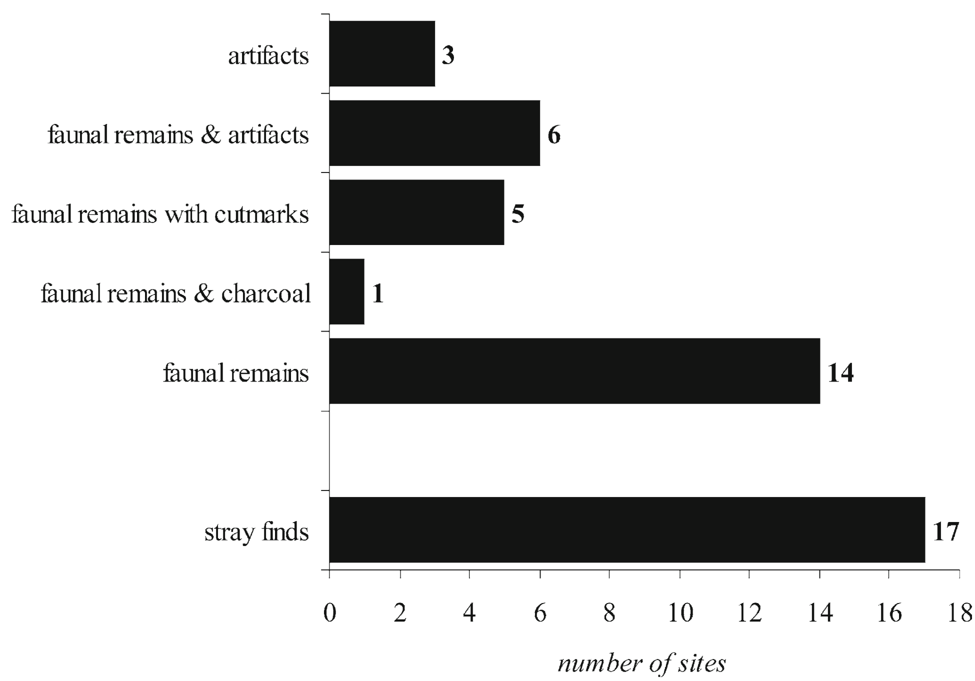

Fig. 4.6 The Garzweiler sites (MIS 4): histogram of absolute frequencies of site categories ($N = 46$; Modified after Uthmeier 2006a: Fig. 14)

removed by mining operations before the project started. The valley of the Elsbach may have originated during the Middle Pleistocene (Boenigk and Frechen 1995) and was as wide as 400 m during the last interglacial. Being aquiferous until the Holocene, the valley also contained wet sediments, which in part could be dated to the Denekamp Interstadial due to their vegetation remains (Meurers-Balke 1990), but yielded no archaeological material. If compared to the southern mining field, the northern mining field is characterized by a reduced loess cover and a more even landscape. Both factors, e.g. higher chances of archaeological remains to be effected by post-depositional processes and a landscape ecologically less advantageous for both animals and humans may explain the marked differences observed in the frequency of finds therein.

Neanderthals in the Cold: The Garzweiler Sites Dating to the First Maximum of the Last Glaciation

In sum, eight sites date to the first maximum of the last glaciation (MIS 4). They were found in different beds of the Keldach Loess (Figs. 4.1 and 4.5). Its geochronological position above the Rhine Interglacial Complex (MIS 5, represented by the Rocourt Solcomplex: Fig. 4.1) and below the Ahrgau Loess (Fig. 4.1: MIS 3) were described in detail elsewhere (Schirmer and Kels 2006; Kels 2007). Two features are important for the understanding of the formation process and the ecological context of the aforementioned archaeological sites: first, the sites were located near to small streams, and second, during the formation of the Keldach Loess there were times when the aeolian sedimentation stopped, or was less intense, and tundra soils – called Kaiskorb Soils (Fig. 4.1) – developed. Despite the dynamic depositional character of the solifluctional, colluvial or fluvial sediments, displacement of archaeological remains was moderate. This is indicated by sharp edges and sharp dorsal scars patterns of lithic artifacts as well as the comparably good preservation of bones and teeth. Several times, complete vertebrae with their fragile lateral processes survived the transport. On the other hand, the repeated representation of individuals by isolated faunal remains only, and the often low number of indentified specimen, suggests high impact of human and non-human agents on the carcasses, followed by low to moderate post-depositional alteration.

Taken together, Garzweiler sites from sediments of the first glacial maximum of the last glaciation yielded 74 faunal remains (Table 4.2). Any interpretation has to keep in mind that faunal remains were found in dynamic environments, making the postulation of contemporaneity between them and artifacts anything but self-evident. If the data is simply taken as presence and absence of species in a given time, it is interesting to see that it includes major species of the mammoth steppe, e.g. mammoth, reindeer, bison, and horse (von Koenigswald 2002: 145). This, combined with the existence of tundra soils, strongly suggests that during the first maximum of the last glaciation (MIS 4), north-western Central Europe was far away from being a hostile cold desert. Topography and formation process of the sites, which can be seen as elongated linear traps representing averages of the then large mammal fauna, could be taken as argument for an interpretation of the faunal data as proxy for climate (rather than human resource acquisition). If so, the absence of species of the mammoth steppe less well adapted to extreme cold, like red deer (von Koenigswald 2002: 83) and giant deer (von Koenigswald 2002: 73), indicates more cold and arid conditions. However, the weak database advises caution not to overestimate the relevance of the absence of single species.

The same accounts for the quantity of species (Fig. 4.7), which cannot be directly interpreted as resulting from human activity. Human activity is irrelevant in the large faunal assemblages from late Pleistocene drainage basins in Alaska (Fig. 4.8) reported by Guthrie (1996: Tables 2–5). Steppe bison dominates by far the faunal assemblages, followed by horse and reindeer. Mammoth (and woolly rhinoceros) as well as wolf are generally rare. Given that Late Pleistocene Alaska is an appropriate equivalent to the natural faunal community of the mammoth steppe in Central Europe during the first maximum of the last glaciation, mammoth and wolf from the Garzweiler sites most probably died from other

Table 4.2 The Garzweiler sites (MIS 4): absolute frequencies of faunal remains

	NISP							
Site	Mammuthus primigenius	Coleodonta antiquitatis	Bos/Bison	Equus sp.	Rangifer tarandus	Canis lupus	unclassified	*N*
FR 99/154	1		1	1	6		9	18
FR 99/247			1	3	3		2	9
FR 99/248	2	1	2	3	6	1	13	28
FR 00/23			1	2			1	4
FR 00/28-2			2	4	4		5	15
N	**3**	**1**	**7**	**13**	**19**	**1**	**30**	**74**

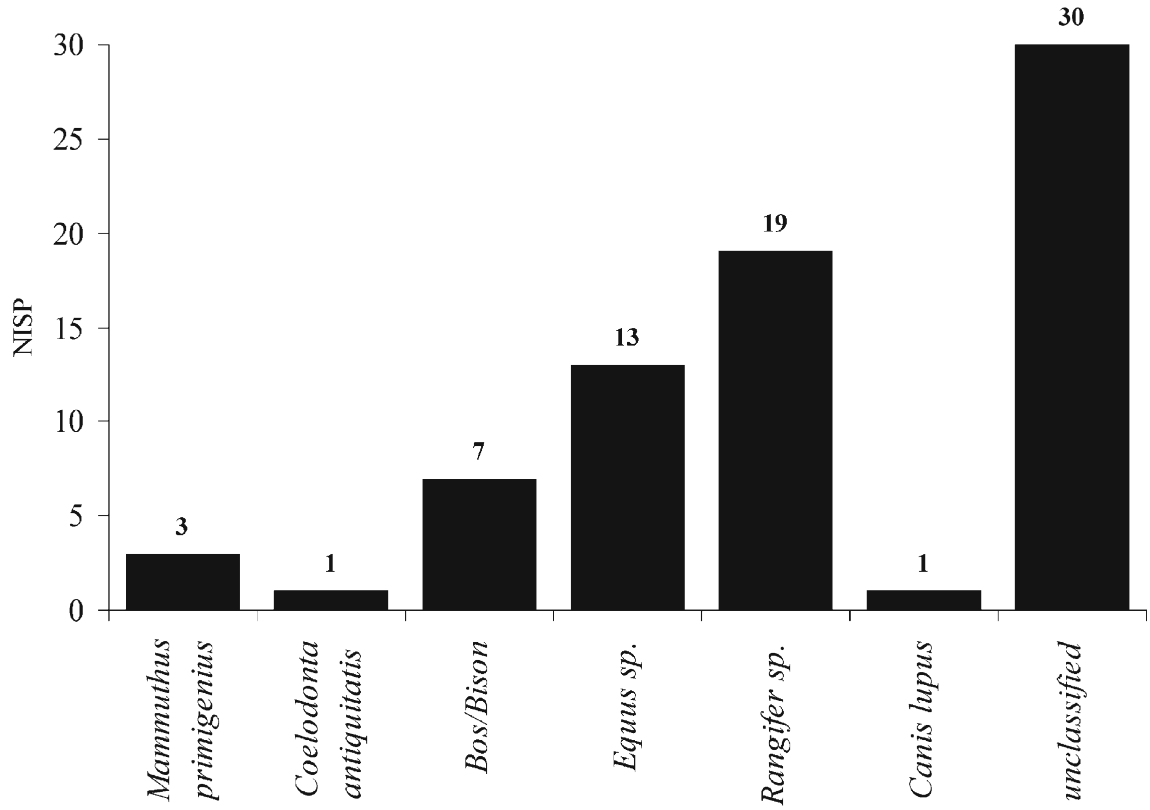

Fig. 4.7 The Garzweiler sites (MIS 4): histogram of absolute frequencies of identified specimen (NISP) per species ($N=74$, Modified after Uthmeier 2006a: Fig. 16)

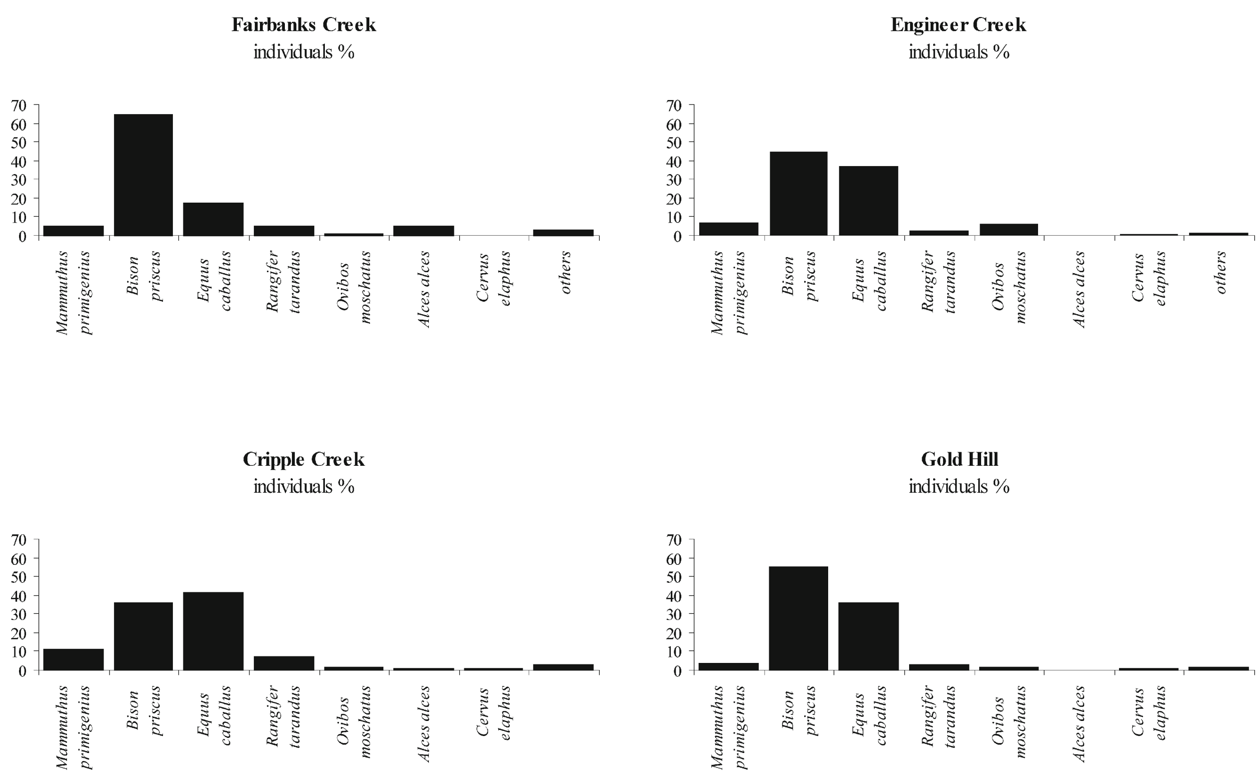

Fig. 4.8 Histograms of relative frequencies of major species of the mammoth steppe in four faunal assemblages from Late Pleistocene river drainages in Alaska (Calculated from data given by Guthrie 1996: Table 1)

Table 4.3 The Garzweiler sites (MIS 4): typical inventories (Modified after Uthmeier 2006a: 17)

Category	N	Comment
Site-Id.: FR 99/248-2		
Canis lupus	1	1 canine tooth
Mammuthus primigenius	2	1 M
		1 fragment of tusk, modified
Bos sp.	2	1 fragment of pelvis
		1 fragment of ulna
Equus sp.	3	1 M
		2 fragments of tooth
Rangifer *sp.*	6	1 rip
		1 humerus of juvenile individual
		1 Metatarsus, extraction of marrow
		2 fragments of long bone
		1 fragment of tooth
Uncertain	2	1 fragment of reindeer-sized long bone
		1 fragment of long bone of rhinoceros
Lithic artifacts	51	1 cortical flake
		1 sidescraper with cortex on dorsal surface
		1 lateral sharpening flake
		48 chips
Site-Id.: FR 00/028-2		
Bos sp.	2	1 fragment of long bone, gnawing marks from hyena
		1 fragment of neck vertebra
Equus sp.	4	1 M
		1 fragment of molar
		1 neck vertebra
		1 fragment of ulna
Rangifer *sp.*	>4	1 fragment of molar
		1 M, burned
		1 fragment of pelvis, burned
		several fragments of tarsal bones, burned
Lithic artefacts	2	Lateral retouch on crested retouched flake

Underlined: faunal remains showing human modification (modification probable, but not secure)

causes than human predation. Otherwise, one would expect quantities exceeding those reported from the natural taphocoenosis. At one of the Garzweiler sites (FR 99/248-2), the tusk of a woolly mammoth shows probable traces of human modification (Table 4.3). As at other Middle Paleolithic sites with megafauna and artifacts, e.g., Gröbern, Neumark-Nord, or even Lehringen (Uthmeier 2006b), it seems more probable to assume that large herbivores served as raw material source, or were scavenged when meat was still fresh. The frequencies of bison, horse and reindeer are another matter, as those documented at the Garzweiler sites (Fig. 4.7) are reverse to those from the Alaskan assemblages. Reindeer lives in vast herds, especially when migrating between seasonal grazing grounds, whereas horse gathers food in small groups within stationary territories. In contrast to the aforementioned mid-sized species, Bison is that large and dangerous that it is supposed to mark the upper border of live weight of preferred Neanderthal prey (Uthmeier 2006b). If viewed from a Neanderthal optimal foraging perspective, the ascending order of frequencies of herbivores from Garzweiler given in Fig. 4.7 reflects an increase in group size, and, at the same time, an decrease in the ability of self-defense. Thus, although the taphonomy of the Garzweiler faunal assemblage from first maximum of the last glaciation (MIS 4) is problematic, it seems justified to assume that the dominance of reindeer results from human hunting.

This is illustrated by empirical data from the archaeological sites itself. Table 4.3 gives an overview over two typical assemblages (FR 99/248-2 and FR 00/028-2). Again, the slightly relocated origin of the finds allows hypothetical statements only. But while all faunal remains theoretically may be remnants of human kill and butchering sites near streams, this gains more probability only in the case of reindeer. Faunal remains of this species show direct evidence for human use via burning and extraction of marrow.

Like faunal remains, lithic artifacts might have been transported. If so, distances must have been short, because edges and dorsal scars are sharp, water patina is absent, and even small chips exist. At the site FR 99/248-2 (Table 4.3), flakes with cortex prove on-site blank production from raw nodules. A sidescraper on flake with cortex (Fig. 4.9(10)) shows that blanks were produced for immediate use. On the contrary, one isolated resharpening flake from an unknown tool, as well as the absence of cores, points to items that were produced at the site, but transported elsewhere (maybe in combination with meaty parts of prey). The same accounts

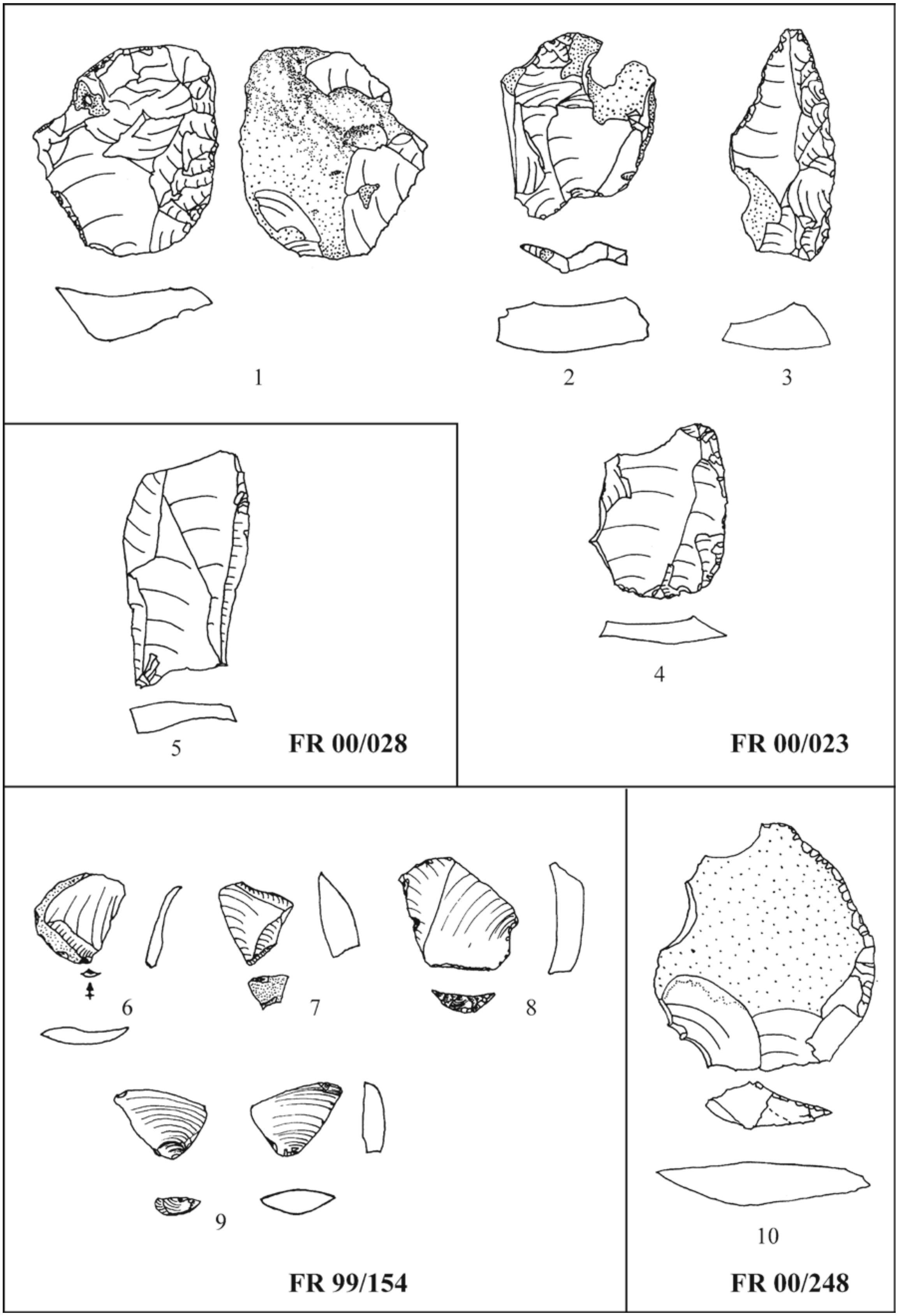

Fig. 4.9 The Garzweiler sites (MIS 4): artifacts from selected sites (scale 1:1; Modified after Uthmeier 2006a: Fig. 18)

for the second exemplarily site, FR 00/028-2 (Table 4.3). Again, the blanks of two isolated tools, one of which has a lateral crest (Fig. 4.9(5)), derive from initial phases of the reduction sequence. A high frequency of cortex also characterizes the assemblage of FR 00/023. The size of an initially prepared core (Fig. 4.9(1)) with large amount of cortex on the striking platform fits well to a flake with distal remnant of cortex (Fig. 4.9(2)), indicating small sized raw nodules. Rather small dimensions also account for two laterally retouched blanks (Figs. 4.9(3) and 4.9(4)). To conclude, the aforementioned lithic assemblages stem from initial phases of the *chaîne opératoire*. In all cases, chalky cortex indicates primary raw material sources. As these are unknown in the Garzweiler area where only gravel from river terraces is available, raw material must have been carried along for activities that led to the formation of the sites analyzed here. On the contrary, the site FR 99/154 only had chips (Figs. 4.9(6)–4.9(9)). The lack of any other artifact category suggests that these were struck to retouch or rejuvenate working edges. One chip from surface shaping (Fig. 4.9(6)) as well as a Kombewa flake, supposingly from ventral thinning, are part of working steps for the production or resharpening of bifacial tools. Despite the small numbers, each lithic assemblage shows a number of coherent features. The majority can be interpreted as *ad hoc* flaking of imported raw nodules. In one case, bifacial flaking was applied either to finish an already existing preform, or to rejuvenate a bifacial tool (Fig. 4.9).

Discussion and Conclusion

Even if both sources of information, faunal remains and lithic assemblages, are combined, sites from the Garzweiler pit dating to the first maximum of the last glaciation still fall into the category of “off-site archaeology” in the sense that they are part of a clustered scatter of cultural remains loosely

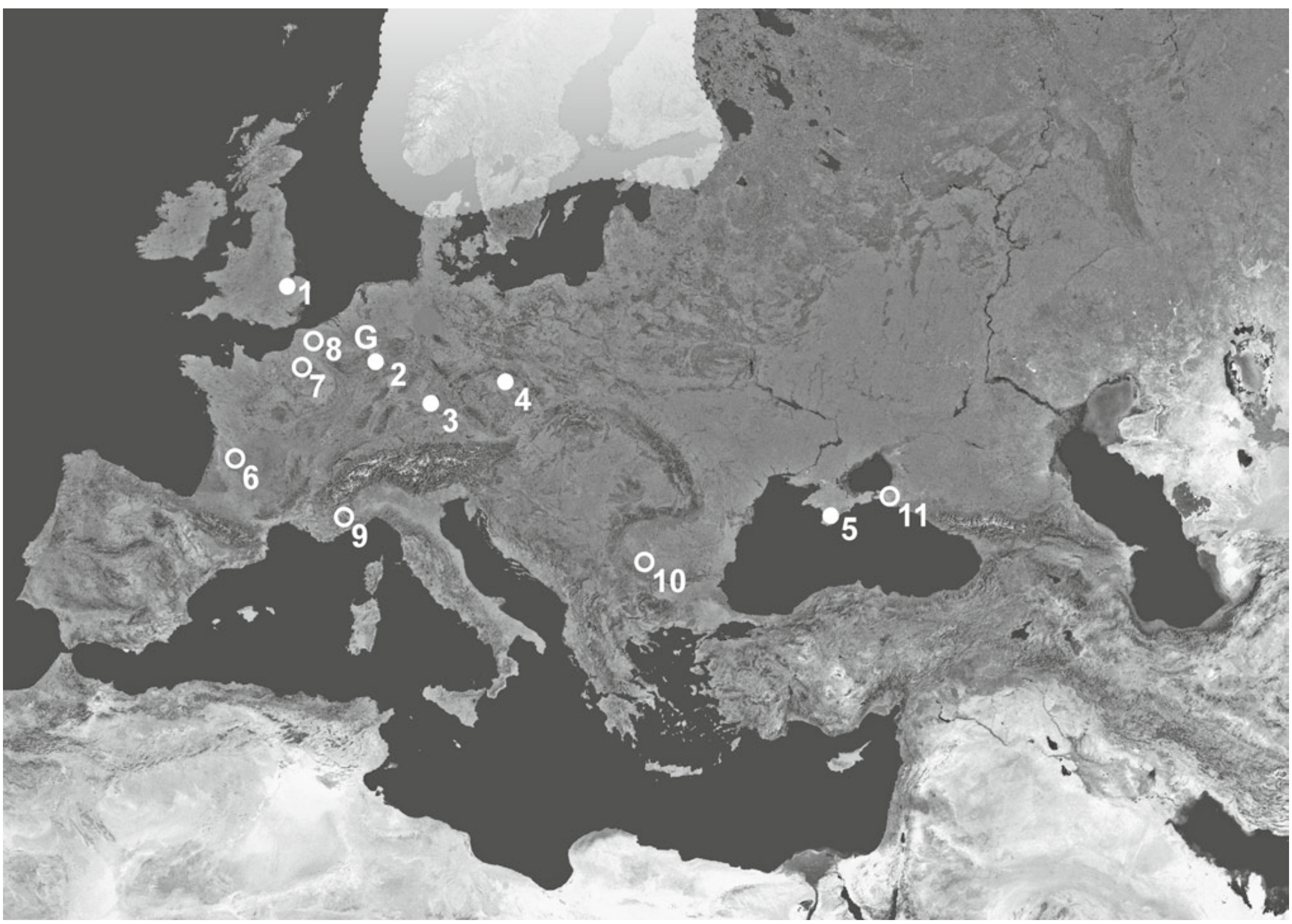

Fig. 4.10 Selected sites dating to MIS 4 (*1*: Lynford Quarry [Boismier 2006]; *2*: Tönchesberg [Conard 1992]; *3*: Sesselfelsgrotte [Weissmüller 1995]; *4*: Kulna [Valoch 1988]; *5*: Kabazi II [Chabai 2005]; *6*: Combe Grenal; *7*: Beauvais (?); *8*: Riencort-les-Bapaume; *9*: Pié Lombard; *10*: Temnata; *11*: Il’skaya II [All after Gamble 1999, Tab. 5,2; for the uncertainty about the datation of Beauvais see Locht et al. 1994], G: Garzweiler. The extension of the Scandinavian ice sheet is taken from van Andel 2003)

distributed in the landscapes. Though being affected by natural site formation processes, the good preservation of lithics and the meaningful combination of artifact classes in each assemblage make the sites more than just remnants of “reworked cultural landscapes” (Beck et al. 2007). Instead, the diversity of water volume and stream velocity in braided river systems augmented the chances of artifacts and faunal remains abandoned in lateral parts of the river valley to be preserved from long-distance transportation. The Garzweiler sites give an impression how landscapes of the first maximum of the last glaciation used by Neanderthals looked like: they were covered by patches of kill and butchering sites locally isolated in space and time, their original position being marked by lithics rather than carcasses. The latter were already broadly decayed by both human and natural agency before covered by sediment. Admittingly, this seems banal, as all hunter-gatherers leave behind such sites regardless of their subsistence tactics (Binford 1980). However, some details are nevertheless intriguing.

First, mid-sized animals, and especially reindeer, were the preferred prey. Second, the presence of raw nodules flaked for immediate needs suggests that hunting activities were started from nearby residential camps; otherwise, one would expect prepared cores and/or ready-made tools, which either are absent in the lithic record, or underrepresented. And, third, activities cluster near to braided river systems and their tributaries. After 3 years of continuous surveys, these conclusions can be taken as representative for those periods preserved in the sediments of the Garzweiler pit. The role of riverbeds in the formation of archaeological landscapes – and, therefore, in the Neanderthal’s creation of mental maps – during the first maximum of the last glaciation may have been manifold. In the more or less treeless tundra, river valleys offered preferable conditions for both vegetation and animals, as they were more moist and protected from chilly winds. Even more important was the availability of water. During the short, but dry summers, and during winter, when the ground was deeply frozen, rivers must have been essential to satisfy water supply of large mammals including humans. And finally, it is conceivable that in the even landscapes of the Lower Rhine, rivers functioned as major orientation for logistical as well as residential moves.

On a large scale, the Garzweiler sites from the first maximum of the last glaciation are far from being an isolated phenomenon in Central and Eastern Europe (for an overview see Gamble 1999: Table 5.2). Quite to the contrary, the widespread distribution (Fig. 4.10) raises the question under which environmental conditions these sites came into being. A closer look at the fauna and vegetation from selected sites (Table 4.4) reveals surprisingly moderate conditions if, for example, compared to the second maximum of the last glaciation.

At the open-air site of Lynford Quarry (Boismier 2006) near Norfolk, Great Britain, paleochannel deposits yielded a beetle fauna that allowed to reconstruct the mean temperatures of the warmest month of 13°C and of below –10°C for the coldest. This allowed the growth of cool open grassland even in northerly latitudes near to the ice sheet, with cold tolerant large mammal species like woolly mammoth, woolly rhinoceros, reindeer, horse and bison, but also brown bear and, perhaps, red fox. The diverse fauna at Lynford Quarry also includes fishes and amphibians. The latter two animal families are also reported from the small rock shelter of Sesselfelsgrotte in southern Germany (Weissmüller 1995; Richter 1997). Here, amphibians, fishes and birds were found in the debris of layers L and K along with small mammals adapted to extreme cold, e.g., *Lagurus lagurus*. The situation in Kůlna Cave near Brno is more complicated, as there is no consistency about the geochronology. In contrast to K. Valoch (1988), W. Weissmüller (1995) assumed that layer 7b is the equivalent of the first maximum of the last glaciation. The sediment of layer 7b is described as niveo-aeloean formed under extreme cold conditions. Despite the harsh, more continental conditions with annual means as low as –3 to –4°C, mammoth, reindeer, woolly rhinoceros, horse and cave bear lived around the cave. All these environments sharply contrast to habitats reported from more southerly regions. During most part of the last glaciation, the Crimean Peninsula was part of the continent and covered by boreal forest-steppe vegetation (Chabai and Uthmeier 2006). Although non-arboreal pollen dominate the samples from Kabazi II, there were still patches of forests characterized by pine trees. The restriction of the large mammal fauna at Kabazi II to one species, *Equus hydruntinus*, is explained by human choice of prey. In general, the long vegetation record of Kabazi II shows little changes in the time between the end of the last interglacial (MIS 5) and the interpleniglacial (MIS 3). Therefore, the major prey of Crimean Neanderthals, *Equus hydruntinus* and *Saiga tatarica*, were always present in the region (Chabai and Uthmeier 2006).

Judging from the presence of staple food resources, which mainly was meat (Bocherens et al. 2005), all European habitats from the first maximum of the last glaciation (MIS 4) briefly examined here must have been suitable for Neanderthal survival. However, low mean temperatures in winter combined with delicate wind chill (Aiello and Wheeler 2003) certainly required sophisticated body isolation as well as dwellings. Apart from this, reachability of prey in appropriate annual territories might have been a limiting factor especially in Central Europe, which perhaps lowered population densities. If carrying capacities for both Neanderthals and other carnivores were adequate on the long run is another question, but obviously Middle Paleolithic humans were able to cope with food competitors (Mussi 1999). Therefore, the

Table 4.4 Sites of the first maximum of the last glaciation (MIS 4) in Central and Eastern Europe: environmental information (?: classification not secure)

Site	Geological layer	Archaeological horizon	Literature	Animals	Vegetation
Lynford Quarry	Main paleochannel deposits (OSL: 64 ± 5 ka BP, 67 ± 5 ka BP) *Industry*: Mousterian of Acheulean Tradition (MtA)		Boismier (2006)	*Fishes*: stickleback, perch, *Amphibians*: frog(?), *Insects*: dung beetle, carrion beetle; beetle assemblages: mean warmest month (July) 13°C, mean coldest month below –10°C *Vertebrates*: wholly mammoth, wholly rhinoceros, reindeer and horse (extraction of marrow), bison (all herbivores: scavenging?), Red or artic fox, brown bear	*General features*: cool open grassland, with patches of bare, disturbed, and wet ground with small stands of birch trees or scrub; *AP* (low counts): birch, pine, spruce, bilberry *NAP*: grasses, sedges, chickweeds, meadow rue, thistle, dandelion
Tönches-berg I	TÖ1B (at TÖ2 TL: 66 ± 6 ka BP), redeposited by solifluction; *Industry*: undiagnostic chipped quarz assemblage		Conard (1992)	*Vertebrates*: *Equus sp.*, *Cervus elaphus*, *Rangifer tarandus*, *Coelodonta antiquitatis*, *Equus hydruntinus*	
Sesselfels-grotte	Layer K (large sized debris and large boulders)	Sterile	Weissmüller (1995) Richter (1997)	*Fishes* *Amphibians* *Birds* *Vertebrates*: *Lupus lupus, Lagurus lagurus, Dicrostonyx torquatus*	*Pinus cembra, Pinus silvestris, Larix/Picea,*
	Layer L (small sized debris, loamy, dark			*Amphibians* *Birds* *Vertebrates*: *Lagurus lagurus*	*Pinus cembra, Pinus silvestris, Larix/Picea,*
Kůlna[a]	7b (niveo-aeolean sediment with annual means of –3 to –4°C)	Sterile	Valoch et al. (1969), Valoch (1988)	*Birds* *Vertebrates*: maximum of *Lagurus lagurus*, presence of *Dicrostonyx torquatus*, *Mammuthus primigenius*, *Rangifer tarandus*, *Coeleodonta antiquitatis*, *Equus sp.*, *Ursus spelaeus*	
Kabazi	Stratum 10A (colluvial, but very low sedimentation)	II, IIA/4B *Industry*: Crimean Micoquian (low density of artefacts, no vertical or horizontal concentration, but *in situ*)	Chabai (2005), Patou-Mathis (2006), Chabai and Uthmeier (2006), Gerasimenko (2007)	*Vertrebrate*: *Equus hydruntinus* (hunting of family groups)	*General features*: NAP > AP; boreal forest-steppe type vegetation; forests dominated by pine trees, with alder in patches wetted by ground water *AP*: sharp drop of broad leaved trees leading to total disappearance, increase of *Pinus* *NAP*: increase of xerophytes; no pedogenetic processes

[a]Geochronology after Weissmüller (1995: 234)

absence of archaeological material in Sesselfelsgrotte and Kůlna seems more a matter of chance or lack of preserved sediments rather than resulting from a demographic decline of Central European Neanderthals. This notion is supported by the presence of Neanderthals in northern latitudes as high as Garzweiler and Lynford Quarry.

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Chapter 5
Neanderthal Occupation in the Verdon Valley (Haute-Provence, Southeastern France)

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Abstract Many cavities in the Verdon Valley (Southeastern France) have been used as shelters by prehistoric people, for at least 400 ka. The Neanderthals occupied some of these cavities, especially in the middle and lower gorges of the river, and sometimes also left a few artifacts at open air spots. Three caves or shelters yielded significant lithic assemblages which allow tracing the evolutionary trends of the technical behaviors: the Baume Bonne cave, the Abri (rock shelter) Breuil and the Sainte Maxime cave. The faunal remains, often badly preserved, mostly comprise Ibex, Horse and Bovids. It is to be noted that *Ursus spelaeus* occupied some of the caves in alternation with Neanderthals.

The late Middle Paleolithic, considered as the lithic industrial complex of the typical Neanderthals, actually results, in this region, from a gradual evolution of the technology, as shown in the long sequence of the Baume Bonne cave. The Levallois core reduction method punctually appears right from the MIS 8, but starts developing progressively in the second half of the MIS 6, in association with the selection of better quality, exotic raw materials. It becomes a common practice, in the Verdon Valley, from the end of the MIS 5, yet in shares with other methods like discoid or opportunistic/direct knapping; this variety of methods may be partly related to the raw materials (good quality flint and quartzite, local as well as exotic, are preferred for the Levallois method). In this technological context, some elongated flakes and blades are produced through uni-bipolar Levallois or semi-turning methods. All the lithic assemblages are rich in scrapers, and this feature was already characteristic of the earlier lower Middle Paleolithic phases.

Despite the gaps in the settlement records (absence of people and/or erosion), the lithic technology of the Neanderthals appears to be in continuity with that of their predecessors. If the Verdon Valley has undergone cold climatic phases due to the proximity of the Alps, its relative closeness to the Mediterranean shore (80 km) and easy accessibility from the Rhône corridor through the Durance valley might have maintained certain continuity in human occupations and technical traditions.

Keywords Middle Paleolithic • Mousterian • Cave site • Discoid • Levallois • Gradual technical evolution

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Introduction

The first human occupation in Haute-Provence (Southeastern France) and in the Verdon Valley probably started in an early phase of the Lower Paleolithic. This is indicated by some lithic industries discovered on the surface of the Plio-Pleistocene Valensole plateau (Fig. 5.1), especially in the South at "Plaine de Laure", where the highly patinated quartzite core tools may date back to the Lower Pleistocene (Dubar 1974, 1979). But these industries always occur without stratigraphic context and therefore they remain undated. Only in the Baume Bonne cave at Quinson, the stratigraphic sequence allowed establishing the chronology: the earliest occupation level corresponds to the MIS 10, with an industry related to the early Middle Paleolithic.

During the evolved phase of the Middle Paleolithic ("classical" Middle Paleolithic or Mousterian), with the development of the Neanderthal populations in Europe, the occupation in the Verdon Valley increased. Several cave sites were intensively occupied: La Baume Bonne cave and Sainte-Maxime cave at Quinson, Abri Breuil at Montmeyan, Sauzade cave at Esparron-de-Verdon, Grotte Murée at Montagnac-Montpezat, for the main ones. In many other cavities and shelters, only a few stray artifacts, related to the Middle Paleolithic, could be found. No open air sites have

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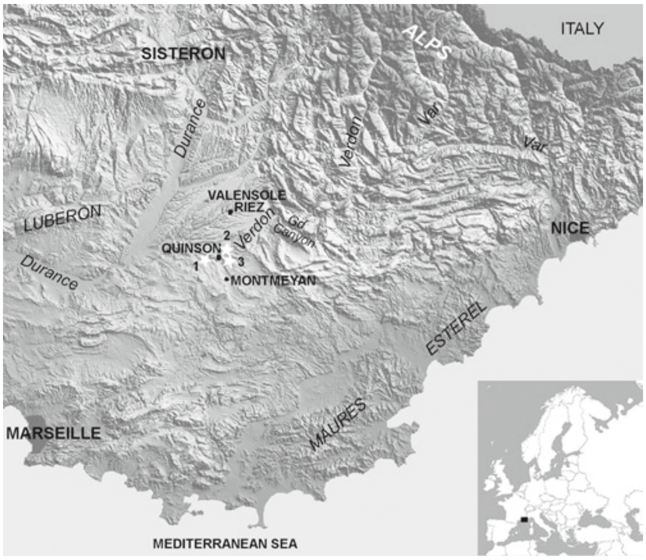

Fig. 5.1 Map of Provence (Southeastern France) showing the location of the sites. *1*: Sainte-Maxime; *2*: La Baume Bonne; *3*: Abri Breuil

been excavated so far, although on all the plateaus (of limestone or conglomerate) and river terraces, Middle Paleolithic artifacts systematically occur, either isolated or in scatters, of various importance.

The Baume Bonne cave, Abri Breuil and Sainte Maxime cave are the only three excavated sites where the lithic industry amounts a sufficient quantity to provide significant results regarding the typo-technology. Moreover, this material is included in stratigraphic sequences, but only the sequence of La Baume Bonne has been dated (Falguères et al. 1993), and this is a limitation for the chronological significance of the present article. Starting during the MIS 10, the Baume Bonne sequence then continues up to the historical times, with human occupations throughout, while in the other two sites, the deposits are much less developed and the occupations were probably for shorter periods or occasional (or maybe scoured out).

The paleo-environmental contexts are also badly understood due to the poor preservation of the macro-fauna and the lack of micro-faunal and palynological studies (except at La Baume Bonne, where the results are not statistically significant). The few identifiable remains mainly include Ibex on the one hand, Horse and Ox/Bison on the other hand, and suggest that these animals, respectively familiar to the cliffs (Verdon lower and middle gorges) and to the plains (Quinson-Montmeyan depression) of the surrounding landscape, also were the favorite game of the Neanderthal groups (and their ancestors as well).

Consequently, in the Haute-Provence and the Verdon Valley, the Middle Paleolithic, and especially its later phase considered in this paper, can be approached only through the lithic industries. Despite the absence of human remains, indicating who the author of these industries of the later phase was, it can be assumed that the Neanderthal populations were responsible for them, since they belong to the beginning of the Upper Pleistocene (for sure at La Baume Bonne, very probably in the other two sites).

Geographical Settings

The Verdon River flows across several geological units: the crystalline rocks of the Alps, where it originates, the limestone formations of the Pre-Alps, where it cuts the very scenic “Grand Canyon” and, downstream, the calcareous plateaus of Provence, before merging into the Durance River (Fig. 5.1). Only the lower Verdon Valley (from the “Grand Canyon” downward) is considered in this work; the upper Valley was never systematically explored and no site has been excavated there.

The average altitude of the study area reaches ca. 400 m; the Mediterranean Sea lies about 100 km away from the sites (Fig. 5.1) and the climate is mostly of Mediterranean type, with marked alpine influences, especially in winter. During the glacial periods, the Verdon and Durance glaciers were coming down to nearly 50 km from this sector and the plateaus were covered with steppe. During the temperate phases, the deciduous forest develops (shrub and oak forest). The Verdon River always flows throughout the year and the raw materials in it remain available.

Raw Materials

The maximal distance between the three sites presented here is hardly more than 5 km and therefore the Neanderthal inhabitants were benefiting of the same available raw materials. The lithic assemblages are mostly struck from siliceous rocks of local origin (dominantly flint, then chert and rarely quartzite, quartz, sandstone, rhyolite). Two detritic formations provide the major part of them, in the form of river cobbles in both cases (Fig. 5.2). One is the Valensole Formation, providing siliceous rocks in different proportions according to the location and stratum; the second is the Verdon alluvium, where the siliceous rocks are rather abundant, especially flint of good to medium quality, in the form of rather small cobbles (rarely more than 10 cm), and chert, less siliceous than flint, but in the form of bigger cobbles (up to 20–30 cm).

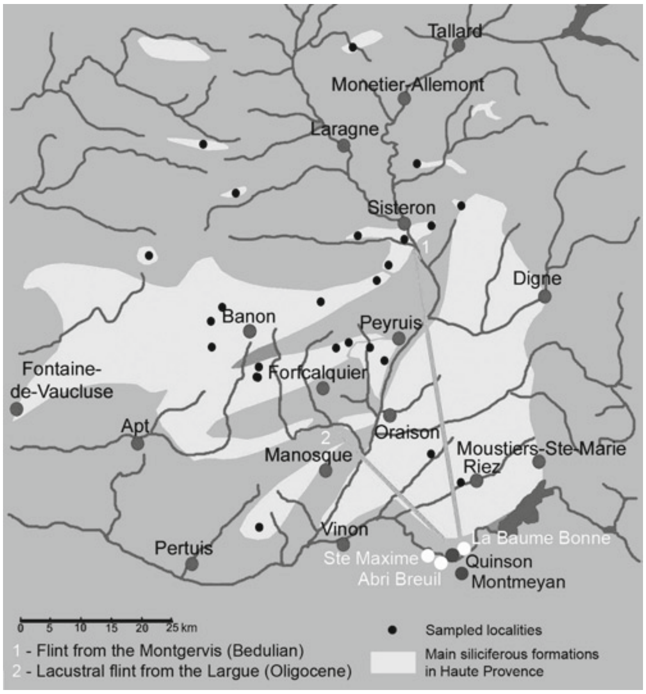

Fig. 5.2 Map of the Haute-Provence region showing the siliceous raw material sources

Some exogenous rocks could be identified: Bedoulian flint from Montgervis, at Sisteron, more than 50 km away, and Oligocene lacustrine zoned flint from the Largue River, 40 km away (Fig. 5.2). Other rock sources are not yet identified. Some chalcedony and jasper flints as well as chalcedoneous breccia may originate from more than 50 km westward; the rhyolite may come from the local Valensole Formation (secondary position) or from the Maures and Esterel Massifs, 100 km to the South-East. The origin of a fine grained, light grey flint (favored for the Levallois production in the late Middle Paleolithic at La Baume Bonne) is still unknown, as well as the source of a very good quality, homogenous black flint, knapped in the Sainte Maxime cave.

In the present state of knowledge, it seems that the large majority of rocks are local. The few exogenous rocks, whose origin is confirmed, indicate that prehistoric populations used to move within a 50–60 km radius territory, stretching from the Verdon in the South, the Sisteron gap in the north, the right bank of Durance River and eastern Lubéron hills in the west, the Alps mountain range in the East.

Chronostratigraphic Context

Modern methods were applied in the Baume Bonne cave, in order to understand better the stratigraphy and to place it in a chronological scale. The Middle Paleolithic stretches from the MIS 10 to the MIS 4 or 3, i.e. about 300 ka (Fig. 5.3); it therefore offers exceptional conditions for understanding the modalities of the technological evolution in this sector of Southwestern France. Human occupations at La Baume Bonne are mainly observed during the cold periods (MIS 10, 8, 6 and 4), while the temperate periods did no record much anthropogenic activities (MIS 5). Actually the interglacial phases did not allow any deposition of sediment and they are conspicuously marked by geo-chemical processes, especially phosphatation-decalcification (MIS 9 and 7) as well as stalagmitic formations (MIS 5).

In the present state of knowledge, it is difficult to place the Breuil shelter and Sainte Maxime cave in such a chronological frame. Henry de Lumley-Woodyear, who excavated and studied these sites (de Lumley-Woodyear 1969) proposed chronoclimatic interpretations and related their deposits to the Würm II and, for the top of the Breuil shelter to the inter-Würm II-III. Lithic assemblages do not contradict these attributions, even though they should not be a reference as far as chronology is concerned. Anyway, these sites deserve more accurate dating, along with updated studies, and a research project will be proposed in this respect by the Musée de Préhistoire des Gorges du Verdon, at Quinson.

The Middle Paleolithic and Late Middle Paleolithic Industries from La Baume Bonne (Quinson)

The Baume Bonne cave opens 40 m above the river level, in the lower part of the Verdon middle gorges, about 300 m from the transverse plain of Quinson-Montmeyan. It has been excavated in three series of field seasons: 1946–1956 under the direction of Bernard Bottet, 1957–1967 under the direction of Henry de Lumley-Woodyear, and 1989–1997 under the direction of Jean Gagnepain and Claire Gaillard. This latter work led to reconstructing the chronostratigraphic frame, in correlation with the techno-cultural sequence (Fig. 5.3).

The Paleolithic assemblages from the Baume Bonne cave (ca. 40,000 items) are characterized by a very gradual evolution: innovations discretely appear and progressively replace the technological ground of the earlier occupation levels. All along the sequence, the lithic production was mostly processed in the site and the totality of the debitage (all phases of blank production) seems to be represented, from the smaller flakes to the largest ones, along with a large number of cores. Nevertheless, very few refittings could be worked out.

Local flint amounts to 70–80% of the total assemblage and chert to 15–25%. Exogenous rocks (ca. 50 km), of very good quality, become conspicuous in the upper levels, from the middle of the MIS 6 onwards, together with core reduction methods allowing a better control on the flake production. Within this technological continuity, four evolutionary phases are distinguished for the Middle Paleolithic. The first three ones can be considered as early Middle Paleolithic and were probably the work of pre-Neanderthal populations (*Homo heidelbergensis*). Due to the very few hand axes (0.1% of the artifacts > 2 cm), manufactured mainly during the MIS 8, they may be qualified as Acheulian, but the technical continuity in the flake production also speaks for a single and uniform denomination as early Middle Paleolithic. The fourth phase is a late ("classical") Middle Paleolithic (Gagnepain and Gaillard 2005), occurring after the stalagmitic formation dated to the MIS 5e (Falguères et al. 1993) and therefore belonging to the end of the MIS 5 and/or to the MIS 4. This phase is mostly represented by an important series of material collected during the first excavations, between 1946 and 1957 (Bottet and Bottet 1947; Bottet 1956); this series comprises a very high proportion of shaped tools for many unretouched artifacts (earlier known as "waste") were left behind in the shoveled earth. It appears particularly rich in well finished scrapers and points, Levallois cores and flakes. This obviously corresponds to a Mousterian industry processed, for a large part of it, by the Levallois core reduction method; but technical details remain undetermined, given the lack of unretouched debitage products. The latest excavations (1989–1997) have exposed this industry on a small surface (1.5 m²) at the base of the layer M (Fig. 5.3; Gagnepain and Gaillard 1996, 2005). The few items then collected confirm the quality of the selected raw materials and the mastering of the flaking, often through the Levallois method (recurrent-centripetal pattern or unidirectional). In the case of the only one core found in that 1.5 m square, this Levallois method was applied on both the faces, one after the other (Fig. 5.4(4)). Other methods, comparable to those used in the lower levels (especially discoidal) remain common, and the use of the *Kombewa* method increases (Fig. 5.4(2)). The pointed tools are significantly more frequent than earlier (Fig. 5.4(3)).

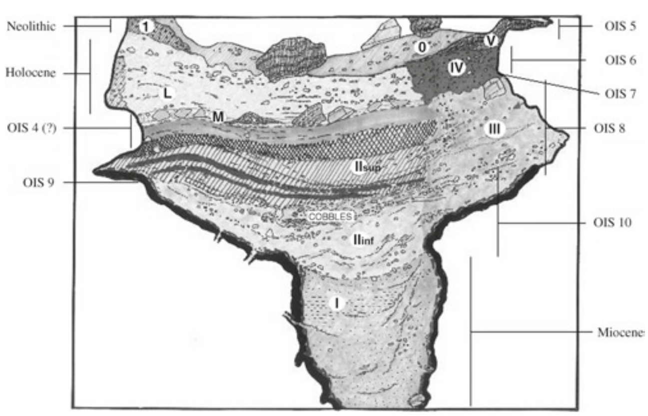

Fig. 5.3 Composite stratigraphy of La Baume Bonne cave and correspondence with the OIS scale. The unit I was deposited by the Verdon River. Then sedimentation in the cave mainly occurred during the cold stages, whereas the warm stages correspond to weathering. Chemical processes have severely decalcified and phosphatized the unit II, while the unit III, more or less synchronous with unit II, has been hardened by calcium carbonate. After the deposition of unit IV, the filling of the cave was partly eroded and later deposits may lie at the same altimetric level as earlier ones

It is interesting to note that in the underlying levels, corresponding to the second half of the MIS 6, the industry was already announcing the characters of the "classical" Middle Paleolithic, by the increasing use of exogenous good quality flints and by the development of more efficient methods than just the discoidal one (still mainly used): unidirectional-convergent (with self maintenance of the lateral convexities; Fig. 5.5(1)), *Kombewa*, Levallois (mostly unidirectional) and semi-rotating methods. These methods allow a better control of the convexities of the flaking surfaces and therefore of the products morphology. Often they were oriented towards the production elongated flakes and blades (Fig. 5.5(2)–(5)). However, the shaped tools are less standardized than in the following technological stage.

The Late Middle Paleolithic Industry from Abri Breuil

Abri Breuil is a rock shelter close to the Verdon River but opening on the Quinson-Montmeyan plain and not directly on the water course, in the gorges, like the other two caves. This rock shelter has been excavated under the direction of Henry de Lumley-Woodyear in 1961 and 1962. The stratigraphic sequence, totalizing about 1.5 m thickness is rather homogenous, but four units were distinguished and considered as belonging to the Würm II for the lower three ones and to the inter-Würm II-III for the upper one (de Lumley-Woodyear 1969).

The lithic industry (about 1,600 artifacts) is almost entirely made from local rocks: flint (60%) and chert (35%, significantly more frequent than in the other two sites); the exogenous rocks represent less than 5% (while in the late Middle Paleolithic of La Baume Bonne they exceed 10%). The three groups of artifacts, distinguished according to their stratigraphic position, show little technical differences: the use of the Levallois method increases slightly, but it however remains secondary in comparison with the discoidal (unifacial or bifacial) or orthogonal flaking (polyhedral cores). In general, the cores are very small in size, possibly due to exhaustion, but also due to the intentional production, at least for the flint, of very small flakes (less than 1 cm), especially in the upper layers. Apart from these numerous small flakes, the other ones are usually thick and often backed, by expanding on the face of the core adjacent to

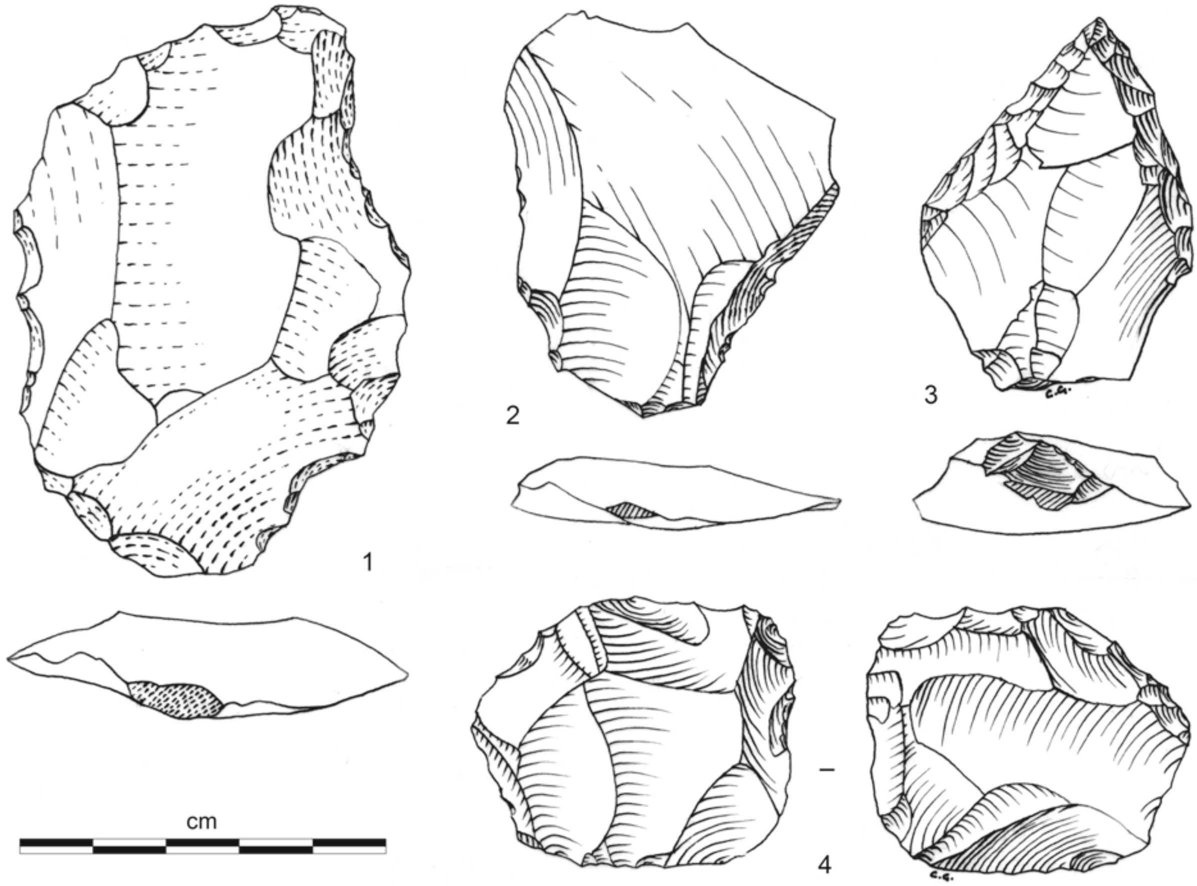

Fig. 5.4 Late Middle Paleolithic industry (Mousterian) from the layer M, at La Baume Bonne (Quinson). *1*: Levallois flake in quartzite; *2*: Kombewa flake; *3*: retouched point; *4*: Levallois core successively exploited on both faces

the striking platform (*éclats débordants*). A few of them are retouched (Fig. 5.6), mostly into sidescrapers and, in the upper layers, into denticulates.

The Late Middle Paleolithic Industry from Sainte Maxime (Quinson)

The Sainte Maxime cave, in the lower gorges of the Verdon River, opens about 50 m above the water level. It was excavated by Henry de Lumley-Woodyear, between 1957 and 1962 (de Lumley-Woodyear 1969). Nearly 500 artifacts have been collected, along with a fauna mainly composed of Ibex and Horse. The rocks used for making the industry are mostly flints of good quality, the chert being very rare. One variety of flint is outstanding for its excellent quality and homogeneity, its black color and its production of blades and long flakes. This rock represents about 10% of the artifacts that may come from the same one or two blocks. The origin of this black flint is still unknown; the only certainty about it is that it does not come from a river alluvium, since its white cortex is unrolled.

The core reduction methods are diversified: discoidal, orthogonal flaking surfaces, Levallois, unidirectional-convergent: the debitage products are equally diversified but the Levallois flakes are in a higher proportion than in the other two sites, as well as the blades (15%). The rare shaped tools comprise mostly scrapers and denticulates. Three series of artifacts could be refitted at Sainte Maxime. One represents the first reduction stages of a flint cobble, following the method of alternating or orthogonal flaking surfaces. The other two ones concern the conspicuous good quality black flint; they probably belong to the same block and would represent, on the one hand, the beginning of the block exploitation and, on the other hand, the end of it. However, it was not possible to match these two refitting series together, for the intermediate products (at least some of them) are absent from the collection. The latter series, as corresponding to the last phase of exploitation, includes the final core and is very interesting for it shows the details of the unidirectional-convergent method, whose advantage is the production of elongated flakes and sometimes blades (Fig. 5.7). The core is very similar to that from La Baume Bonne, at the end of the MIS 6 (Fig. 5.5(1)). The exploitation process is based on a triangular flaking surface, with only one striking platform;

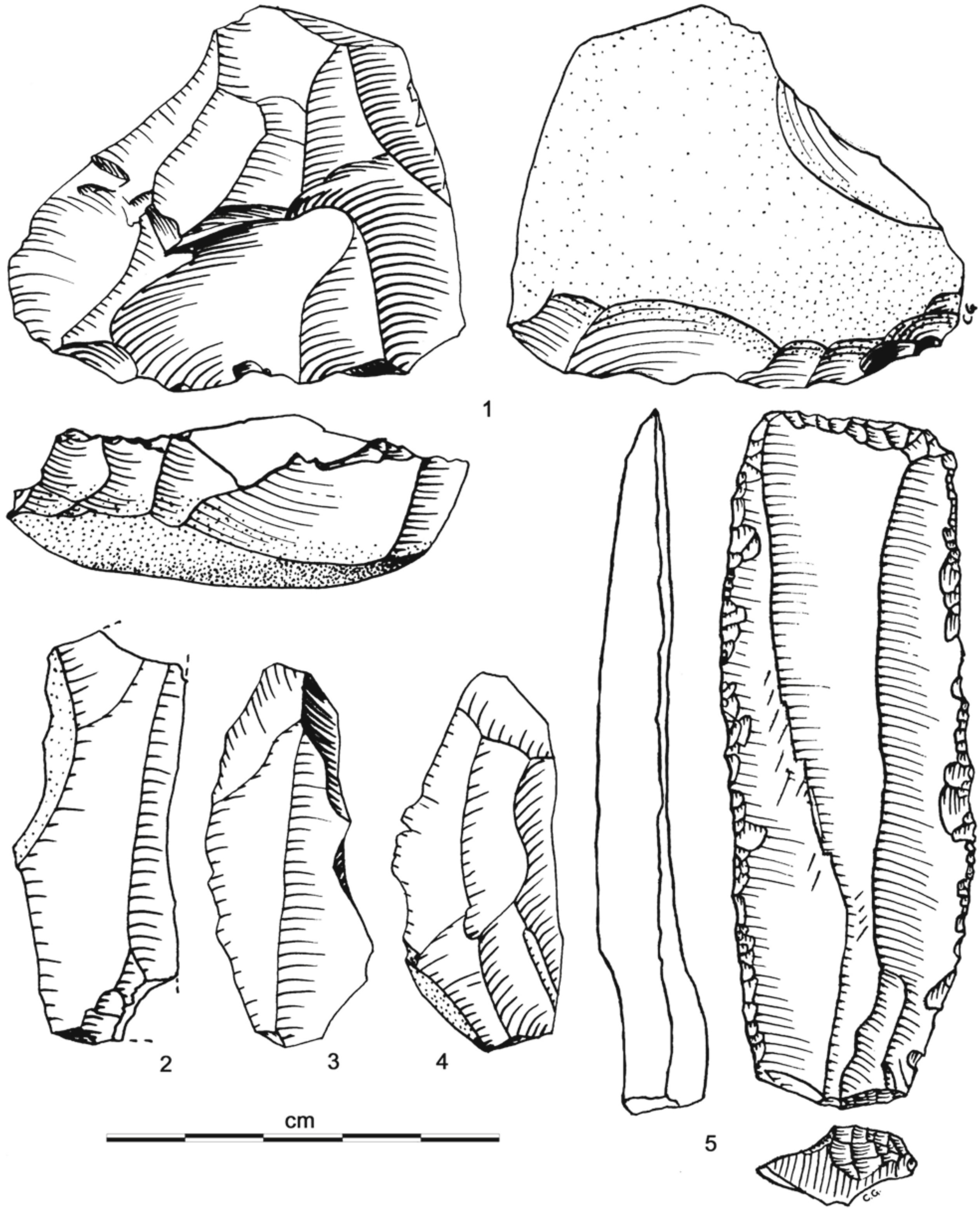

Fig. 5.5 Industry from the unit IV-sup (end of MIS 6) at La Baume Bonne (Quinson). *1*: unidirectional-convergent core; *2–4*: elongated flakes with a partial back (in cortex for *2* and *4*); *5*: retouched blade in flint from Montgervis (exogenous)

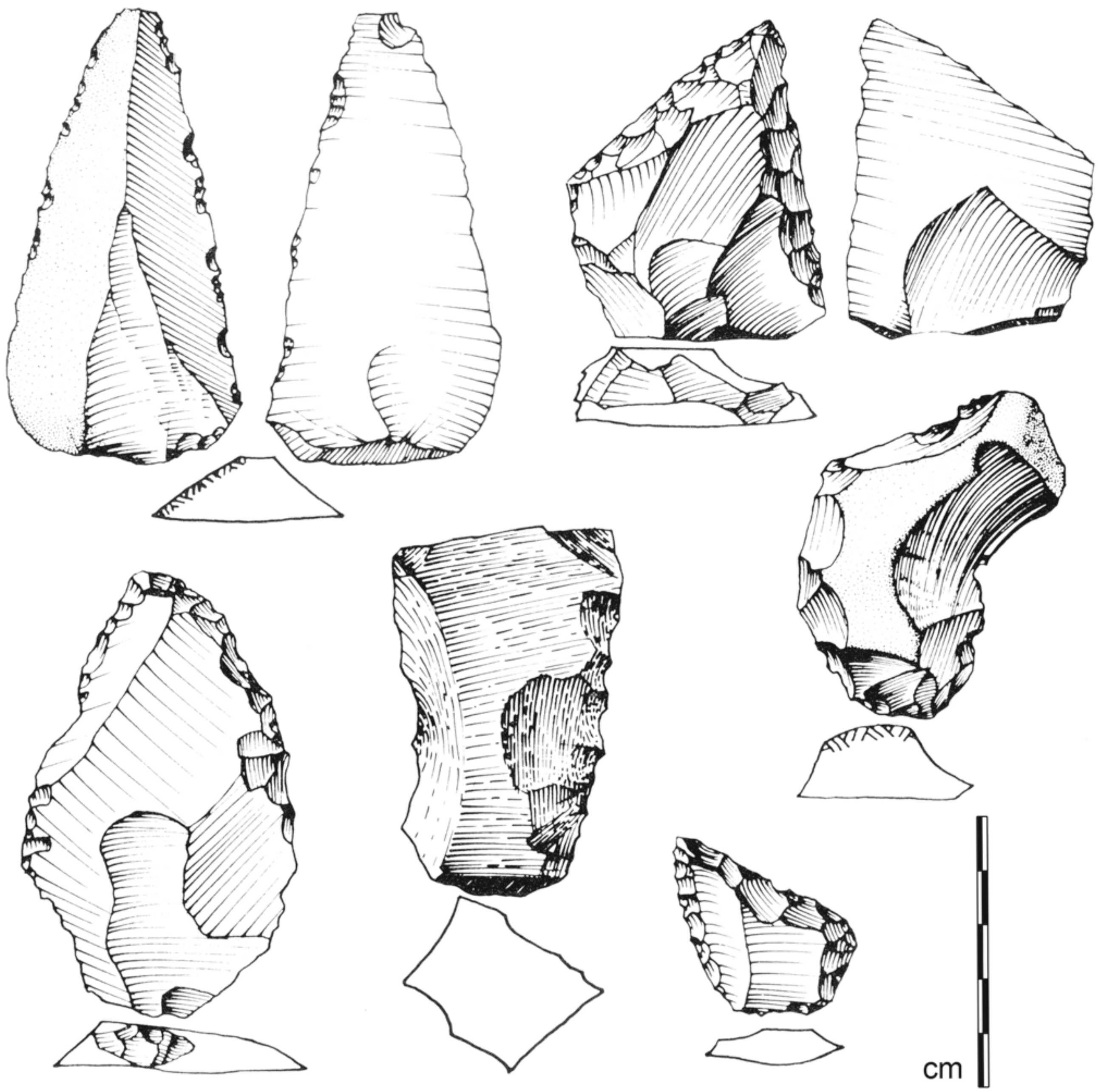

Fig. 5.6 Industry from Abri Breuil (Montmeyan; After de Lumley-Woodyear 1969)

the marginal blades or long flakes, with a cortical back (expanding/*débordants* products), contribute to maintaining the lateral and distal convexities and allow this way a recurrent production (Gagnepain et al. 2004).

Conclusion

The three sites presented here, along with the numerous smaller cave and open-air sites, allow grasping some features of the Neanderthals life way in this sector of the lower Verdon Valley, in Haute-Provence. For making their stone implements, they were using different methods, in order to get a large variety of products, in the continuity of the technical practices of their ancestors, but with addition of some improvements for a better control of the shapes. It seems they oriented their production differently in each site: more Levallois products in La Baume Bonne, more blades or long flakes in Sainte Maxime, thicker flakes and many very small flakes in Abri Breuil. These differences may be related to particular activities, difficult to ascertain, and probable chronological heterogeneity has to be kept in mind.

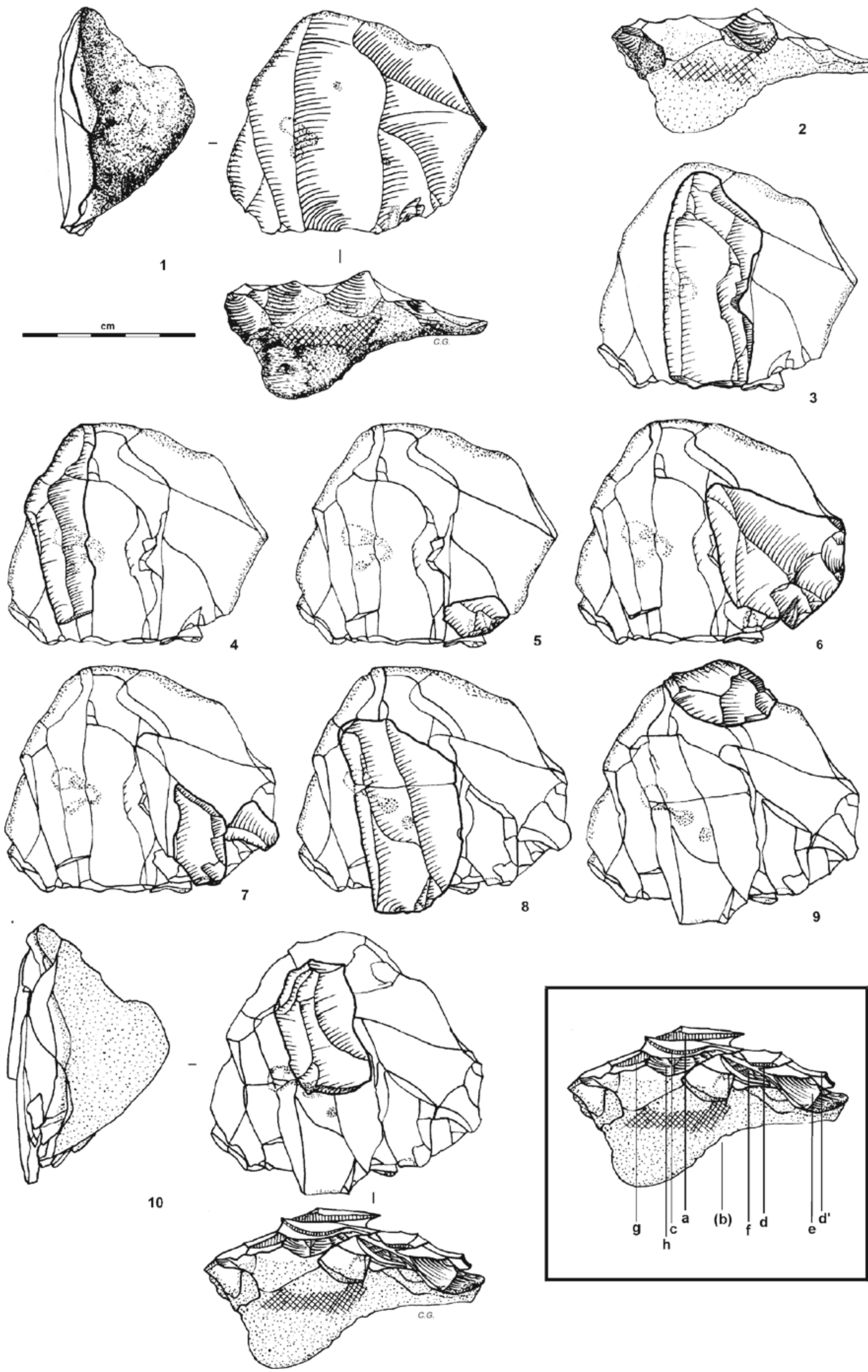

Fig. 5.7 Refitting from Sainte Maxime: unidirectional-convergent core and its 11 last flake and blade products

The Neanderthals of these sites were mostly depending on local resources for both their food and raw materials; nevertheless they sometimes brought good flint from far away. The only moving direction that could be clearly traced so far, on the basis of the lithology, corresponds to the North-North-West and follows the Durance River basin, where they could cover more than 50 km carrying some blocks or at least stone implements. The study of the raw materials provides indications of possible movements towards West (jasper) and South-East (rhyolite) but they remain very minor, whereas Neanderthal occupations are well known in these directions, as for instance in the Lubéron and Vaucluse in the West (La Combette at Bonnieux, Bérigoule at Murs, Baume des Peyrards at Buoux, Bau de l'Aubesier at Monieux, etc.) or in the Ligurie in the South-East (Balzi Rossi at Grimaldi, Fate at Finale Ligure, Madona dell'Arma at San Remo, etc.). If this observation remains valid after complete identification of the raw materials, and keeping aside the question of chronology, it would confirm the independence of the Neanderthal groups from one another and their relative isolation within their respective territories.

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Chapter 6
Dating Small Heated Flint Artifacts: A New Thermoluminescence Technique

Daniel Richter

Abstract Thermoluminescence (TL) dating of heated flint is frequently used to establish the age of Paleolithic sites. It is a dosimetric dating method, which employs the accumulation of radiation damage in crystal lattices through time. A flint artifact can be dated by TL methods if it has been heated in a prehistoric fire to about 400°C. The TL-age estimate refers to the last heating and therefore provides a direct date for a prehistoric event. Sample sizes for standard procedures require pieces of at least 10–15 g. A new TL-dating technique has been developed which uses only a few mg of material, thus reducing the minimum sample size significantly, and now allows the chronometric dating of sites which do not provide sample material for standard dating approaches.

Keywords SAR TL • Paleodose • Verification in laboratory simulation/archeological samples

Introduction

Chronometric dating of Paleolithic sites, especially beyond the range of radiocarbon (^{14}C) dating, relies to a large extend on dosimetric dating methods, like Electron Spin Resonance (ESR or EPR), Thermoluminescence (TL) and Optically Stimulated Luminescence (OSL) dating. Broad agreement is usually obtained especially between ESR and TL (e.g. Roberts 1997), but also significantly different chronologies were determined for certain sites (e.g. Tabun: Grün and Stringer 2000; but see also Mercier and Valladas 2003). Results from ESR dating of teeth often are considered to be less useful, compared to TL dating of heated flint artifacts, because the latter usually is less dependent on poorly controlled environmental parameters shared by both methods (i.e. external γ-dose from the surrounding sediment of the sample). However, the methods should be considered as complementary because different sample types are used for dating and in many sites only either of the sample types is available. Both methods require samples of certain sizes, which cannot be provided from all sites. Especially the size/weight requirements of 10–15 g for standard TL dating are frequently not met, and the respective site(s) cannot be dated by TL, or not at all, if no other material for another dating technique is available either (e.g. Richter et al. 2000a).

Thermoluminescence (TL) Dating

Thermoluminescence dating of a heated flint (or chert, hornstone, quartzite, etc.; the term flint is used here as a general descriptor of material composed of SiO_2 with a low crystallinity index) determines the time elapsed since the last incidence of firing, which is usually associated with prehistoric activities. Naturally occurring fires are unlikely to be responsible for the heating of material in the vast majority of Paleolithic sites (see also Alperson-Afil et al. 2007). In any case, the penetration depth of fire in sediment is very low (Bellomo 1993) and burning roots do not produce high temperatures. It is thus unlikely that artifacts were heated by natural fires to the extend required for successful TL-dating application in most cases.

Principle of Thermoluminescence Dating

Dosimetric dating methods are based on structural damages/faults in the crystal lattice of minerals and an omnipresent ionizing radiation from radioactive elements from the surrounding sediment and the sample itself, as well as secondary

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cosmic rays. This causes a radiation dose (paleodose or P) to accumulate in the crystal in the form of electrons in excited states. For dating application only those electrons in meta-stable states are targeted, which are resident over periods of time several magnitudes longer then the anticipated age. Descriptions of the principles of luminescence dating methods can be found elsewhere (Aitken 1985, 1998; Wagner 1998; Bøtter-Jensen et al. 2003).

The paleodose (P) is proportional to the dose rate ($\dot{D}$; the ionizing radiation per time unit), which provides the clock for the dating application. Exposure to light or temperature causes the electrons to relax to a ground state, sometimes by emitting a photon, the luminescence. If the temperature is high enough (> ~400°C) the drainage is sufficient to relax all electrons relevant to the luminescence method used, i.e. the clock is set to zero by this event. The completeness of the resetting of the TL-signal used for dating is checked for with the 'heating plateau' test in the case of heated flints. A flat ratio (Fig. 6.1: dotted line) of the TL-signal from unirradiated (Natural) versus TL emitted by additionally irradiated material (Natural + dose) indicates the sufficiency of the prehistoric heating event (Fig. 6.1). The intensity of the luminescence signal (number of photons) increases with the total absorbed dose (P) in a crystal and is therefore a function of exposure time to radiation.

An age can be calculated with the following simplified formula,

$$\text{age} = \frac{\text{paleodose}}{\text{dose rate}} = \frac{P_{(Gy)}}{\dot{D}_{(Gy \cdot a^{-1})}},$$

where the paleodose (P) is expressed in Gy and the dose rate $\dot{D}$ in Gy per time unit (usually in a or ka).

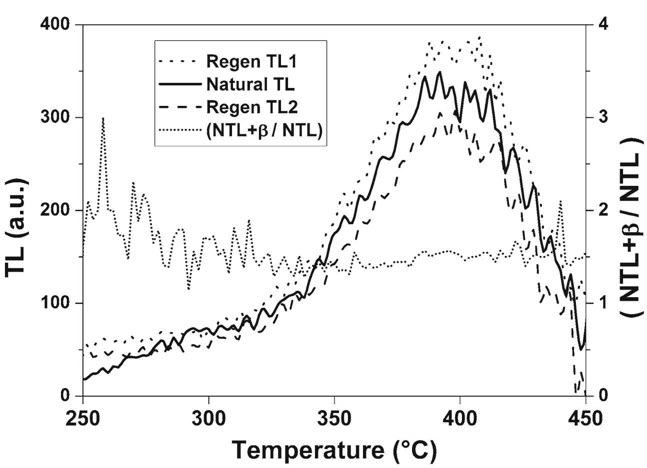

Fig. 6.1 TL glow curves and heating plateau for sample AUB-168. In principle, only one aliquot is needed for the three TL-measurements (natural signal and two regeneration points – Regen TL 1 and 2). The regeneration signals have to bracket the natural signal very closely. The ratio of NTL+b with NTL provides the heating plateau, evidencing the sufficiency of the prehistoric heating by its flat ratio over the peak temperature

The Dose Rate ($\dot{D}$)

The denominator $\dot{D}$ of the age formula consists of two parameters, the internal ($\dot{D}_{internal}$) and the external dose rate ($\dot{D}_{external}$).

$$\text{age} = \frac{P_{(Gy)}}{\dot{D}_{(Gy \cdot a^{-1})}} = \frac{P}{\dot{D}_{internal} + \dot{D}_{external}}$$

Any variability of one of the parameters of $\dot{D}$ through time makes it difficult to estimate the age of a heated flint (e.g. Richter 2007). All parts which are considered to be potentially geochemical instable, like cortex or patinated areas, are removed from the flint samples for TL-dating. The internal dose-rate ($\dot{D}_{internal}$) is thus considered as being constant over the time-span of interest. This is an advantage of heated flint TL-dating over most other dosimetric dating methods, and reduces the standard deviation given for any age estimate. Most uncertainties in TL-dating of heated flint derive from the error estimates associated with the ionizing radiation from the surrounding sediment ($\dot{D}_{external}$). In order to simplify the estimation of $\dot{D}_{external}$, and thus reduce the uncertainties, each sample is carefully stripped of its outer 2 mm surface area (the range of β-radiation from the surrounding sediment) with a water cooled diamond saw prior to analysis. This leads to a minimum thickness of samples of ~6 mm, and the loss of a lot of material because of the irregular shapes of most samples. The β-dose rates from the surrounding sediment can be modeled (e.g. Tribolo et al. 2006), but at the costs of an increased uncertainty, which has to be estimated. However, this might lead to such a loss in precision that no meaningful answer to the archaeological question can be provided anymore.

The Paleo- or Absorbed-Dose

The absorbed dose is commonly denominated paleodose (P) in TL dating. This paleodose (P) is determined from the TL signal, which is measured by heating sample aliquots at a constant rate, producing the glow curves (Fig. 6.1). The standard approaches for the determination of P use two series of aliquots with several mg of grains from the crushed 'stripped core' of the sample (Multiple-Aliquot-Additive-Regeneration = MAAR). The sensitivity of the sample to ionizing radiation is determined by the luminescence yield after irradiation with increasing doses from calibrated radioactive sources. Some aliquots receive additive doses, while others get heated in the laboratory and then irradiated. Various regression/fitting analyses are used to determine P (see e.g. Richter 2007, for an overview). These approaches require about 500 mg of a certain grain size fraction from the crushed sample material, thus the application is limited to large samples with ‘core’ weights of about one gram after stripping.

Procedures

While the paleodose can be measured even for museum specimens (unless the rock material is translucent) in the laboratory, access to the site under investigation is always needed for the measurement of the external dose-rate ($\dot{D}_{external}$), which is one of the parameters of the numerator ($\dot{D}$) of the age formula. Measurements have to be done in sections to be excavated in the future, or sections containing the same sediment as the one the dating samples are originating from (see Richter 2007 for a more detailed discussion). The measurements can be achieved directly with a portable gamma-spectrometer within an hour or so, or by implanting small dosimeters into the profiles for several weeks up to 1 year. Only in very special circumstances sediment samples from old excavations are sufficient for the determination of $\dot{D}_{external}$.

A New Technique for TL-Dating of Small Heated Flint Artifacts

The need to provide age estimates for sites where only small heated flint artifacts are available led to the development of a new technique of TL-dating of such material. This technique employs a regeneration protocol (SAR) for the determination of the paleodose (Murray and Wintle 2000). This can be achieved with very few aliquots, thus reducing the requirements for sample sizes drastically (Richter and Krbetschek 2006; Richter and Temming 2006).

The luminescence is detected in a more favorable wavelength band (orange-red) instead of the traditionally used UV-blue (Haustein and Krbetschek 2002). The orange-red TL-emission does not suffer from severe sensitivity changes due to the heating during measurement, and thus allows the application of a single-aliquot-regeneration (SAR) protocol with the measurements of the natural TL, and the luminescence from two artificial doses (regeneration points) for each aliquot (Richter and Krbetschek 2006). If these two regeneration points are set very closely and produce TL-signals just below and above the natural TL-signal, then a straight line (Fig. 6.2, grey line) is a sufficient representation of the growth curve of the TL-signal with dose (Fig. 6.2, dashed line), even at doses where the curve exhibits a strong curvature (saturation). The paleodose is determined by interpolating the natural TL-signal (Fig. 6.2, arrow left to right) on the straight line between the luminescence signals of the two dose points on to the dose axis (Fig. 6.2, downwards arrow).

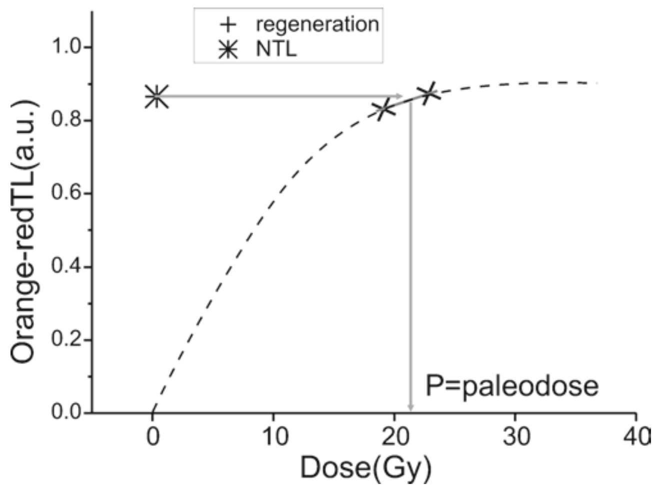

Fig. 6.2 The paleodose is determined by interpolating the natural TL-signal (*star with left to right arrow*) on a straight (*grey*) line between the luminescence signals of the two dose points (*crosses*) on to the dose axis (*arrow downwards*). Provided that these two points are set very close to each other, a straight (*grey*) line is a sufficiently accurate representation of the dose curve (*dashed line*), even for regions of strong curvature

The basic assumption of no significant sensitivity change between the measurements after the natural TL is checked by the TL output from the repetition of one of the artificial irradiations. In principle, it is possible to determine a paleodose (P) with just a single aliquot of 4–10 mg of sample material from the ‘stripped core’ with an additional aliquot to determine the heating plateau. However, in practice these aliquots serve as the starting point to determine the regeneration doses to be applied and subsequently several additional aliquots are measured in order to obtain a statistically more valid result from core sizes of 100–200 mg before stripping and crushing. In practice a few percent of aliquots fail to encompass the natural TL-signal, but with the increasing knowledge of the paleodose with increasing number of aliquots the number of failures can be minimized by measuring only few aliquots at once.

Verification of the Approach by Laboratory Simulation

The new technique was verified by simulating the prehistoric heating and the irradiation during burial in the laboratory. Geological samples from non archaeological contexts were used in order to avoid having to make assumptions about their temperature and radiation history. The samples were heated (simulating the zeroing in a prehistoric fire) in the laboratory (500°C for 30 min) and irradiated with calibrated radioactive β-sources with doses comparable to archaeological paleodoses (Richter and Temming 2006). Such dose recovery tests are commonly employed to evaluate the techniques used to determine the absorbed dose.

The luminescence properties, including TL-spectra (Richter et al. 1999), are known for the three German samples used in these experiments. Materials from rather different geological settings and genesis were selected: a flint sample from the Baltic Sea (NORD-1), a nodular hornstone from the Swabian Alb (JU-2), and a piece of tabular hornstone from the Franconian Alb (PLA-1). Various techniques were used in order to verify accuracy and precision of the luminescence techniques used, including standard protocols and the new technique (Richter and Krbetschek 2006; Richter and Temming 2006). Figure 6.3 shows that the applied artificial doses were recovered successfully with the new technique for all three samples. For most of them the obtained doses agree to a statistically satisfying degree (within their 1-σ error envelope) with the applied dose (Fig. 6.3).

However, the dose rates used in the simulation, and thus the time length of the artificial irradiations is shorter by several orders of magnitude then the natural one. This could lead to long term differences which cannot be tested for because of the time involved. It is essential to test any new dating method or technique on samples of known age. Such a requirement is notoriously difficult to meet, because truly independent age estimates are available for very few sites only. Therefore, the comparison here has to be limited so far to the results obtained by standard TL-techniques which had been verified to provide good age estimates for another sites. However, it is possible to check the new technique by using identical archaeological samples and compare it directly with the results obtained by established standard techniques.

Verification of the New Technique with Archaeological Samples

A set of flint samples from various archaeological contexts which had already been measured using standard TL (UV-blue) methods (Lebel et al. 2001; Richter et al. 2000b; Richter et al. 2002) were dated with the new technique. Samples from the Middle and Early Upper Paleolithic sites of Bau de l'Aubesier (AUB) in France, Jerf al'Ajla (JA) in Syria and the Geißenklösterle (GK) in Germany were used. For some of these associated radiocarbon data is available as well, which is in agreement with the results obtained by standard TL-dating for these samples with *a priori* unknown irradiation and thermal histories.

The ages obtained with the new technique on 8 aliquots (of ~6 mg) agree very well within 1-σ standard deviation with the ones derived on 400–800 mg by standard techniques (Fig. 6.4). It has to be noted, that the standard deviations obtained with the new technique could be reduced significantly for other studies, if larger aliquot numbers will be used.

Conclusions

Many Paleolithic sites do not yield samples of heated flint large enough for standard TL-dating approaches, and the sites thus may remain undated. Chronometric ages can now be provided for small samples of heated flint with a new orange-red SAR TL-technique. However, in order to achieve a sufficient precision the outer 2 mm surface of the samples still

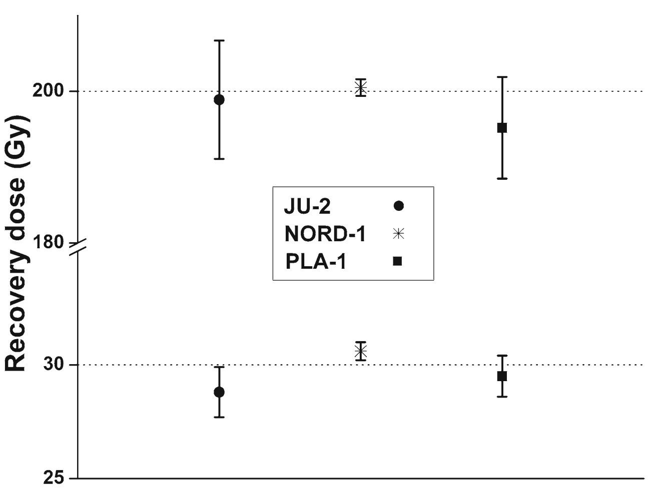

Fig. 6.3 Results of the dose recovery test for the simulation with geological samples (standard deviation of paleodoses for 10 aliquots, 1-σ). The dotted lines represent the applied artificial doses which had to be recovered

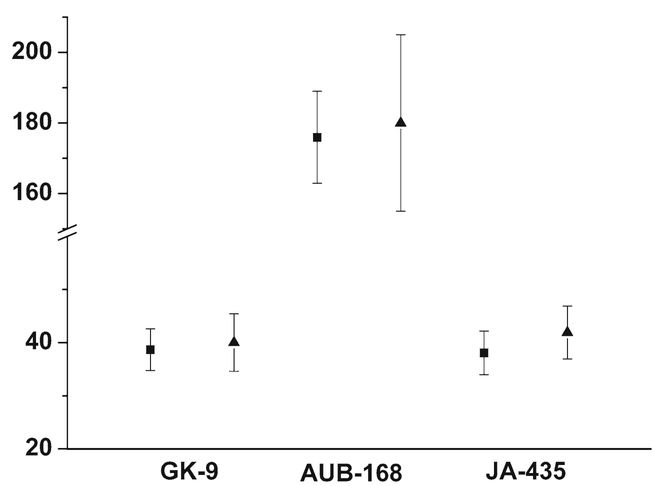

Fig. 6.4 TL-ages obtained for archaeological samples using standard (48 aliquots for additive and regeneration each) UV-blue (*squares*) and the new orange-red SAR (*triangles*, standard deviation of paleodoses for eight aliquots, which includes uncertainties of source calibration and instrumental variation) techniques (1-σ)

have to be removed. Furthermore, the necessity to determine the external dose-rate usually on the site (availability of sediment profiles) applies to this new technique as well.

The principal applicability of the technique is shown by the successful dose-recovery tests, where a prehistoric fire and the burial irradiation are simulated in the laboratory. Furthermore, the comparison with dating results obtained with standard TL-techniques gives perfect agreement of the results as well and thus confidence in the new technique. The dating results with the new technique are of comparably good accuracy, while providing a sufficient precision for answering many archaeological questions.

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Part II
Neanderthal Subsistence and Raw Material Procurement

Chapter 7
On Neanderthal Subsistence in Last Interglacial Forested Environments in Northern Europe

Sabine Gaudzinski-Windheuser and Wil Roebroeks

Abstract There has been considerable debate about Neanderthals' capacities to survive in interglacial environments, especially the last interglacial, the Eemian, and this paper starts with a short review of that debate. The evidence for Neanderthal subsistence during the Eemian suggests that Neanderthal hunting activities may have had a strong focus on large mammals, possibly as a result of the high exploitation costs for smaller sized prey in these interglacial environments. Using recent studies of Neanderthal energetic requirements and their possible implications for Neanderthal behavior, we develop an explanation for the character of the Eemian archeological record from our working area, northwestern and central Europe.

Keywords Eemian • Large mammals • Subsistence • Selective hunters

Introduction

Neanderthals are a puzzling species, in some (morphological) ways close to modern humans, and in some aspects of their archeological record so very different. In the 1990s they fell from grace in terms of their possible contribution to modern human DNA, but recent genetic studies suggest that interbreeding between Neanderthals and modern humans may have occurred after all (e.g., Evans et al. 2006). Neanderthals do constitute by far the best studied extinct hominins, with a rich fossil record sampling dozens of individuals, all but the ones from Engis and Gibraltar discovered in the one and a half century since the Feldhofer Grotte find in August 1856. There is considerable agreement that the individual from the Feldhofer Grotte and its contemporaries formed the end product of a long evolutionary lineage, the first representatives of which colonized Europe somewhere in the first half of the Middle Pleistocene. The rich Sima de los Huesos assemblage from Atapuerca has been interpreted as being near the beginning of the Neanderthal evolutionary lineage (Arsuaga et al. 1997), with new dates suggesting that the 28 individuals thus far discovered there died minimally around 500 ka (Bischoff et al. 2007). If these dates are correct, we are talking about approximately half a million years of Neanderthal existence, with most of the fossils from this species having been unearthed in the western parts of their former range. In fact, the eastern, southern and northern limits to their former distribution are poorly documented because of imbalances in research intensity (Dennell and Roebroeks 2005). It remains to be established whether the currently easternmost and southernmost Neanderthal fossils (from respectively Uzbekistan and the Levant) do reflect the approximate edges of their former range. Indeed, recent genetic studies suggest a Neanderthal DNA-profile for some ambiguous southern Siberian fossils expanding the current estimate for their distribution with some 2,000 km further to the east (Krause et al. 2007).

Zooarcheological studies have established that Middle Paleolithic Neanderthals were capable hunters of medium-sized and large mammals, a view now widely shared, also by former proponents of the hypothesis that scavenging was a very important part of Neanderthal subsistence practices (Stiner 2002). There is only very limited evidence from the earliest sites in Europe for Lower Paleolithic hunting activities, but taphonomic "miracles" such as Schöningen (Thieme 1997) show that we work with a very biased record and that early Neanderthals must have developed basic adaptations for large mammal hunting around the middle part of the Middle Pleistocene, if not earlier (Voormolen 2008). Evidence from Middle Paleolithic Neanderthal sites indicates prime-adult harvesting of bovids and cervids by the later Middle Pleistocene, with a strong focus on high-quality mammals and parts thereof (Gaudzinski 1995; Gaudzinski and Roebroeks 2000; Stiner 2005). The zooarcheological evidence

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testifies to a niche separation from other longer established nonhuman predators, which tend to focus on juvenile and old adult age groups in prey species (Stiner 2005).

Given the abundant presence of burnt flints and bones at many Middle Paleolithic sites, it is safe to assume that Middle Paleolithic Neanderthals controlled the use of fire, though the chronological origins of this practice are still largely unknown. Neanderthals carved their predatory niche with a small range of simple hunting weapons, including wooden thrusting and/or throwing spears, as illustrated by the Schöningen evidence (Thieme 1997; Rieder 2000). It is unclear whether they tipped their spears with stone points, though there is evidence suggesting that they may have done so (see Villa and Lenoir 2006 for a review). Hunting seems to have focused on medium sized and large herbivores, but Middle Paleolithic exploitation of small prey has also been documented, especially at the circum-Mediterranean lower latitudes, where this is largely confined to easily gatherable, sessile or slow-moving animals: marine mollusks, tortoises, legless lizards and ostrich eggs (cf. Stiner 2002). In the southern part of their range Neanderthal hunting activities may occasionally have led to a decline of red deer and aurochs populations, as recently suggested by Speth (2004) and Speth and Clark (2006).

Isotope studies of European Neanderthal fossils suggest that they were top level carnivores, with the bulk of their dietary protein coming from animal sources (Richards et al. 2000). Though limited in numbers thus far, these studies and the zooarcheological evidence suggest that Neanderthals were at the top of the food chain, and hence may have existed at very low densities (Stiner and Kuhn 2006). Mammals constituted the core fuel for the bodies of the Neanderthals, with their – in comparison to anatomically modern humans – high energetic requirements (e.g., Churchill 2007).

Within the known "fossil" range of Western Eurasia, the Neanderthal range varied, expanding and contracting with the rhythms of climate change. During colder periods, southern parts of Europe may have served as refuge for northern populations but alternatively northern Neanderthal populations may have gone extinct during the extreme cold phases of the Pleistocene. The exact nature of the 'ebb and flow' of Neanderthal presence has been the subject of some debate, which has led to a range of studies of the habitats occupied by Neanderthals and their environmental limits (Gamble 1986; Roebroeks et al. 1992; Roebroeks and Gamble 1999; van Andel and Davies 2003; Stewart 2005). Such studies have shown that most Neanderthal sites are associated with faunal remains indicative of so-called mammoth steppe type of environments (Guthrie 1990). Compared to present-day tundra or polar-deserts, the Pleistocene mammoth steppe was a highly productive habitat that supported a rich and diverse grazing community, with the mammoth as its characteristic species. Ice-core studies suggest that climate instability dominated the Neanderthal time range. It is also for this reason that within the monolithic concept of the mammoth steppe one can uncover a great deal of chronological and spatial variation. Individual species ranges would have expanded and contracted constantly, partially in the rhythm of climate changes, leading to strange community associations of floras and faunas and occasionally to the extinction of species.

Whenever floral and/or faunal remains are preserved at Neanderthal sites, these are usually indicative of cold or cool-temperate climatic conditions, which dominated Pleistocene glacial-interglacial cycles in terms of percentage of time (cf. Gamble 1987). The Neanderthals' association with colder climate proxies led to the suggestion that many aspects of their body form were adaptations to cold climates, an interpretation which has become the subject of some debate in recent years, with Aiello and Wheeler (2003) arguing that Neanderthal morphology would have played only a minor role with regard to the minimum temperatures at which they could survive.

This paper deals with Neanderthal presence in types of environment that were comparatively rare during the Middle and Upper Pleistocene in terms of percentages of time (ca. 8%): the interglacials, and more specifically the last interglacial, correlative in broad terms to Maritime Isotope Stage (MIS) 5e, and generally referred to as the Eemian in large parts of (northern and western-central) Europe.

There has been considerable debate about Neanderthals' capacities to survive in such interglacial forested environments, and we will start with a short review of that debate, its background and its (preliminary) outcome. That part is followed by a short overview of the evidence for Neanderthal subsistence during interglacial periods. Next we will try to relate some of the issues at stake in the debate mentioned to the study of Neanderthal subsistence in interglacial environments. Using recent studies of Neanderthal energetic requirements and their possible implications for Neanderthal behavior, we will then discuss a possible explanation for the character of the Eemian archeological record from our working area, Northwestern and Central Europe.

The Challenge of the Forest

Densely forested environments pose specific challenges to hunter-gatherers, to the degree that some workers have suggested that not even modern hunter-gatherers are well suited to such environments (Bailey et al. 1989). Given our "arboreal" past and the distribution of most of today's primates, this shows that the ancestors of extant humans went a very different way than the ancestors of the extant great apes. Like most other primates, we are omnivores, but most other primates are very special omnivores, taking most of their daily diet from plant sources. Somewhere in our past we became generalists, eating a wide variety of plant and animal foods, with much flexibility in dietary breadth, dependent upon the ecological setting. Our evolutionary lineage began to incorporate sometimes significant amounts of animal source food in its diet, leading to a higher quality diet that was to become essential for survival in Eurasia's northern environments by Neanderthal times.

Like modern day temperate and tropical forests, Pleistocene interglacial deciduous forests of the Neanderthal range would have been characterized by a high primary biomass and a high primary production. However, most of this richness would have consisted of trees, woody tissue that was not easily accessible for hungry hominins (Gamble 1986; Kelly 1995). Vegetable foods usable by hominins, such as nuts and other large seeds, would have been relatively expensive to process and only available during short periods of time. Meat must have been the critical food source, especially in winter. In contrast to the open mammoth steppe environments, herbivore mass in forested environments would have been significantly lower, while medium sized and large mammals would have been dispersed in forested environments. Large prey animals were rare and difficult to find. Intercepting animals hence would have needed higher investments in retrieving information on their whereabouts and in terms of search costs. The large species that roamed these forested environments, such as forest elephant and rhinoceros, furthermore had long life spans and low reproduction rates, which made sustained hunting of them a risky strategy.

In non-tropical high-primary-biomass environments many extant hunter-gatherer groups deal with these challenges by a high residential mobility; indeed, as long as a hunter-gatherer group does not depend heavily on aquatic resources, the number of residential moves per year is strongly correlated with primary biomass (see Kelly 1995: 122ff. for a discussion). Camp movement is very frequent in groups living in forested environments, tropical as well as boreal ones, with many groups moving camp after a few days only. Camp movements often serve as foraging trips, with some groups camping on the very spot where prey was captured, as described by Gusinde (1931: 194) for the Selk'nam of Tierra del Fuego. They literally "camp" on their prey (usually a *guanaco*) and after butchering and consumption of the animal the camp is moved. Associated with this high residential mobility is a very limited investment in the construction of huts and dwellings: "Wozu auch viel Mühe auf sie verwenden, da sie nur für eine Nacht oder für wenige Tage ihm und den Seinigen dient!"[1] (Gusinde 1931: 194).

Gamble's (1986, 1987) ecological approach to the Neanderthal archeological record and to the challenges of interglacial forests led to a productive debate about Neanderthals' ability to deal with climax-interglacial forested environments (Roebroeks et al. 1992; Ashton 2002; Roebroeks and Speleers 2002). The initial debate started – and this is important to realize – in a period when many workers assumed that scavenging was an important part of Neanderthal subsistence behavior. The natural "fall-out" of the large groups of herbivores roaming the rich mammoth steppe would have provided scavengers with a steady supply of dead individuals (a view of life in the Pleistocene North that has been thoroughly discussed and discarded, e.g. by Guthrie 2005: 238–239). In interglacials, such large herds were absent, and for the reasons given above, interglacial forests would have constituted too big a challenge for pre-modern hominins, which would explain the virtual absence of their traces over major parts of Europe during full-interglacial forested conditions. As Gamble stated: "Let me make it clear: they never lived in those 8% forests" (Gamble 1992: 569).

Others (e.g., Roebroeks et al. 1992) argued that Neanderthals were present in interglacial environments, as shown by a number of sites that could unambiguously be situated within the last interglacial, the Eemian. In their view, the apparent rarity of Neanderthal traces in interglacial deposits was the result of various factors, including the short time interval of the interglacials and a combination of geological and research-historical factors (Roebroeks et al. 1992; Roebroeks and Speleers 2002). The subsequent focus of those favoring a Neanderthal preference for open environments shifted to the (by then acknowledged) presence of Eemian sites in Central Europe, and their absence in Western Europe. In this view, the more continental conditions of Central Europe would have "broken up" the closed forest cover and created a mosaic vegetation pattern, whereas the dense forests of western, Atlantic Europe would have been impenetrable to Neanderthals (Gamble 1992; Ashton 2002). Palynological studies of the sediments yielding Eemian archeology however did not point to significant differences in terms of vegetation being more "mosaic" in Central than in Western Europe. Furthermore, the "taphonomical" interpretation has been strengthened considerably by the recent discovery of a full-interglacial Eemian site at Caours in the Somme valley, in northern France. Excavations (2005–2006) by Jean-Luc Locht and his team have yielded thus far five archeological levels in Somme fluvial deposits, associated with a fauna of full interglacial character, including *Dama dama*, *Capreolus capreolus*, the forest rhino *Stephanorhinus kirchbergensis* and *Sus scrofa*. Plant remains fossilized in tufa also testify to the full interglacial character of this Middle Paleolithic site (Locht, personal communication, 2006).

The presence of Neanderthals in full-interglacial forested conditions in western and central parts of Europe is now well

[1] "Why should they invest much effort in such structures, as they only serve them and their families for one or a few nights only?"

established (as are their hunting capacities, discussed above). In fact, in recent years we have seen accumulating evidence that pre-modern hominins were able to survive in full interglacial environments, possibly even from their very first presence in temperate Europe onward, e.g. at Pakefield (Parfitt et al. 2005). The rich paleoenvironmental evidence from the English Hoxnian (MIS11?) site at Beeches pit is associated with primary context flint artifacts which show that hominins were present from the beginning of the interglacial phase, through the height of it and persisted into the ensuing cold phase (Preece et al. 2007).

We also have gained a better insight into the character of Pleistocene interglacial environments, partially as a result of the debate referred to above. According to most palynological studies, during interglacials associated with a high sea level – most notably the Eemian – dense deciduous forest vegetation would have covered major parts of Western and Central Europe (cf. Zagwijn 1989). The mammalian record of the Eemian (and of earlier high sea level interglacials, such as the Hoxnian) however does contain species indicative of more open types of environments. The contradictory evidence of the floral and faunal record indicates that the Eemian interglacial vegetation, like that of any interglacial period, certainly did not consist of dense closed forest only: storms, periodical fires and floods may have created open patches in these environments, while grazing activities of large herbivores such as elephant, rhino and (west of the Rhine) hippopotamus must have created large open areas along rivers and possibly also along lakes (cf. Turner 1975; Vera 1997), and it is there that we find the unambiguous traces of former human presence in interglacial environments. Let us have a look at these traces, especially at the evidence for Neanderthal subsistence during the Eemian interglacial.

Neanderthal Eemian Interglacial Subsistence

The Eemian interglacial provides an interesting case study of Neanderthal exploitation of forested environments. This last interglacial period has been studied in great detail, not least because of the hope of retrieving information which might be relevant for current discussions on global climate change. The Eemian started around 130 ka and lasted approximately 10–11 kyr. The Eemian was an Interglacial with a high sea level stand which created oceanic conditions over major parts of the Neanderthal range, much further to the east than at present (Zagwijn 1989). During the Eemian the vegetation gradient was very gradual and the forest succession was remarkably uniform over large parts of Europe. As we are dealing with a (in Pleistocene terms) short time period and a rather homogeneous environment, it is worthwhile to discuss information on Neanderthal subsistence from the few sites we have from this time range. As discussed elsewhere (Roebroeks and Speleers 2002), the majority of archeological sites from Eemian deposits have been uncovered from very specific sedimentary settings such as travertines and lake-basin deposits. Many of these sites, such as Stuttgart Bad-Cannstatt, Stuttgart-Untertürkheim, Burgtonna or Weimar (all in Germany), have been a focus of Quaternary studies for decades or even centuries already, and documentation and collection of bones and lithics was often very limited, likewise limiting the degree to which we can draw reliable inferences on the formation of these records. As a result only a limited number of sites can be taken into account when we try to make inferences on subsistence practices in the Eemian. We can, furthermore, only construct a very partial picture of former subsistence, as the limited data we have are heavily biased towards the larger mammal species that Neanderthals were consuming. Such animal remains are indirect measures of past diets at best, as they may relate to single events or activities typical of specific parts of a landscape only. A direct method for reconstructing past diets consists of the chemical study of the stable isotopes of Neanderthal bones. Apart from the obvious difficulties in obtaining Neanderthal samples for this destructive analysis, a major problem has been to extract well-preserved collagen from such samples. These are amongst the reasons why, thus far only eight Neanderthal bone collagen carbon and nitrogen isotope results have been published. The oldest one is from the Scladina Cave in Sclayn, Belgium, and concerns a fossil that has been presented as deriving from an interglacial Eemian Neanderthal (Bocherens et al. 1999). The signature obtained from the Scladina Neanderthal however cannot be related to the Eemian *sensu stricto*, only to MIS 5 *in toto*, and hence is of less relevance here than the information we can distil from the faunal assemblages from Eemian s.s. archeological sites (Fig. 7.1).

It needs to be pointed out that the open air sites we discuss here contain unambiguous evidence for full interglacial occupation. There are more sites for which such interpretations have been put forward, besides Scladina cave, e.g. Wallertheim in Germany and Level XI from the prolific Taubach cave site in Czechia. Although not improbable, the arguments to situate these sites in a full interglacial context are less solid than for the sites reviewed here, where the environmental evidence is excellent.

Sites in Former Lake Basins

A number of sites were uncovered from lake-basin sediments exposed in various pits in Germany. Important exposures have been (and still are) created there, especially in former eastern Germany, where post-World War II political developments led to the emergence of large-scale open cast lignite mining and the concomitant exposure of Pleistocene sediments, including last interglacial lake infills. Disco vered during commercial exploitation of these quarries,

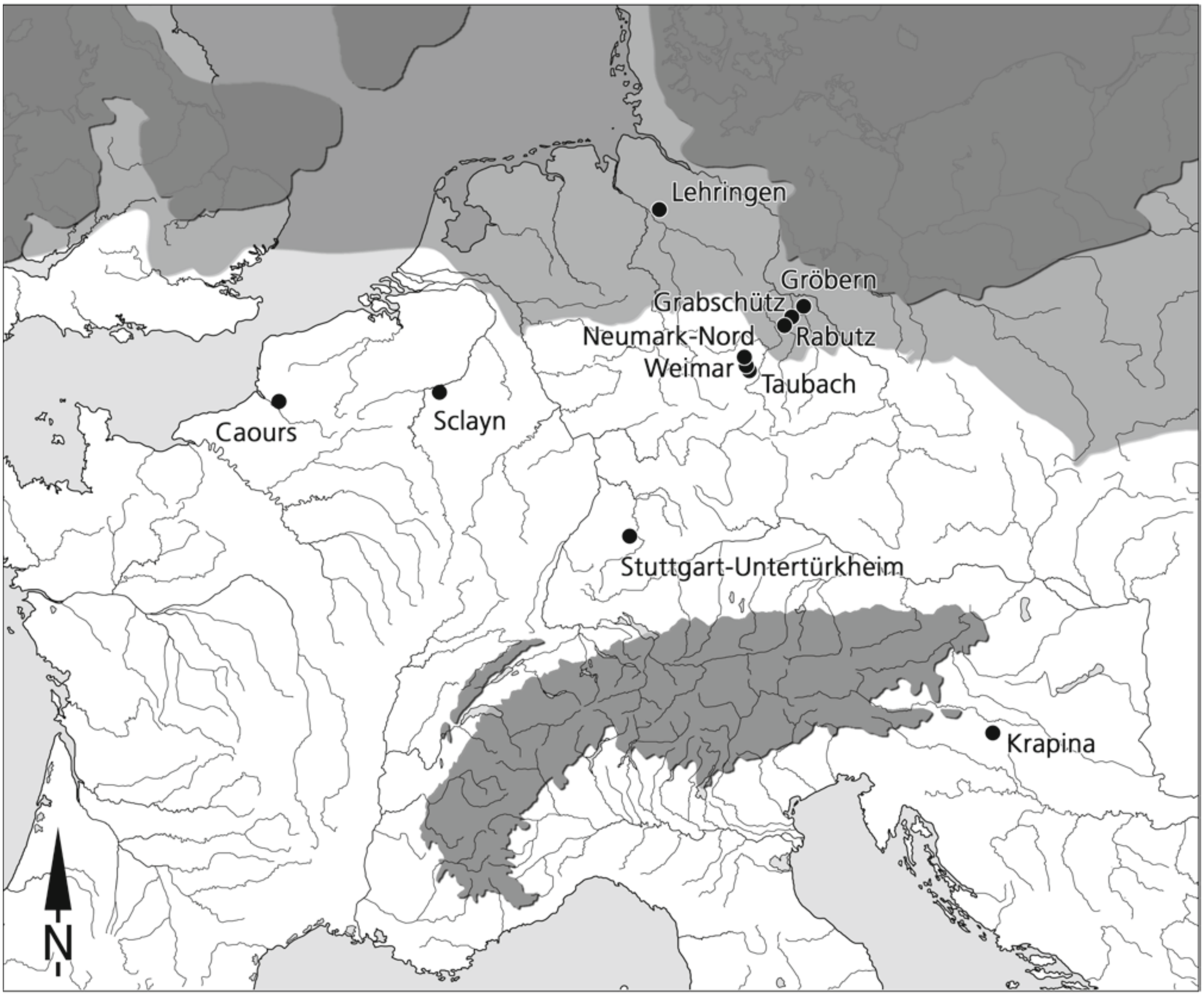

Fig. 7.1 Sites mentioned in the text

archeological documentation of these localities usually had to take place under severe time constraints in the form of limited rescue excavations, if serious fieldwork was possible at all.

Lehringen

Lehringen is perhaps one of the most well-known sites from Eemian contexts because of the yew spear found in association with lithics and faunal remains. The find locality was situated in a marl pit, ca. 35 km southeast of Bremen on the Northwest German plain. The find distribution was recorded in 1948 (Adam 1951; Deibel-Rosenbrock 1960; Sickenberg 1969; Thieme and Veil 1985; Wenzel 1998), with most of the original spatial layout destroyed before archeological intervention at the site. However, sufficient information was recorded in the field for a solid reconstruction of the find circumstances, as shown by Thieme and Veil (1985). At Lehringen, a single *Paleoloxodon antiquus* carcass was found within Eemian Interglacial limnic sediments. Amidst the bones of this approximately 45 year-old individual, the famous Lehringen yew spear was present, 2.40 m in length (cf. Thieme and Veil 1985: for details). Twenty-seven unmodified flint flakes were scattered around the head of the animal. All lithic artifacts were made of Baltic flint. Analysis showed that the raw material originated from various raw material units. As only some of these flakes could be refitted, it was argued that the lithic assemblage originally associated with the animal carcass must have been much larger (Thieme and Veil 1985). The archeological remains were found in sediments the palynological record of which was correlated to the *Corylus-Taxus-Tilia* pollen zone of the Eemian (after Litt 1990). Hence they date to 2–3 ka after the beginning of the Eemian Interglacial *sensu stricto* (see Fig. 7.2).

Various other large mammal remains were collected from the Lehringen marl pit in the course of its exploitation, likewise originating from the lake basin deposits. Represented are *Castor fiber, Canis lupus, Ursus* sp. *arctos*, *Dicerorhinus*

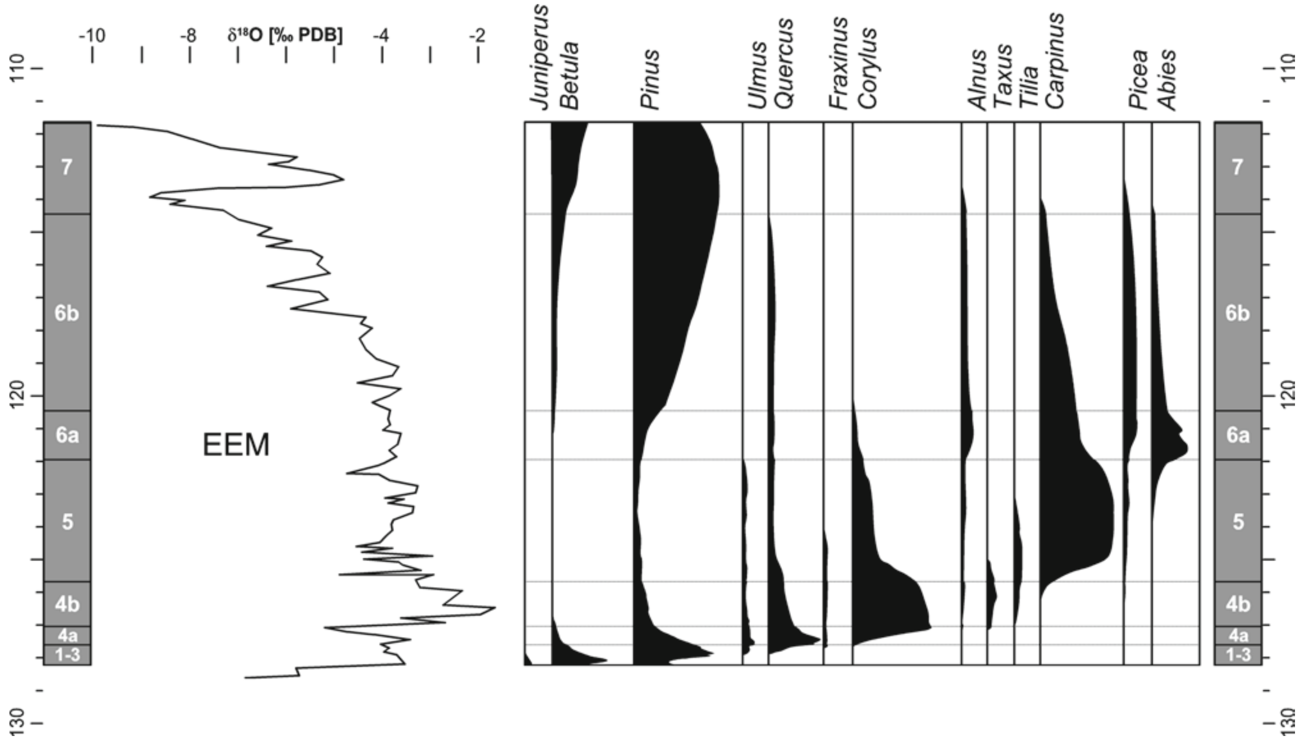

Fig. 7.2 Oxygen Isotope Oscillations in the Gröbern Lake Basin and schematic pollen diagram of Eemian deposits (Litt 1990). Vegetation phases: *1* Birch Phase, *2* Pine-Birch Phase, *3* Pine-Mixed Oak Forest Phase, *4a* Mixed Oak Forest-Hazel Phase, *4b* Hazel-Yew-Lime Phase, *5* Hornbeam Phase, *6a* Hornbeam-Fir Phase, *6b* Pine-Spruce-Fir Phase, *7* Pine Phase

kirchbergensis, Equus sp., *Equus hydruntinus, Cervus elaphus, Dama dama, Capreolus capreolus, Megaloceros giganteus* and *Bos primigenius*. The majority of these species is represented by complete bones and/or complete skeletons without any traces of hominin interference. Sickenberg (1969) suggested that these individuals were part of a natural background fauna. Wenzel (1998) demonstrated that hominins as well as carnivores repeatedly took advantage of these individuals. Some of the bones, such as a distal bear femur, an indeterminate rib fragment and a pelvis fragment of a beaver, displayed cut-marks.

Gröbern

A site which resembles the Lehringen one in many aspects was documented at Gröbern (Mania et al. 1990), about 35 km north of Leipzig. In 1987, rescue excavations uncovered 195 well-preserved bones of *Paleoloxodon antiquus,* distributed over an area of 20 m² in partially articulated position. The remains belonged to a 35–40 year old individual that suffered from osteitis. Gnawing marks on the epiphyses of some long bones showed that wolves had access to the carcass. Between the elephant bones 20 artifacts made of Baltic flint were found, mostly large, unmodified flakes. It was possible to assign the raw material to 5–7 raw material units, which indicates that the lithics were not produced on the spot (Heußner and Weber 1990).

The bones were deposited in sediments of the swampy littoral zone of a eutrophic shallow lake, during the transition phase between the *Corylus-Taxa-Tilia* and the *Carpinus-Larix* phases of the Eemian Interglacial (Litt and Weber 1988). Based on the anatomical position of the bones, Erfurt and Mania (1990) inferred that the elephant was still partially buried in the lake mud when sedimentation of its encasing matrix. They suggested that hominins either killed an animal already weakened by disease or took advantage of an already deceased individual.

Other large mammal species recovered from the calcareous mud of the limnic basin at Gröbern include *Dicerorhinus* sp., *Cervus elaphus* and *Dama dama.*

Grabschütz

The site of Grabschütz is located c. 7 km southwest of Delitzsch. For this site we lack faunal evidence from the lake shore, as this was largely destroyed during lignite extraction. However at some distance from the basin area, 13 lithic artifacts were embedded in sandy sediments, remnants of the former shore zone, which interfingered with the limnic basin deposits (Weber 1990). Only for the lake basin faunal remains were uncovered. The fauna comprised *Dicerorhinus* sp., *Equus* sp., *Cervus elaphus*, *Capreolus capreolus* and *Bos/Bison*. Unlike Lehringen these bones showed no indication of hominin involvement and lithics found in direct association with the bones have also not been reported. Hominin occupation occurred during the *Carpinus-Abies* and *Pinus-Larix-Abies* phase of the Eemian Interglacial.

Rabutz

The site of Rabutz is located ca. 15 km southeast of Halle and was discovered in a brick quarry. A homogeneous archeological find horizon in limnic sediments characterized by charcoal patches yielded c. 240 artifacts made of Baltic flint, mostly simple flakes ($n=165$) (Toepfer 1958; Weber 1990). Highly fragmented faunal remains were associated with these artifacts, including remains of *Canis lupus*, *Ursus arctos*, *Panthera leo, Dicerorhinus kirchbergensis, Equus* sp., *Sus scrofa*, *Megaceros giganteus*, *Cervus elaphus*, *Capreolus capreolus*, *Alces* sp., *Bos primigenius*, and *Bison priscus* (Soergel 1920). Most of these species have an MNI of 1, with the exception of *Capreolus capreolus* (MNI = 2), *Bos primigenius* (MNI = 4) and *Dicerorhinus kirchbergensis* (MNI = 5). The fauna is dominated by remains of *Cervus elaphus* (MNI = 14). Soergel (1920) used various aspects of the *Cervus elaphus* assemblage, such as its age structure, the antler record as well as the overall high bone fragmentation and its association with stone artifacts, to argue for hominin involvement with the accumulation of the fauna. To some degree his interpretation has found support in a recent study by Wenzel (1998), which revealed cut-marks on a cervical vertebra of *Dicerorhinus kirchbergensis*. Toepfer (1958) reported charred hazelnuts at the site and suggests that these were roasted by hominins.

Sites Embedded in Travertins

Taubach

The travertine site of Taubach, ca. 4 km southeast of Weimar, provides a very intriguing faunal record of the Eemian Interglacial. The history of investigation at this site starts as early as the 19th century when the travertine, which extends over a small area of 0.2 km² only, was still exposed (Soergel 1912; Kahlke 1977; Bratlund 2000). The Taubach deposits *in toto* are dated to the maximum of the Eemian Interglacial (Kahlke 1977; Heinrich 1994). As the evidence for the dating of the archeological horizon was obtained from deposits in the upper part of the Taubach sequence, Bratlund suggests that this date represents a *terminus ante quem* for the archeological horizon at the base of the sequence, and an earlier age might be possible (Bratlund 2000).

The archeologically interesting find level is encased in a sandy travertine, the so-called *Knochensand*. A total of ca. 900 lithics and ca. 4,500 large mammal remains were recovered from this horizon. Over the years of exploitation of the quarry, several “hearth layers” have been reported, which seem to have been deposited in close association with the bones. The former presence of fire at Taubach was confirmed by Bratlund’s (2000) observation that numerous bones from the site were calcinated and showed traces of burning (see Table 7.1 below).

The faunal remains recovered from the archeological horizon of the “Knochensand” were collected over the years by various collectors. The collection is definitely biased against certain species and skeletal elements. Nevertheless, as shown by Bratlund (2000), the assemblage (Table 7.1) contains important information on Neanderthal subsistence. The Taubach fauna is dominated by Merck’s rhino, (*Stephanorhinus kirchbergensis*, MNI = 76) and by brown bear (*Ursus arctos,* MNI = 51) followed by large bovids (MNI = 17) and beaver (MNI = 10). Numerous cut marks especially on the bones of *Stephanorhinus kirchbergensis* ($n=99$ ~ MNI = 10) and *Ursus arctos* ($n=292$ ~ MNI = 9) point to an extensive exploitation of some of these animals by hominins (Bratlund 2000). The age structure for rhinoceros

Table 7.1 Taubach. Faunal representation

Species	NISP	N – Bone fragments excluding antler and teeth	N – Bones and bone fragments with cutmarks
Castor fiber	319	161	10
Ursus spelaeus	7	1	–
Ursus arctos	1537	1120	292
Panthera leo	5	2	–
Crocuta crocuta	1	–	–
Sus scrofa	96	47	–
Megaloceros giganteus	6	2	–
Cervus elaphus	207	34	2
Capreolus capreolus	58	16	–
Bison priscus and *Bos primigenius*	533	357	25
Stephanorhinus sp.	1224	856	99
Equus taubachensis	161	21	1?
Paleoloxodon antiquus	182	72	–
Unidentified bone fragment	86	86	3

Number of identified specimen per taxon (NISP), number of bone fragments excluding antler and teeth, and number of bone fragments with cut-marks (after Bratlund 2000). The *Stephanorhinus* sp. sample includes remains from *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus*. The sample is dominated by *Stephanorhinus kirchbergensis.* For the narrow-nosed rhino, *Stephanorhinus hemitoechus,* only a single P4 was recorded (Bratlund 2000).

is characterized by a high number of juvenile individuals. According to Bratlund (2000) juveniles or young sub-adults are present with an MNI of 44 in addition to 7 older sub-adults. Only 25 adult or old sub-adults were present.

For brown bear the sub-adult age class is represented by at least 6 individuals, an MNI of 34 is given for the adult age class and finally at least 12 individuals represent senile animals. The age structure of the bovids can best be described as prime-dominated, whereas the numerous elephants are mainly represented by juvenile individuals (Bratlund 2000; Guenther 1977). For *P. antiquus* MNI (Minimum Numbers of Individuals) have not been calculated. However, Guenther (1977) reconstructed a number of 53 mandibles and jaws from considering dentition stages for M2 and mm2 only. This just gives an impression of the high number of elephants originating from the site.

Bratlund (2000) argues that the high number of rhino and bear individuals, their solitary lifestyle as well as the age structure documented for these species can only be interpreted in terms of deliberate hunting by hominins. She moreover emphasizes that an accumulation of faunal remains in the quantities seen at Taubach can only be explained by a repeated use of the site as hunting ground, a usage which may even have covered centuries (Bratlund 2000).

The old excavations at Taubach report hearth structures at different locations within the travertine exposures (Klopfleisch 1883; Götze 1892). Klopfleisch noted a layer consisting of ashes and bones extending into the travertine sand in addition to fire-reddened pieces of travertine, charcoal and charred bones (Klopfleisch 1883). In documenting charred bone fragments ($n=56$), Bratlund underlined the presence of fire at Taubach. The majority of fragments derive from rhinoceros ($n=24$) and bear ($n=25$), the prominent species at Taubach.

Weimar Parktravertin

The Weimar Parktravertin site is located in the city area of Weimar. Like many of the sites at stake here, the Weimar Parktravertin has a long history of investigations which already started in the 18th century when the small travertine exposure was still exploited. Lithic and faunal remains have been uncovered from two distinct find horizons at the base and within the travertine sequence (Schäfer 1987). Today c. 1,396 lithic artifacts are known to originate from the Weimar Parktravertin site, the majority of which was made from Baltic flint. The fauna uncovered here represented the following species: *Emys orbicularis*, *Lynx lynkx, Felis sylvestris*, Hyaenidae indet., *Vulpes vulpes*, *Mustela eversmanni*, *Ursus arctos*, *Castor fiber*, *Paleoloxodon antiquus*, *Dicerorhinus kirchbergensis*, *Dicerorhinus hemitoechus*, *Equus taubachensis*, *Equus hydruntinus*, *Megaloceros giganteus*, *Dama dama*, *Cervus elaphus*, *Capreolus capreolus* and *Bison priscus* (Kahlke 1984). MNI-values have only been provided for *Emys orbicularis* (MNI = 17) (Ullrich 1984) and for *P. antiquus* (MNI = 13) (Guenther 1984). Guenther (1984) pointed out that the age structure for the elephants at the Weimar Parktravertin site is comparable to the age structure he documented for the elephants at Taubach and he concludes that at both sites elephants were part of the hominin prey. Unlike Taubach, the Weimar Parktravertin has never been subjected to a taphonomic analysis. Thus hominin involvement with the fauna remains obscure.

Biedermannhöhle/Stuttgart-Untertürkheim

The Biedermannhöhle represents a fissure-cave within the travertine quarry at Stuttgart-Untertürkheim in southern Germany, exposed between 1937 and 1939 (Lehmann 1949). The record mainly consists of faunal remains among which *Castor fiber*, *Canis lupus*, *Vulpes vulpes, Ursus arctos*, *Meles meles*, *Panthera leo spelaea*, *Dicerorhinus hemitoechus*, *Equus hydruntinus*, *Equus* sp., *Megaloceros giganteus*, *Cervus elaphus*, *Capreolus capreolus* and *Bos primigenius* were recorded. Indications for hominin activities are scarce and consist of five stone tools only, whereas so far no taphonomic study of the faunal assemblage has been undertaken. Preliminary observations suggest hominin interference with parts of the fauna, as indicated by a cut-marked horse pelvis and a cut-marked humerus of *Cervus elaphus* (Wenzel 1998).

A Signal from Central Europe: Krapina

All the assemblages reviewed above were situated in full-interglacial Eemian deposits and all are situated within Germany. There are simply no other unambiguous archeological sites with evidence of Eemian subsistence published thus far, with one important exception though: the Croatian site of Krapina (Gorjanovic-Kramberger 1906; Malez and Malez 1989; Simek 1991; Patou-Mathis 1997; Wolphoff 1978). With species such as *Cervus elaphus*, *Capreolus capreolus*, *Dama dama*, *Alces alces*, *Sus scrofa* and *Paleoloxodon antiquus*, the faunal composition is clearly of interglacial character. In addition layers 1–8 have been dated by ESR to 130 ± 10 kyrs (Schwarcz et al. 1995). The complex character of the Krapina fauna was outlined by Patou-Mathis (1997) and it has been suggested that the Krapina cave served as a hyena den and place for hibernation for cave bears. Nevertheless the faunal assemblage bears some striking similarities to some of the German sites reviewed above. The Krapina fauna is dominated by *Dicerorhinus merckii* (MNI = 42) followed by *Bos/Bison* (MNI = 26) and *Castor* *fiber* (MNI = 14). In addition *Ursus spelaeus* is present with at least 22 individuals. The age structure of most of the species is comparable to the one described for Taubach. At Krapina young rhinos are numerous (MNI = 19), as are old individuals of cave bear. For *Bos/Bison* and *Castor fiber* the age structure is dominated by adult individuals (Patou-Mathis 1997). All of these species show traces of hominin exploitation of meat and/or marrow as well as traces of burning. This is also true for *Ursus spelaeus* even though it has been suggested that the primary origin of their remains is from natural death during hibernation.

Discussion

Our short review of the Eemian archeological record shows that the evidence is limited, comes from a few sites only and that the Taubach site is an exception with its high MNI and the quality of the study of the faunal assemblage. The limited evidence available does suggest that Neanderthal hunting activities may have had a strong focus on large mammals, possibly as a result of the high exploitation costs for smaller sized prey in these interglacial environments. Studies of Neanderthal subsistence have taught us that they were often very selective hunters, who went for nutritionally rich (often: prime-aged) medium sized and large gregarious prey animals in a wide range of open (mammoth steppe-like) environments (Gaudzinski 1995; Gaudzinski and Roebroeks 2000; Gaudzinski 2004; Roebroeks 2006). In interglacials, open patches in the forested environments may have afforded them with opportunities to zoom in on the animals aggregating there. These were probably always smaller in numbers than in the open environments pre- and postdating the interglacials. Their focus on young adult rhinos at Taubach (and Krapina) may have been the result of the lower costs (and hence higher returns) associated with hunting young inexperienced individuals as against the more dangerous adult rhinos. The same can be said about the two elephant individuals, both of them singled out for their weak state of health.

As mentioned above, we have evidence that Neanderthals also captured small game, usually easily collectable prey. From the Mediterranean area we know that Neanderthals extensively captured tortoises. Percussion fractures and traces of burning on shell fragments of *Testudo* cf. *graeca* (spur-thinged tortoise) together with a dominance of upper limb bones suggest collecting and systematic processing of these animals by hominins at Hayonim Cave in Israel (Stiner and Tchernov 1998). The pond tortoise *Emys orbicularis* was present during full interglacials in the northern and central parts of Europe, but we thus far lack any indication of the exploitation of this species from the sites reviewed above. However, what we do observe repeatedly, as at Taubach and Krapina, is a rather extensive exploitation of beaver, if the number of cut-marked bones is taken as an indication here. Beaver is an excellent source of fat, especially during winter when the animal's body fat functions as a stored food cache. Recent hunter-gatherers often trap beavers in untended facilities, but they are also actively hunted (Holliday and Churchill 2006).

The lithic assemblages from the Eemian are few in number and small in size, and mostly consist of simple unretouched flakes or simple scrapers and denticulates, as at Taubach. Together with the geological and research-historical factors mentioned above, the small sizes of these assemblages add to the low visibility of the last interglacial Neanderthal presence. The Eemian record is a strongly biased record, as we can only recognize artifacts and fossils as being Eemian in age if they were deposited in sediment receiving environments. In the Eemian, this usually means lake deposits and other types of water laid sediments, such as fluvial ones. Hence, we can expect floral and faunal remains that reflect former lake side or river habitats rather than the closed environments traditionally associated with the Eemian interglacial. Such water bodies may have acted as magnet locations where prey animals aggregated.

The high energetic requirements of Neanderthals (Churchill 2007), their high trophic level and the lower mammal biomass of the interglacial environments may have led to a high residential mobility (Verpoorte 2006), with as result less risk of overexploiting these large mammals (see above). In fact, camp movement may often have served as a foraging trip, a strategy well documented for recent hunter-gatherers in forested environments with dispersed animal resources (Kelly 1995), as for the Selk'nam of Tierra del Fuego mentioned above (Gusinde 1931). These three factors could also have caused very low population densities for Eemian (and earlier interglacial) Neanderthals. Nevertheless, the record of their presence in the European Eemian has crossed the threshold of archeological visibility, despite all the geological and research-historical filters that blur our view of this short but extremely interesting slice of Pleistocene time.

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Chapter 8
Diet and Ecology of Neanderthals: Implications from C and N Isotopes

Insights from Bone and Tooth Biogeochemistry

Hervé Bocherens

Abstract After reviewing the current knowledge on paleoecological tracking using carbon and nitrogen stable isotopes in fossil bones and teeth, the contribution of this new approach to key questions of Neanderthal diet and ecology is examined. In particular, the determination of ungulate habitat (open environment versus closed forest) is discussed. Thanks to the carbon and nitrogen isotopic differences observed in the main ungulates available as prey to Neanderthal of OIS 3, it is possible to evaluate quantitatively the contribution of different prey in the diet of Neanderthals. The results of this approach suggest that megaherbivores, such as mammoth and woolly rhinoceros, were the most important providers of proteins to the Neanderthal from Saint-Césaire and probably also to one Neanderthal specimen from Spy. In addition, the conclusions of zooarcheological and isotopic dietary determinations are not always in agreement, possibly due to taphonomic biases and site specialization.

Keywords Stable isotopes • Carbon • Nitrogen • OIS 3 • Prey • Megaherbivores

Introduction

One hundred and fifty years after the discovery of the Neanderthal fossils in Feldhofer cave, scholars are still debating about the reasons why this hominid form is not around any longer. Several hypotheses dealing with the extinction of Neanderthals involve the diet and ecology of this hominid. One may think that after one century and a half of scientific studies, these key aspects of the paleobiology of this hominid are reasonably well known. Indeed, an impressive amount of data from various scientific fields, such as paleoanthropology, paleontology, paleobotany, geology, and paleoclimatology has been gathered thanks to the investigations of many research groups around the world. These works lead to interesting hypotheses on the paleobiology of Neanderthals, but the conclusions of these investigations do not always provide a consistent picture of the Neanderthal way of life and many aspects, including diet and ecology, are still controversial. For instance, questions such as: "was the diet of Neanderthals different from the diet of anatomically modern humans?" and, "were Neanderthals more cold adapted than anatomically modern humans?" still remain with no firm and definitive answers (e.g., recent reviews in Churchill 1998; Marean and Assefa 1999; Hockett and Haws 2005; Weaver and Steudel-Numbers 2005; Adler et al. 2006).

One of the main problems is the geographical disjunction between the paleoclimatic indicators, which are mainly recovered from polar icecaps, as well as marine, lacustrine, and loessic sediments, and the sites where the Neanderthal fossils and settlements are found. Potential paleoenvironmental indicators are also found in the sites themselves, in the form of fossil mammal and plant remains and geological features. However, it is generally not straightforward to associate the last two tracers with human occupation, and using fossil mammals as paleoecological tracers is not without some difficulties. Indeed, some of these fossil mammals belong to extant species, such as reindeer, red deer, roe deer and horse, while others belong to extinct species, such as woolly rhinoceros and woolly mammoth. In the case of extant species, the basis of the paleoecological interpretations is taxonomic uniformitarianism, which implies that ancient representatives of a species have the same ecological requirements, such as range of temperature, humidity, and food resources, than the modern representatives of the same species. Such an assumption is a reasonable starting point, but presents some problems if used too rigidly. A first caveat is that the modern geographical and climatic range of the taxa does not extend to the maximum area and climatic conditions which the animals might tolerate. This can be due to recent distribution areas restricted by interfering human

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impact and to possible changes of physiological limits through time between populations considered to belong to the same species by paleontologists. A second difficulty in this approach is that fossil assemblages are often mixtures of species that do not cohabit in the modern world. Is this due to time averaging of the assemblages, or to the actual existence of "non-analogue communities" (communities including species that have non-overlapping distributions in the modern world), meaning that the ecological requirements of a species can change through time? This question raises interesting implications about the fact that fossil taxa may not be identical to modern ones, as they may represent different genotypic populations (Stewart et al. 2003). In addition, some community inertia has been demonstrated for some terrestrial mammal communities during the Pleistocene (McGill et al. 2006), which makes paleoenvironmental inferences based on community composition even more complex to raise. In the case of extinct species, the reconstruction of their paleoecology is even more complicated since assumptions are based on skeletal remains, sometimes fragmentary, and they are therefore less secure than the conclusions based on extant species. Tracers that would be taxa-independent but environment-dependent and measured on the fossils themselves would greatly improve our knowledge of the paleobiology of Pleistocene mammals relevant to issues related to Neanderthals, especially ancient diets and environments.

In this context a new disciplinary field, based on the isotopic biogeochemistry of vertebrate skeletal fossil tissues, yields new data since about 15 years in situations relevant to the questions of Neanderthal paleobiology (e.g., Bocherens et al. 1991, 1999, 2005b; Fizet et al. 1995). The results of this novel approach, in addition to those of other fields of research, have yielded valuable insights on the diet and ecology of Neanderthals. This approach is based on the fact that during an individual's life, its tissues, including bones and teeth, incorporate carbon and nitrogen atoms that reflect the isotopic composition of the consumed food (e.g., DeNiro and Epstein 1978, 1981). Since different food items can be distinguished through their carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) stable isotopic signatures, information about the diet of fossil hominids can be retrieved (e.g., Drucker and Bocherens 2004; Lee-Thorp and Sponheimer 2006), as well as information about the life environment of animals found in prehistoric sites (e.g., Koch et al. 1989; Bocherens et al. 1994, 1995, 1997, 2006, 2007; Iacumin et al. 1997; Drucker 2005, 2007; Bocherens and Rousseau 2008). The application of this approach requires that diagenetic modifications suffered by the specimen since its burial in the sediment did not change significantly the isotopic signatures recorded during the life period, and that the rules of isotopic variations linked to dietary and environmental factors are reasonably well-known. This paper will review the current status of this field of research, emphasizing the basic rules of application, and describing some of the most important finds so far.

Isotopic Records in Bones and Teeth as a Tracer of Paleobiology: Potential Use and Limitations

Bones and teeth include mineral and organic components, both containing carbon, while only the organic fraction of skeletal tissues contains significant amounts of nitrogen. Both fractions are subject to modifications during the fossilization process, and great care has to be taken before interpreting the isotopic signatures measured on fossil material in paleobiological terms (e.g., DeNiro 1985; Bocherens et al. 2005a; Lee-Thorp and Sponheimer 2006). Carbon in the mineral fraction occurs as carbonate ions incorporated into the bioapatite (calcium phosphate) of bone, dentine and enamel. Although carbon isotopic compositions of carbonates can be measured in almost any fossil bone or tooth, not all values have survived unchanged since the animal's death. The poorly crystallized minerals of the organic-rich bone and dentine are very sensitive to alteration and generally do not preserve their biogenic isotopic signature for more than a few thousand years contrarily to the highly mineralized enamel crystals which are very resistant to diagenesis and usually preserve their biogenic isotopic signature for several million years (e.g., Lee-Thorp and van der Merwe 1991; Ayliffe et al. 1994; Koch et al. 1997; Lee-Thorp and Sponheimer 2003).

Collagen represents about 25% of the dry weight of fresh bone and dentine and exhibits very invariable chemical characteristics across taxa. Collagen from mammal bones and teeth has a very narrow range of carbon and nitrogen content, a property that is routinely used to monitor the reliability of collagen extracted from fossil bones (e.g., DeNiro 1985; Ambrose 1990). It is widely accepted that any extract with a C/N atomic ratio lower than 2.9 or higher than 3.6 is to be discarded since these values are clearly outside the range exhibited by collagen extracted from fresh bone. However, the lower acceptable limit for carbon and nitrogen percentages in fossil bone extracts is evaluated case by case. Collagen-like extracts with carbon and nitrogen percentages lower than those measured in collagen extracted from fresh bones, i.e. 36% and 12%, respectively (Rodière et al. 1996), should be considered very cautiously, especially if they are outliers compared to other collagen extracts from the same site.

Different techniques can be used to extract collagen from fossil bones (e.g., Longin 1971; Bocherens et al. 1997; Higham et al. 2006), all of them aiming at the elimination of any component other than collagen while losing a minimal proportion of the remaining collagen. The contaminations include the mineral fraction containing carbonate as well as exogenous organic matter that could have impregnated the bone sample during burial. Although collagen remnants have been identified in fossils as old as dinosaurs (e.g., Wyckoff 1969; Bocherens et al. 1988; Ostrom et al. 1993; Asara et al. 2007), most applications of collagen isotopic biogeochemistry have been restricted to the last 200 kyr (Jones et al. 2001) and to material coming from regions with temperate or cold climates since the rate of collagen loss is temperature dependant (e.g., Holmes et al. 2005). Under warmer climatic conditions, as in Mediterranean areas, and in less protected environments, as in open-air sites, bone is usually less well preserved and collagen is often too altered to yield reliable isotopic signatures. These are cases where it is nevertheless possible to measure carbon isotopic signatures in the mineral fraction of tooth enamel (e.g., Bocherens et al. 1995; Lee-Thorp and Sponheimer 2006; Bocherens and Rousseau 2008).

The isotopic analysis of animals raised on controlled diets or monitored in natural environments yielded the general rules of isotopic record in bone collagen and the carbonate fraction of bioapatite. Dietary reconstruction is based on the isotopic composition of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$). These ratios are commonly expressed using the "δ" (delta) value as follows: $\delta^{13}C = [(^{13}C/^{12}C)_{sample}/(^{13}C/^{12}C)_{reference} - 1] \times 1{,}000$ (‰) and $\delta^{15}N = [(^{15}N/^{14}N)_{sample}/(^{15}N/^{14}N)_{reference} - 1] \times 1{,}000$ (‰), with the international reference being V-PDB for $\delta^{13}C$ values and atmospheric nitrogen (AIR) for $\delta^{15}N$ values. Carbon is provided by the whole food consumed by an organism, while nitrogen is provided by the protein fraction of the food. The carbon isotopic signature of an animal is globally equivalent to that of its average food (DeNiro and Epstein 1978). However, different fractions of the body present varying carbon isotopic signatures compared to the whole body. For example, the collagen of an organism raised on a homogenous diet exhibits $\delta^{13}C$ values enriched by 5‰ while the carbonate fraction exhibits $\delta^{13}C$ values enriched by 9–14‰ relative to the diet and the whole body (e.g., DeNiro and Epstein 1978; Cerling and Harris 1999; Passey et al. 2005). The variations of this enrichment in the carbonate fraction seem to relate to different dietary physiology and are higher in large herbivores than in small herbivores and carnivores (e.g., Passey et al. 2005). These differences may be partly linked to the impact of ^{13}C-enriched CO_2 generated through methane production especially high in ruminants (e.g., Hedges 2003; Passey et al. 2005). As a consequence, the difference between the $\delta^{13}C$ values of collagen and carbonate bioapatite is higher in herbivores (7.9 ± 1.1%) than in carnivores (4.7 ± 0.4%) (Bocherens 2000). Flesh is slightly enriched compared to the average diet, which is why the $\delta^{13}C$ values of the collagen of a predator are enriched by around 1‰ (from 0.8 to 1.3‰) compared to the $\delta^{13}C$ values of the collagen of its average prey (Bocherens and Drucker 2003).

Contrary to carbon, the nitrogen-15 content is higher in a given organism than in its food, with the $\delta^{15}N$ values of an organism being 3–5‰ more positive than those of its average diet (DeNiro and Epstein 1981; Schoeninger and DeNiro 1984). When the $\delta^{15}N$ values of the bone collagen of a predator are compared to those of its average prey, a similar enrichment of 3–5‰ is found (Bocherens and Drucker 2003). Some tentative links have been suggested between some variations in this enrichment factor and physiological or environmental parameters. For instance, the fact that a given herbivorous species exhibits increasing $\delta^{15}N$ values with decreasing annual precipitation in Africa and Australia led to the suggestion that aridity would increase the ^{15}N enrichment between plant food and body tissues in herbivores, due to changes in water and nitrogen metabolism under water and dietary stressed conditions (e.g., Ambrose and DeNiro 1986; Heaton et al. 1986; Sealy et al. 1987; Ambrose 1991; Gröcke et al. 1997). However, more recent works based on a larger dataset seem to indicate that the observed increase in $\delta^{15}N$ values is due to an increase in the $\delta^{15}N$ values of plants with aridity and a relatively constant fraction of nitrogen between plant food and herbivores (Murphy and Bowman 2006). This does not preclude some variability in the trophic enrichment of ^{15}N. For instance, in herbivorous mammals, such variations were observed in controlled feeding experiments of different herbivorous species such as alpaca, cattle, goat, and horse with diets differing in their protein levels (Sponheimer et al. 2003). The extreme fractionation values are, however, obtained with diets exceeding the nitrogen requirements of the animal or leading to starvation and weight loss. Moreover, they were measured on tissues recording short-term variations, such as hair and blood. These results may thus not be relevant for the isotopic record of tissues averaging long periods of life such as bone in animals living under natural conditions. Some differences have also been observed in omnivorous mammals fed on diets with differing protein contents. For instance, a review of fractionation values measured for bears suggests an increasing difference between blood and food $\delta^{15}N$ values for bears fed on diets presenting decreasing nitrogen content, such as fish (2.3 and 3.6‰), flesh (3.8 and 4.1‰), and fruits (4.2 and 5.8‰) (Robbins et al. 2005). Such variations may also exist in humans according to their diet quality (review in Hedges and Reynard 2007).

Collagen and carbonate reflect the isotopic composition of the food consumed during the period during which they were synthesized. In large mammals, bone collagen reflects several years of an individual's lifetime before its death, while tooth collagen and enamel carbonate sampled along a tooth crowned reflect a much shorter period, during which this tooth part was formed, usually during the first months or years of an individual's life. This situation has important implications in mammals, especially in the case of young individuals and of high-crown teeth of herbivorous mammals with prolonged growth periods. Young individuals are raised on their mother's milk, which exhibits $\delta^{15}N$ values around 3‰ higher than those of the adult diet (Fogel et al. 1989). For these reasons, the $\delta^{15}N$ values of tooth collagen do not always reflect the adult diet in mammals and they should be treated cautiously if used in paleodietary reconstruction (Bocherens et al. 1994; Bocherens and Mariotti 1997). For the same reason, bone collagen of young individuals, from birth until a few years after weaning, is affected by the consumption of ^{15}N-enriched milk, and several studies have demonstrated the consequences in the isotopic variations of the youngest individuals, up to 3 years old human babies, in modern and archeological human populations (e.g., Fogel et al. 1989; Katzenberg and Pfeiffer 1995; Fuller et al. 2006; Clayton et al. 2006). Similar patterns have been shown in the bones of young animals (e.g., Balasse et al. 1997). The isotopic signatures of such individuals are therefore difficult to address for paleodietary reconstruction. In high-crowned herbivorous mammals, such as horse and bovids, serial sampling of dentine and enamel bands along the crown perpendicularly to the growth direction yields varying isotopic results that correspond to seasonal or ontogenic changes in diet (e.g., Koch et al. 1989; Balasse et al. 2001; Drucker et al. 2001; Nelson 2005).

In summary, carbon isotopic signatures, measured on collagen or enamel carbonate bioapatite, yield direct information on the type of plants consumed by herbivores, and therefore on the vegetation surrounding the Neanderthals. In the case of predators, their $\delta^{13}C$ values are informative in the case of potential preys with differing carbon isotopic signatures. Nitrogen isotopic signatures of bone collagen reflect the trophic position of an individual within its food web. Some variations in plants linked to environmental parameters are transferred to herbivores and their predators, shifting the $\delta^{15}N$ values of the whole food web but keeping the nitrogen isotopic differences between predators and their prey within a predictable range. Examples relevant to the case of Neanderthals will be presented in the following sections.

Isotopic Variations and Ecology of the Middle and Late Pleistocene

Carbon-13 in Herbivores and the Vegetation Around Neanderthal

Carbon isotopic signatures, measured on collagen or enamel carbonate bioapatite, yield direct information on the type of plants consumed by herbivores, and therefore on the vegetation surrounding the Neanderthals. The main carbon isotopic distinction in terrestrial vegetation is due to the photosynthetic pathway used by the plants, i.e. the so-called C_3 and C_4 pathways. C_4 plants are absent or very limited in environments with a temperate or cold growing season, as in Europe, including the Mediterranean area, northern latitudes and high altitudes (e.g., Ehleringer et al. 1997). The geographical extension of Neanderthals was deeply rooted in Europe, with representatives in the Middle East and central Asia (e.g., Bolus and Schmitz 2006; Finlayson and Carrión 2007). Within this range, C_4 plants may be present as a significant but minor component in the Middle East and some dry sections of Central Asia (e.g., Bocherens et al. 2000). When present, these C_4 plants are grasses or forbs. In environments where all plants use the C_3 photosynthetic pathway, which correspond to the large majority of sites where Neanderthals occurred, an isotopic distinction can be seen between plants growing under a closed canopy, which have lower $\delta^{13}C$ values than plants growing at the top of the canopy or in open environments, such as open woodland, grassland, steppe and tundra (reviews in Tieszen 1991; Heaton 1999). The tissues of herbivores consuming plants from a closed canopy also exhibit lower $\delta^{13}C$ values than those of herbivores consuming plants from an open environment (e.g., van der Merwe and Medina 1991; Cerling and Harris 1999; Drucker et al. 2003b, 2008; Cerling et al. 2004; Drucker 2005, 2007). The differences in $\delta^{13}C$ values can reach 5‰ in boreal and temperate contexts between open and closed areas. Shifts of $\delta^{13}C$ values of plants and their consumers can also be due to other environmental factors such as altitude and humidity. The isotopic shifts are, however, more limited, of about 1.1‰ increase in $\delta^{13}C$ values per 1,000 m increase in altitude and $\delta^{13}C$ values 0.5‰ lower in humid grassland compared to drier ones (e.g., Schnyder et al. 2006; Männel et al. 2007).

The use of $\delta^{13}C$ values measured in the bones and teeth of herbivores found in prehistoric sites provide a tool to investigate whether animals dwelling in dense forests were part of the subsistence strategies of Neanderthals living during periods of forest development. As expected, the $\delta^{13}C$ values of herbivores found in sites dated from OIS 3 are all within the range of animals consuming plants from open environments without dense canopy forests, as in Saint-Césaire, in Les Pradelles, in layer 1A in Scladina cave, and in layers 6a and 7a in Kůlna (e.g., Fizet et al. 1995; Bocherens et al. 1997, 2005a; Patou-Mathis et al. 2005) (location map on Fig. 8.1).

Only sites from more temperate periods, such as some phases of OIS 5, yielded herbivores with $\delta^{13}C$ values negative enough to be consistent with dense canopy vegetation that could generate low $\delta^{13}C$ values in plants. This was the case in layer 4A from Scladina cave, and in layer G from Payre (Bocherens et al. 1999; Bocherens and Rousseau 2008). The distribution of these low $\delta^{13}C$ values in the different herbivorous species and in remains from animals hunted by humans or by carnivores tells us even more about the environment, the paleobiology of herbivorous mammals, and

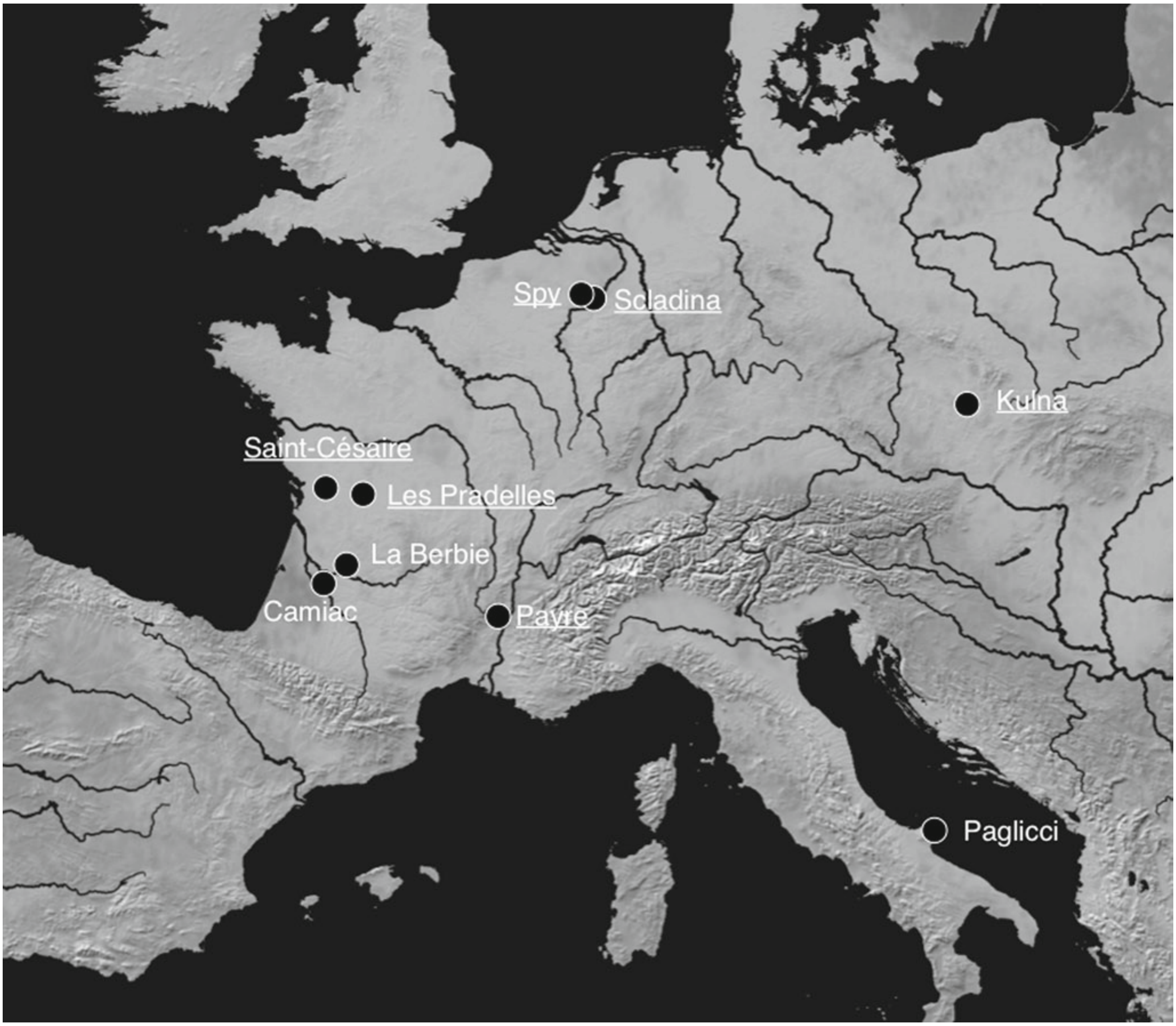

Fig. 8.1 Location of the sites discussed in the text. The underlined names correspond to sites that yielded bones from Neanderthals

the subsistence strategies of Neanderthals. In layer 4A from Scladina cave, fallow deer exhibit low $\delta^{13}C$ values, which is not surprising for this species of which extant representatives dwell in well forested landscapes. However, the occurrence of two horse specimens with $\delta^{13}C$ values as low as those of fallow deer shows that some representatives of this species could be present even under forested conditions. Similar results were found for horses from Holocene sites in France (Bocherens et al. 2005a). These results show that ancient horses were not systematically associated to open environments, such as grasslands or steppes, but could also be present in forested environments. In both cases, horses were nevertheless a minor component of the fauna which was dominated by taxa more linked to forested environments such as cervids. In layer 4 from Scladina cave, it is striking that although a majority of analyzed herbivorous mammals yielded $\delta^{13}C$ values indicative of a dense canopy forest, the $\delta^{13}C$ values directly measured on a Neanderthal specimen indicate consumption of resources from open environments (Bocherens et al. 1999). This could indicate that, in a landscape with open and forested dietary resources, Neanderthals from layer 4A of Scladina cave focused on food from the open landscape. Due to limited data such a conclusion cannot be generalized to all Neanderthal populations living under temperate conditions. Indeed, the results obtained in layer G from Payre on large bovids and deer teeth indicate that these species were hunted by Neanderthals in dense forest environments (Bocherens and Rousseau 2008). The isotopic approach allows thus to determine the origin of hunted game within a mosaic landscape where open and forested areas

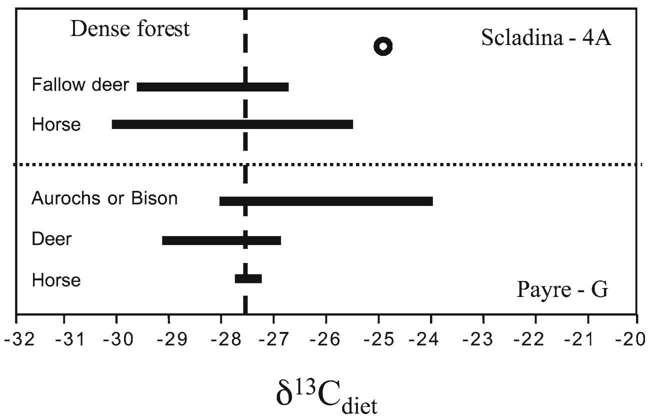

Fig. 8.2 Carbon isotopic signatures of the average diet reconstructed from collagen (Scladina, layer 4A; Bocherens et al. 1999) and from enamel carbonate apatite (Payre, layer G; Bocherens and Rousseau 2008) $\delta^{13}C$ values. Neanderthal from Scladina layer 4A (*open circle*) exhibits $\delta^{13}C$ values indicative of open environment, contrarily to some herbivores found in the same level, such as fallow deer and horse. In Payre layer G, some of the hunted herbivores, especially deer, exhibit $\delta^{13}C$ values typical of dense forest environment, thus indicating that Neanderthals in Payre exploited herbivores from forested environments (Bocherens 2008)

were present, and to compare the subsistence strategies of different Neanderthal populations through space and time (Fig. 8.2). The development of this approach should be fruitful in the debate over the ecological tolerance of Neanderthals (e.g., Roebroeks et al. 1992).

Nitrogen-15 in Herbivores: The Effect of Environmental Factors

As described in the previous section, $\delta^{15}N$ values of adult herbivores reflect those of the consumed vegetation. A recent review of variations of $\delta^{15}N$ values in soils and plants demonstrated that, on a global scale, temperature and humidity are the main factors impacting on the $\delta^{15}N$ values of plants, which decrease with decreasing temperature and increasing humidity (Amundson et al. 2003). The same factors have been shown to have similar effects on the $\delta^{15}N$ values of plants and their consumers at more local scales, for instance with increasing altitude and on the scale of a continent such as Australia (Murphy and Bowman 2006; Männel et al. 2007).

In the context of European Late Pleistocene, large variations of $\delta^{15}N$ values in herbivore collagen have been reported. The pattern of such variations in western Europe during the time range from 35 to 10,000 years ago has convincingly demonstrated that temperature played a driving role in the decreasing of $\delta^{15}N$ values in herbivore collagen during and just after the Last Glacial Maximum, between 20 and 12,000 years ago, with an amplitude increasing when the distance to the polar front decreases (Drucker et al. 2003a). In the peri-Mediterranean realm, this drop in herbivore $\delta^{15}N$ values during the Last Glacial Maximum is not observed, as in the site Paglicci in southern Italy (Iacumin et al. 1997). This clearly illustrates that different environmental changes occurred in different areas during the climatic fluctuations of the Late Pleistocene.

Other episodes of shifts of herbivore $\delta^{15}N$ values have been reported in the Late Pleistocene, but the environmental cause is not so well understood. For instance, at a time that seems to correspond to the beginning of the Aurignacian and in localities from different areas of Europe, the $\delta^{15}N$ values of horse, large bovids, as well as of a predator, the wolf, are 3–5‰ more positive than those of the same species before and after the Middle to Upper Paleolithic transition (Drucker and Bocherens 2004). Such an isotopic shift is very difficult to link to climatic changes, since it seems to correspond to a time of decreasing temperature, which should lead to a decrease of $\delta^{15}N$ values in plants and herbivores as seen during the Last Glacial Maximum, and not to an increase in $\delta^{15}N$ value as it is observed. Further research should help to better characterize this isotopic shift chronologically and spatially. One hypothesis to be tested is the possible link between this isotopic shift and the Campanian ignimbrite eruption, which occurred around this time and is likely to have disrupted ecosystems on a large scale in Europe (Fedele et al. 2002).

There are also some hints of such increases in $\delta^{15}N$ values during earlier periods. One such episode was recognized in the study of Les Pradelles, where specimens belonging to reindeer, horse, bison, and wolf from layer 7 exhibited significantly higher $\delta^{15}N$ values than specimens from the same species coming from layers under- and overlying (Fizet et al. 1995). Paleoclimatological proxies point to a very dry and cold climate during the deposition of this layer (Fizet et al. 1995). Reports of unusually high $\delta^{15}N$ values have also been made for bison bones from England older than 55 ka (Jacobi et al. 2006), and for bison and proboscideans from a 200 ka old English site (Jones et al. 2001). Aridity is often presented as the most likely cause of these positive excursions of $\delta^{15}N$ values (Fizet et al. 1995; Jones et al. 2001), but the biogeochemical behavior of nitrogen under the unique environmental conditions of the Late Pleistocene in Europe is not yet well understood and requires further investigations. In particular, it would be necessary to consider the possible influence of the herbivore community on the biogeochemistry of nitrogen, since grazing is a factor known to increase the $\delta^{15}N$ values of plants and soils (e.g., Neilson et al. 2002), especially through manuring (e.g., Simpson et al. 1999; Choi et al. 2002; Frank et al. 2004; Dijkstra et al. 2006).

Therefore, changes in the herbivore communities through the Late Pleistocene may be also responsible for some variations observed in the $\delta^{15}N$ values of terrestrial ecosystems. Even if the actual causes of these isotopic fluctuations are still not fully understood, it is essential to take them into account in the paleodietary interpretations, as it will be illustrated in the following sections.

Choice of Prey by Predators

Carbon isotopic signatures yield direct information on the type of plants consumed by herbivores. In the case of predators, their $\delta^{13}C$ values are informative in the case of potential preys with differing carbon isotopic signatures, such as herbivores from dense forests, herbivores from open environments, freshwater resources, and marine resources. Nitrogen isotopic signatures of bone collagen reflect the trophic position of an individual within its food web. Some variations in plants linked to environmental parameters are transferred to herbivores and their predators, shifting the $\delta^{15}N$ values of the whole food web but keeping the nitrogen isotopic differences between predators and their prey within a predictable range. Therefore, in a given paleoecosystem, using the $\delta^{13}C$ and the $\delta^{15}N$ values from collagen allows to determine which prey were consumed by predators, if different prey species exhibit significant differences in their isotopic signatures.

A compilation of carbon and nitrogen isotopic data obtained on fossil mammals dated to OIS 3, between 24 and 60 ka, showed that a consistent pattern of isotopic variations existed between ungulates living in the so-called "steppe-tundra" or "mammoth steppe", from western France to Alaska (see review in Bocherens 2003). Although the environmental setting of this unique biome has no real modern equivalent, it seems that the isotopic variations observed in various herbivorous mammals such as reindeer, large bovids, horse, and mammoth, seem to relate to isotopic differences in their preferred plant food items that follow the same isotopic discrimination as modern plants in boreal and arctic environments. Lichens, which exhibit less negative $\delta^{13}C$ values than vascular plants, lead to more positive $\delta^{13}C$ values in reindeer collagen than in coeval herbivores due to the high proportion of these plants in reindeer diet (e.g., Fizet et al. 1995; Drucker et al. 2003a). The herbivores with the most positive $\delta^{15}N$ values, such as mammoths and large bovids, seem to be the ones relying most on grass rather than shrub leaves. These two types of plants differ greatly in their strategy of nitrogen intake, grass having no symbiotic association with fungi, while most shrubs and trees obtain most of their nitrogen from symbiotic fungi, with significant isotopic fractionation leading to more negative $\delta^{15}N$ values in shrubs and trees than in grass (e.g., Högberg et al. 1996; Michelsen et al. 1996; Commisso and Nelson 2006; Hobbie and Hobbie 2006).

The large range of variation of $\delta^{15}N$ values in plants from arctic and boreal environments linked to their differences in nitrogen metabolism is sufficient to explain the pattern of isotopic variation exhibited by herbivores, especially since the nitrogen isotopic fractionation between herbivore tissues and their diet varies less than originally believed (see review in previous paragraphs). Even the large difference in $\delta^{15}N$ values of around 4‰ observed between the most ^{15}N-enriched and the most ^{15}N-depleted herbivore in a given paleoecosystem, such as mammoth and cave bear in layer 1A of Scladina cave, is well within the observed range of variation of $\delta^{15}N$ values between grass and shrubs. These observations cast serious doubts upon recent works based on models that advocate physiological factors such as hyperphagia, lactation and suckling as the cause for cave bears having lower $\delta^{15}N$ values than those of sympatric herbivores (Balter et al. 2006), especially when considering the absence of difference between the $\delta^{15}N$ values of male and female cave bears (Bocherens, unpublished data), a side-effect predicted by this theory, and the absence of such an effect in modern bears, which do have hyperphagia and hibernation but do not differ from other carnivores in the fractionation of their nitrogen compared to their food (Hilderbrand et al. 1996; Felicetti et al. 2003).

The consequences of these significant isotopic differences in terrestrial prey species available to Neanderthals and coeval predators is the possibility to evaluate quantitatively the proportions of the different prey that they consumed. In two case studies dealing with Neanderthals and coeval herbivores and carnivores dated to the end of OIS 3, around 40–35 ka, and located in two different regions, Western France and Belgium, the isotopic pattern exhibited by the different herbivorous and carnivorous species are strikingly similar (Fig. 8.3).

In both cases, mammoths exhibit the most positive and reindeer the least positive $\delta^{15}N$ values of herbivores, while reindeer exhibit the least negative and horse and mammoth exhibit the most negative $\delta^{13}C$ values of herbivores. Hyenas present $\delta^{15}N$ values slightly more positive than those of mammoths and about 3–4‰ more positive than those of the bulk of herbivores, while Neanderthals are about 2‰ more positive than hyenas.

In the case of Saint-Césaire Neanderthal, the use of a mathematical model was possible thanks to the diversity and the richness of the coeval fauna that provided robust end-members for potential prey species available to the predators and allowed quantitative estimates for the contribution of various prey in the average diet of Neanderthals and hyenas (Bocherens et al. 2005b). The results point to a much larger proportion of mammoth and rhinoceros in the diet of Neanderthals than for hyenas, while hyenas consumed more reindeer than Neanderthals. The relative contribution of the other ungulates, such as horse, large bovids and large deer, were ranging similarly for both predators. This result indirectly suggests that mammoth and rhinoceros were hunted rather than scavenged. Otherwise hyenas would also have a better access to these carcasses which was not the case.

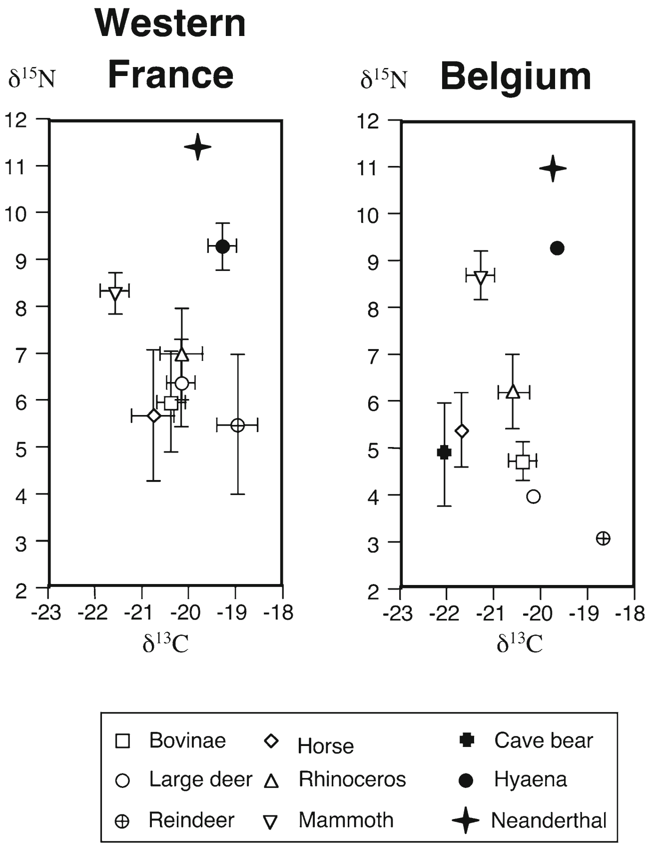

Fig. 8.3 Carbon and nitrogen isotopic signatures of collagen from herbivorous and carnivorous mammals in Western France (Saint-Césaire, La Berbie, Camiac) and Belgium (Spy, layer 1A in Scladina cave) (Modified from Bocherens et al. (2005b))

An alternative explanation for the more positive $\delta^{15}N$ values in Neanderthals than in hyenas is the consumption of freshwater resources by the humans (Drucker and Bocherens 2004; Balter and Simon 2006). However, the complete lack of archeological evidence for exploitation of fish in sites occupied by Neanderthals, as well as the very tight clustering of the isotopic values of Neanderthal specimens from a given site, make it unlikely that fish were significantly involved in the diet of the studied Neanderthals. Moreover, the trace-element data presented to support fish consumption by Neanderthals by Balter and Simon (2006) are affected by diagenesis and lack faunal comparison data, which make them unreliable for dietary reconstructions (Lee-Thorp and Sponheimer 2006).

In the case of Belgian samples, no detailed mathematical reconstruction has been attempted yet since the association between the Neanderthal specimen from Spy and the mammalian fauna from Scladina is not as secure as in western France. But the similar isotopic pattern among species suggest a similar result for dietary reconstruction, with megaherbivores such as mammoth and rhinoceros representing a much higher percentage in the diet of Neanderthals than in the diet of hyenas. These results suggest the possibility of a niche partitioning between Neanderthals and hyenas, the hominids aiming at the largest herbivorous prey while the hyena relied more on smaller sized prey, such as large bovids, cervids and horses. The hunting technology of Neanderthals could have given them an advantage in the hunting of very large herbivores, opening them an ecological niche unavailable to other predators and allowing the cohabitation of several large predators in late Pleistocene Europe without too much dietary overlap between predatory species.

Comparison of Isotopic and Zooarcheological Dietary Reconstruction

The exploitation of megaherbivores such as proboscideans and rhinoceros by Neanderthals and other fossil European hominids has been previously suggested based on the study of animal remains found in prehistoric sites (e.g., Scott 1980; Thieme and Veil 1985; Auguste 1995; Auguste et al. 1998; Bratlund 2000; Patou-Mathis 2000, 2006; Conard and Niven 2001; Moncel 2001; Piperno and Tagliacozzo 2001). However, the consumption of such a large proportion of up to 70% mammoth and up to 56% rhinoceros meat as reconstructed with the isotopic approach is not generally deduced from zooarcheological studies of Neanderthal food leftovers (Bocherens et al. 2005b). For instance, in the case of Saint-Césaire, the zooarcheological study points to a large proportion of bovinae in the meat consumed by Châtelperronian Neanderthals, while mammoth and rhinoceros would account for 16% and 9%, respectively (Patou-Mathis 2006). One common conclusion of isotopic and zooarcheological investigations is the very low proportion of deer and reindeer in the diet of Neanderthals (Fig. 8.4).

Therefore both approaches agree that Neanderthals have consumed more meat from large mammals than from small ones. The difference in the conclusions of both approaches regarding mammoth and rhinoceros could be due to the consequence of transport decision, since bones of very large herbivores are not expected to be transported from the butchery to the occupation site, only meat filets would be transported leading to an underrepresentation of the role of large-bodied animals in Middle Paleolithic diet (e.g., Rabinovitch and Hovers 2004).

Another case of discrepancy between the conclusions of zooarcheological and isotopic dietary studies is provided by the Les Pradelles site, in Charentes (France). Three Neanderthal specimens from this site have yielded reliable collagen that was analyzed isotopically, as well as specimens of coeval horse, large bovids, reindeer, wolf and hyena (Fizet et al. 1995; Bocherens et al. 2005b). Based on zooarcheological analysis of the fauna from layers 9 and 10 where the Neanderthals come from suggest a site where essentially reindeer were hunted, with 55 individuals, while other species

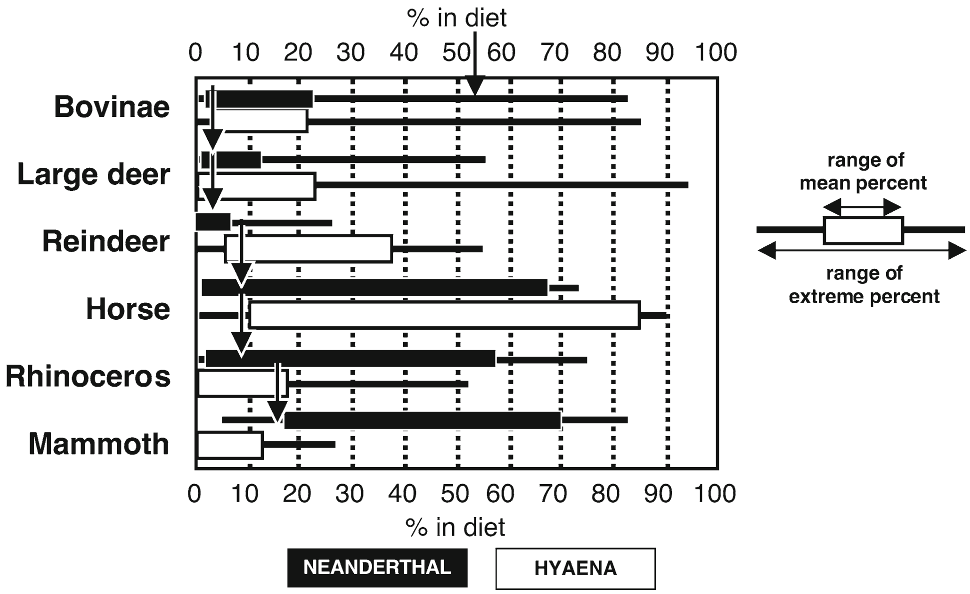

Fig. 8.4 Range of proportions of different prey species in the diet of Neanderthal from Saint-Césaire and hyenas from western France (Modified from Bocherens et al. 2005b). The *vertical arrows* correspond to the proportions of meat weight of different prey species calculated from the results of zooarcheological study (Patou-Mathis 2006)

yielded much less individuals, i.e. 3 red deer, 11 horse and 8 large bovids (Costamagno et al. 2006). The isotopic results indicate that the contribution of prey with high $\delta^{15}N$ values, i.e. large bovids, has to be important in order to fit the observed isotopic values for all three Neanderthals (Fig. 8.5).

The apparent discrepancy in terms of hunted individuals is partially corrected if we calculate the maximum percent meat obtainable from the different species, taking into account that an adult reindeer yields around 50 kg meat, and adult horse 200 kg and an adult large bovid 750 kg (based on Patou-Mathis 2006). Due to these differences in size, eight large bovid individuals would provide around half the meat of all herbivores found in Les Pradelles. The isotopic results suggest that bovids should be even more important in the Neanderthal diet, unless other large herbivores with high $\delta^{15}N$ values, such as rhinoceros and mammoths, were hunted but not represented in the site. This is not to say that reindeer were unimportant to Les Pradelles Neanderthals or that zooarcheology yielded false results. Les Pradelles could well correspond to a site where reindeer hunting and processing was a major activity, but that, on average, the main protein source of the three analyzed Neanderthal specimens was meat from large bovids.

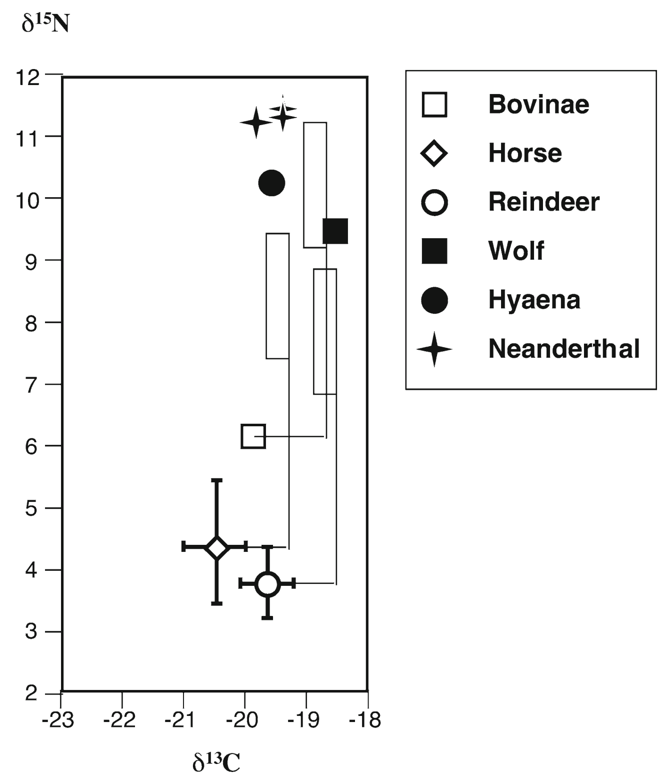

Fig. 8.5 Carbon and nitrogen isotopic signatures of collagen from herbivorous and carnivorous mammals from Les Pradelles, compared to those of coeval Neanderthal specimens (Modified from Bocherens et al. 2005b). *Rectangles* represented the reconstructed range of collagen for predators consuming exclusively one prey species, i.e. Bovinae, Horse or Reindeer. This reconstruction is based on the carbon and nitrogen isotopic fractionations for predators compared to their prey presented by Bocherens and Drucker (2003)

Conclusions and Perspectives

Isotopic investigations of fossil bones relevant to questions of Neanderthal paleoecology are only at their beginning. So far, only about 25 Neanderthal individuals have been attempted using this new isotopic approach, and only 12 specimens yielded well-preserved collagen, ten of them having been published (Bocherens et al. 2005b). The present paper discussed isotopic results obtained on only 5 Neanderthal individuals as the other additional specimens for which isotopic data were published lack either suitable comparison fauna, are juvenile for which interference from suckling milk could not be excluded or their collagen presents preservation problems (see Bocherens et al. 2005b for detailed discussion). There are still a huge number of prehistoric sites dated to the Late Pleistocene that should yield fossil bones and teeth suitable for collagen and/or enamel apatite isotopic studies, allowing paleoecological reconstruction with high spatial and chronological resolution in the coming years. One question that will certainly benefit from the further isotopic investigations is the Middle to Paleolithic transition, especially by testing the possibility of dietary competition between late Neanderthals and early Anatomically Modern Humans in Europe. The results obtained so far are still ambiguous (Richards et al. 2001 contra Drucker and Bocherens 2004). The addition of new biogeochemical tracers, such as sulfur isotopic signatures, could help to solve these controversies (e.g., Richards et al. 2003). In parallel, a better integration of paleoecological results from different indicators, including isotopic tracers, should allow more robust reconstructions of local environmental conditions, which will be fruitfully compared with paleoclimatic reconstructions based on glacial and marine global tracers. Another promising field of research is the combination of isotopic and paleogenetic data that will help to understand the mechanism of population and species evolution in the changing environment of the Late Pleistocene (e.g., Barnes et al. 2002; Bocherens et al. 2006, 2007).

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Chapter 9
Management of Paleoenvironmental Resources and Exploitation of Raw Materials at the Middle Paleolithic Site of Oscurusciuto (Ginosa, Southern Italy): Units 1 and 4

Paolo Boscato, Paolo Gambassini, Filomena Ranaldo, and Annamaria Ronchitelli

Abstract The authors introduce some preliminary data regarding the lithic industries and the faunal remains discovered at the Middle Paleolithic site Oscurusciuto, situated in the ravine of Ginosa, with several layers of anthropogenic frequentation. From 1998 onwards approximately 60 m² with a depth of nearly 5 m, have been systematically excavated by the Department of Environmental Science G. Sarfatti, University of Siena. This study presents the results obtained from technological and typological analysis of the lithic material from US 1 and from a sample area of US 4. Ungulate remains, characterized by the prevalence of *Bos primigenius*, show a selection of skeletal parts related to the exploitation of long bones for the extraction of marrow and the probable use of epiphysis and articular bones as fuel. For the lithic industry is, beside retouched elements, the entire range of the flaking products present, showing that the entire reduction sequence was carried out on site, exploiting jasper pebbles from a nearby stream.

The study of the technological categories indicates a substantial similarity between the two units considered. The amount of cores has allowed the identification of the operational chains. In both units the adoption of unipolar modality of Levallois technique is prevalent. The discoid technique is present in Unit 4, but completely absent in Unit 1. Through the technological study it has been possible to find the relationship between the knapping sequences and the morphology of pebbles used. The results pointed out by the typological approach confirm the ^{14}C date obtained for US 1 (38,500 ± 900 BP) and the cultural attribution of the lithic industry to a final phase of the Middle Paleolithic as a typical Mousterian rich in scrapers.

Keywords Faunal remains • Lithic industries • Technological/typological analysis • Levallois • Discoid technology

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The Deposit

The Oscurusciuto rock shelter opens on the northern side of a ravine cutting through the landscape surrounding the town of Ginosa (Taranto), immediately to the North of the built-up area, with a N-S orientation (Fig. 9.1). Investigations (1998–2006) were carried out by the Department of Environmental Science "G. Sarfatti" of the University of Siena in co-operation with the "Soprintendenza per i Beni Archeologici of Apulia", the municipality of Ginosa and the local division of Legambiente (Boscato et al. 2004). The ravine opens into Mesozoic limestone, on top of which are found formations of Quaternary calcarenite. Starting with the end of the early Pleistocene, progressive uplift caused the paleorivers to incise the Murgian edge, creating deep and narrow valleys (ravines).

The deposit spreads for approximately 60 m² and, as it was evidenced by the trial trench opened along one of the shelter rock walls, the entire stratigraphic sequence reaches, in its central part, a depth of 5 m (Fig. 9.2b). Excavations interest about half of the area and reached the top of US 9 in the 2006 season. The stratigraphical units at the bottom of the sequence include blocks of calcarenite coming from the rock wall collapse. The sediment, which seems to have been deposited in a relatively short time, is constituted for the majority by sand, and in minor quantities, by breccia.

The group of Units 27–15, with a depth of approximately 50 cm, is made of light grey sandy sediment, which is covered by a hardened carbonated surface. Within this deposit, two levels with charcoal concentrations have been identified, one of which (US 27) is certainly associated with a combustion structure. In between the carbonaceous strata, there are strata with numerous faunal remains and lithic artifacts. Of particular interest is Unit 15, a paleosurface with stones and medium-sized bones, sealed by a thick level of tephra (Units 14–13), probably coming from Campania (analysis are in progress), which would have sealed the camp site when it was abandoned, and therefore preserved the original depositional context of the faunal remains and the artifacts used by Neanderthal people. Stratigraphical Units 12–8, of approximately 25 cm in depth, constituted by

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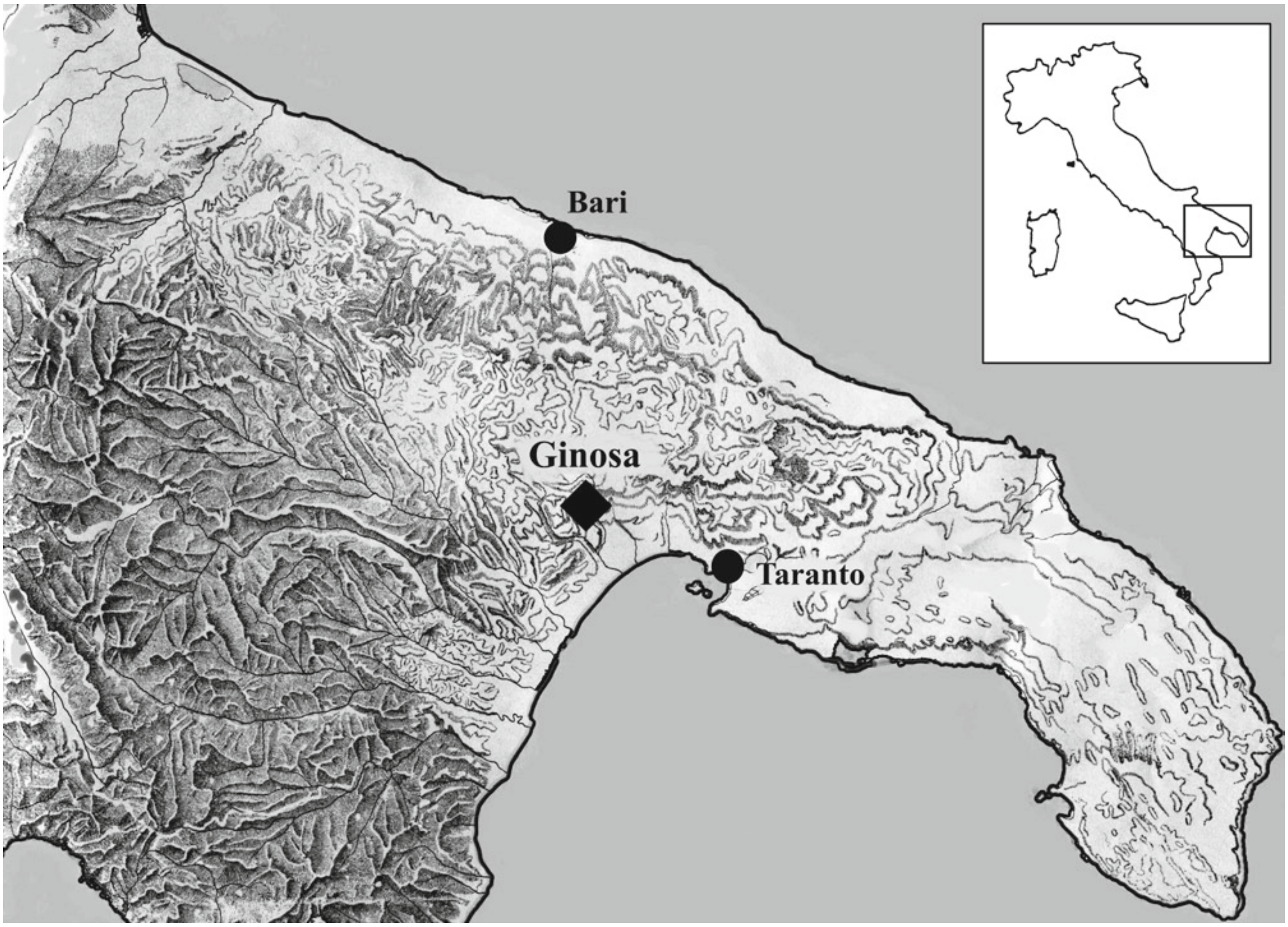

Fig. 9.1 Location map of the site

grey sandy partially concretioned sediment, contain structures and abundant lithic material as well as faunal remains. Unit 8 covers an alignment of small hearths placed in pits.

Subsequent Units 7–4 are characterized by sandy sediment once again, of a yellowish color. Abundant in this phase is the quantity of anthropogenic material recovered. In the N-W corner of the shelter, in Unit 7, a large hearth with a diameter of about 2 m was found, this also structured on a depression filled with dark brown soil (Unit 5), which presents, at the bottom, a level hardened by firing (Unit 6). US 4 shows, on its top, loose medium-sized stones which neither form neither a structure nor a particular alignment (Fig. 9.2a–c). A great quantity of anthropogenic material was found in a sub-horizontal position. In Unit 3, of reddish color sand, lithic artifacts and faunal remains are rare. Units 2–1, once again of sandy composition, respectively dark grey and brown in color, had been reduced by erosion to a narrow strip of deposit, only 100–60 cm wide, which runs along the end wall and constitutes the part of stratigraphy which was visible at the beginning of the investigations. Such levels are particularly concretioned because of calcium carbonate deposits from the percolation of meteoric waters along the rock surface. They include more fragments of calcarenite and abundant faunal remains.

The bottom of Unit 1 was dated (^{14}C on collagen, AMS) to 38,500 ± 900 BP (Beta 181165).

Faunal Remains

The faunal assemblage of macro mammalians recovered from the two Stratigraphical Units analyzed in this work (Units 4 and 1) is composed exclusively by ungulate remains: 40 in Unit 1 and 155 in Unit 4. The absence or extreme scarcity of carnivores characterizes also the middle Units (Unit 2 and Unit 3) in which only a bone of *Panthera leo spelaea* was found (a third phalanx in Unit 2) (Table 9.1). This data, together with the absence of carnivores' gnawing traces on the bones, confirm the anthropogenic nature of the deposit.

As regards Unit 1, the reduced dimension of the survived stratigraphy, limited to the concretioned strip running along the rock shelter wall, is the main cause for the scarce recovery of identifiable remains. In reality, the quantity of bone fragments present in the Unit is very high. These are mainly fragments of long bones without morphological details useful for specific identification. For the post-cranial skeleton, identification

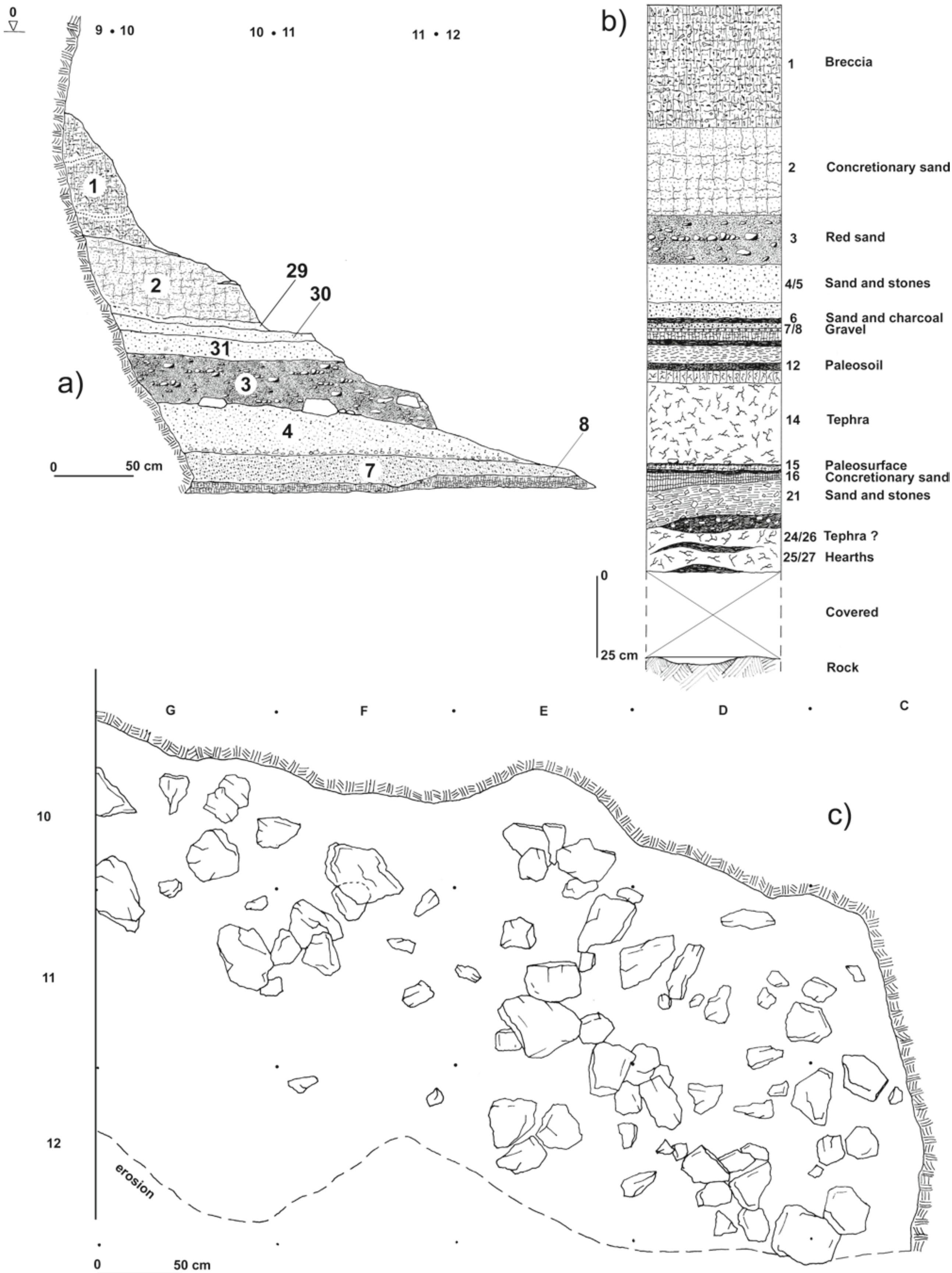

Fig. 9.2 (**a**) Section of the excavated area; (**b**) Schematic stratigraphy with the main units; (**c**) Plan of unit 4

Table 9.1 Identified remains of ungulates and carnivores

	Unit 4		Unit 3		Units 2, 29, 30, 31		Unit 1	
	NISP	%	NISP	%	NISP	%	NISP	%
***cf.* Stephanorhinus**			7	12.3				
Equus ferus	5	3.2	16	28.1	48	25.8	2	5.0
Bos primigenius	114	73.5	15	26.3	82	44.1	20	50.0
Capra ibex	1	0.6	1	1.7	5	2.7		
Rupicapra sp.	2	1.3						
Cervus elaphus	19	12.3	15	26.3	27	14.5	11	27.5
Dama dama	8	5.2	1	1.7	12	6.5	6	15.0
Capreolus capreolus	4	2.6	2	3.5	8	4.3	1	2.5
Cervidae sp.	2	1.3			3	1.6		
Panthera leo spelaea					1	0.5		
Total	**155**		**57**		**186**		**40**	

Table 9.2 Identified anatomical elements of ungulates

	Unit 4		Unit 3		Units 2, 29, 30, 31		Unit 1	
	N°	%	N°	%	N°	%	N°	%
Cranium – mandible – teeth	78	50.3	39	68.4	143	77.3	26	65.0
Scapula	1	0.6			2	1.1		
Long bones	48	31.0	13	22.8	32	17.3	10	25.0
Carpals – tarsals	9	5.8	2	3.5	3	1.6	1	2.5
Phalanges – sesamoids	19	12.2	3	5.3	5	2.7	3	7.5
Total	**155**		**57**		**185**		**40**	

impossibility is linked to both high fragmentation and scarcity of joints and easily recognizable small elements (carpals, tarsals, phalanges, sesamoids) (Table 9.2). Such characters of the animal bone sample are certainly linked to actions carried out by inhabitants of the shelter on the carcasses and on the skeletal parts of the killed animals: (1) selection of anatomical parts (vertebrae and ribs are missing, probably they were left at the killing site and not taken to the camp site); (2) breaking of skeletal elements rich in marrow for the exploitation of this important source of fats; (3) complete destruction of some anatomical elements or parts of them.

In US 4, the presence of limb bones of small dimensions reaches higher values (5.8% for carpals and tarsals, 12.2% for phalanges and sesamoids) (Table 9.2). These figures are higher than those observed at other two Middle Paleolithic cave sites in Apulia: Grotta del Cavallo (Nardò – Lecce) and Grotta di Santa Croce (Bisceglie – Bari) (Boscato and Crezzini 2006). At these two caves, the study of skeletal elements frequency was used to identify some of the differences in bone exploitation between Middle and Upper Paleolithic sites of southern Italy. In particular, the scarcity of phalanges in Middle Paleolithic deposits seems to point at marrow extraction almost exclusively from the long bones. In the Upper Paleolithic deposits, long bones and fragments of phalanges used for marrow extraction constitute a constantly numerous assemblage.

At the Oscurusciuto rock shelter, long bones, highly fragmented, are numerous especially among the unidentified material. Fragments recovered are essentially represented by portions of diaphysis. Remains of aurochs, the ungulate more represented in the Units considered here, consist of long bones such as humerus, radium, femur, tibia and metapodials. These anatomical elements have been recognized from the scarce epiphysis and diaphysis fragments, but also in general, from the great quantity of splinters which, according to their morphology and thickness, could be attributed to long bones of large ungulates. The scarcity of epiphysis, with a spongy bone and rich in fats, could partially be due to their use as fuel. In Unit 4, from the calculation of the minimum aurochs individual number, through the analysis of isolated teeth, it seems that hunting focused on adult animals. Similar data are available at three Final Mousterian sites in central and northern Italy: Tagliente shelter (Thun Hohenstein 2006) and Fumane shelter (Cassoli and Tagliacozzo 1994) in the province of Verona; Breuil cave (Alhaique and Tagliacozzo 2000) on Circeo mountain (Lazio) where there appears a selection towards adult and sub-adult animals. In the case of the Oscurusciuto shelter, however, the quantity of available material is not sufficient to draw a reliable picture of hunting strategies.

Species Frequency and the Environment

The sample of identified bones from Units 1–4 is not made of homogeneous quantities of remains; this however does not prevent to notice in this sequence, clear differences in the distribution of the species in the ungulates assemblages.

Supposing that the hunting territory of Neanderthal groups at Oscurusciuto was subdivided into three main environments (the ravine bottom covered in forests, the vast area higher up with forest steppes and limited rocky areas) it is possible to understand the coexistence in the assemblage of different species (in ecological terms) coming from a probably not very large area.

Of the 155 identified remains from Unit 4, 114 belong to *Bos primigenius*, 15 to red deer, 8 to fallow deer and in minor quantity to horse, roe deer, chamois and ibex (Table 9.1). The prevalence of *Bos primigenius* (73.5%) indicates a particular extent of open environments and forest steppes. Forest ungulates (red deer, fallow deer and roe deer) reach only 20% of the total. In this Unit to be noticed is also the sporadic presence of two mountain species: ibex and chamois.

The subsequent Stratigraphical Unit 3 has provided a limited sample of identified elements: 57 in total, subdivided into 7 ungulate species. In this Unit, find numbers of horse (16), aurochs (15) and deer (15) are nearly equal. There is an ibex bone and some teeth of rhinoceros, which because of their fragmentation could not provide a specific attribution. Fallow deer and row deer are scarcely represented (3 finds in total). In this Unit, the forest species assemblage highlights an increase when compared to Unit 4. Among steppe ungulate species, horse percentage values increased sensitively (Table 9.1), pointing at a dryer climate probably followed by a lower average temperature (presence of ibex and reduction of aurochs and fallow deer).

The group of Unit 2 (Units 2–29 to 30–31), with 186 identified finds, allows a more reliable basis to evaluate the relationship between species. The forest ungulate assemblage, compared with the Unit beneath it, undergoes a slight decrease (26.9% against 31.5% of US 3). To point out is also a reduction of red deer along with an increase of fallow deer, the latter being associated with a temperate environment of Mediterranean type. Among the open environment species, a substantial change concerns the increase of aurochs (44.1% against 26.3% in Unit 3). In this case, cervids and the aurochs-horse group indicate a climatic amelioration, with a contradictory data: the increase, although slight, of ibex, marginal species at this site, but characteristic of open environments in stadial phases.

At the top of the series, US 1 (with 40 identified remains) would point to a continuity of the evolution already detected. Within the forest species assemblage, in this phase, it emerges a further increase of fallow deer, at the same time the gap between horse and aurochs becomes more marked with a sensitive decrease of *Equus ferus*.

The composition of the ungulate assemblage of these four Stratigraphical Units, even though with the bias already mentioned due to the non homogeneous distribution of the finds, seem though to present a landscape/picture characterized by open environments. The ravine bottom can be seen as an island covered in forests within a vast sub-flat region colonized for the majority by herbaceous vegetation. The faunal changes observed would point at a fluctuation to a colder climate in the intermediate Units (Unit 3 and Unit group 2) in between two phases, which tend to a more humid and temperate climate than Units 4 and 1.

The Lithic Assemblage

The study of the lithic assemblage has taken into consideration the items recovered from Unit 1 and a representative sample from Unit 4 which corresponds to 4 m^2 of the excavated surface (Fig. 9.2c). For the latter Unit results are however to be considered as preliminary. Raw material procurement occurred locally, by exploiting pebbles found abundantly in the stream below and on the terrace overlooking the rock shelter. The raw material is characterized by a certain lack of homogeneity due to the presence of fissure plans.

The Lithic Assemblage from Unit 4

Unit 4 is the first deposit not to have undergone substantial erosion and it is therefore the first to have been excavated on a relatively large area. The majority of the lithic material has been found in a sub-horizontal depositional context, 2.1% of it shows burning traces in accordance with the presence of charcoal areas uncovered in this Unit. So far, analysis has taken into consideration 458 artifacts, 25 of which are cores and 86 have been retouched (Table 9.3).

Knapping occurred on site, as it is evidenced by the presence of products resulting from every phase of the reduction sequence: cortex removal, production, exploitation and transformation through retouch; cores are completely exhausted. On site production is also confirmed by refittings. So far eight of them have been identified: among these, two fragments of the same core, one of which continued to be used after breakage, whereas the other was abandoned. Both cores show a functional surface to a Levallois knapping method (Fig. 9.3(5)). Further three refittings, mainly represented by flakes with lateral cortex

Table 9.3 Lithic assemblage

	Unit 4		Unit 1	
	N°	%	N°	%
Unretouched	347	75.8	531	67.7
Retouched	86	18.8	216	27.6
Cores	25	5.4	37	4.7
Total	**458**		**784**	

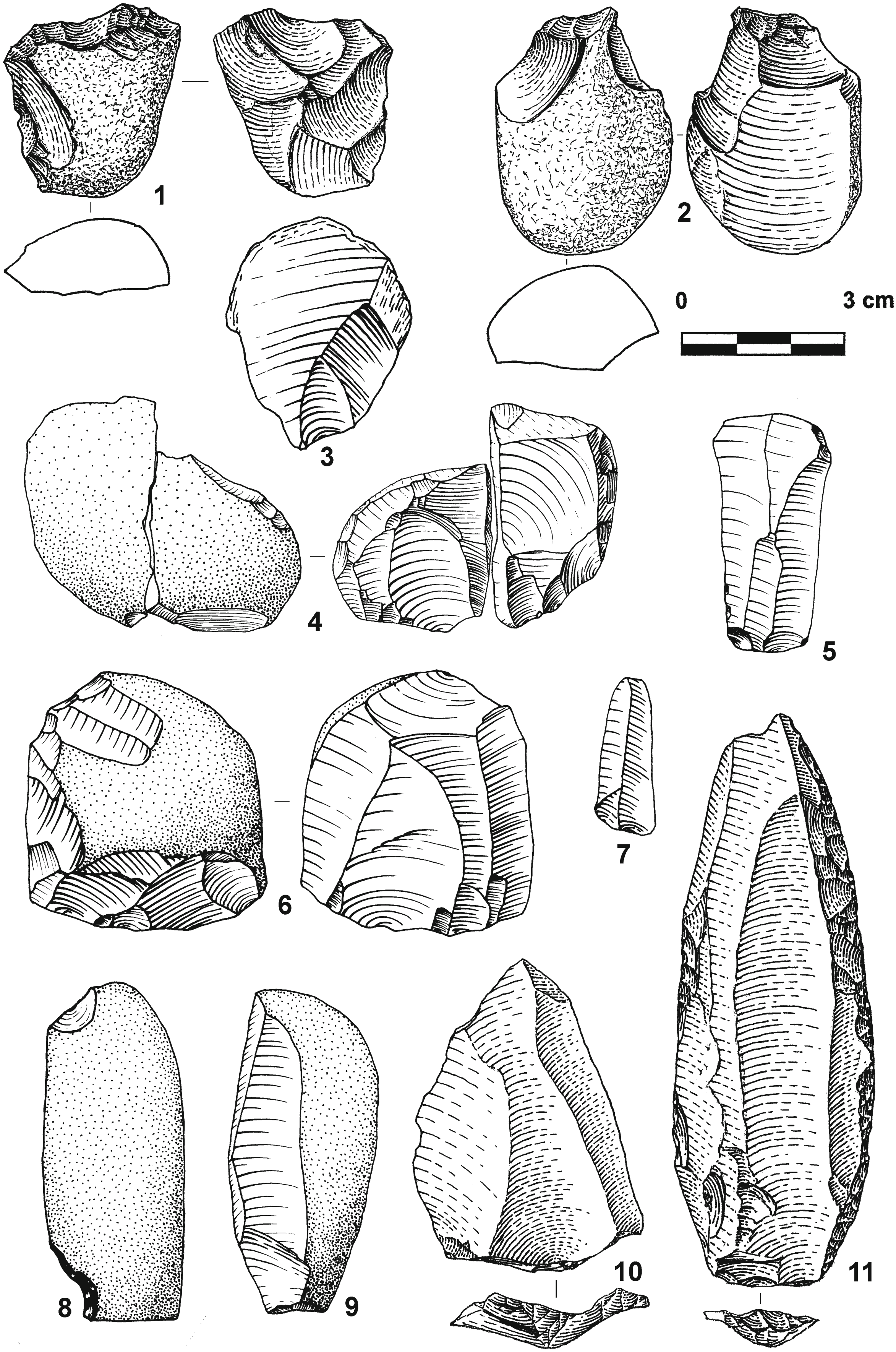

Fig. 9.3 The lithic assemblage from Unit 1 (*1–3*, *5–11*) and Unit 4 (*4*): *1–4*, *6*: cores; *8–9*: cortex removal flakes; *5*, *7*, *10*: products; *11*: long sidescraper (Drawings by G. Fabbri, A. Moroni, F. Ranaldo, S. Ricci)

would point to cortex removal stages or lateral core convexity maintenance. *Apparentements* and *raccords* have been recognized, in particular two corticated crowns: from one of them some decapping flakes were removed, again the other was discarded with no further exploitation. The largely dominant concept is the recurrent Levallois with unipolar, and even though less represented, bipolar modality. Production is expressed by rather flat blade blanks. In the final knapping phases, removal of blanks is converted into a centripetal method which, in one case proceeds by removals no longer parallel but inclined. On 4 cores, flakes were removed with a volumetric orthogonal method. Such flakes are however scarcely or not at all distinguishable from flakes or blade-like-flakes with total or lateral cortex coming from Levallois cores.

Blanks selected for retouch, so far 86, are generally blade-blanks, with a 16% being real blades. Scrapers are dominant (72.1%), and can be subdivided, although with a minimal difference, into marginal and deep, followed by denticulates (20.9%) and points (5.8%) (Table 9.8).

The Lithic Assemblage from Unit 1

The anthropogenic material accumulated against the end wall of the rock shelter is heavily concretioned. Erosion greatly affected this deposit and this is probably the reason for the lack of refittings. Despite this, in this level also, technological elements relating to cortex removal, production, retouching, exploitation up to abandonment, are well represented. Artifacts amount to 784: among these 216 are retouched tools and 37 are cores. In addition there are some thousands debitage flakes coming from the maintenance and rejuvenation of the striking platform and from retouching itself (Table 9.3). Although a considerable part of the lithic assemblage is fragmentary (54%), the data obtained are statistically reliable. The raw materials employed have been so far identified by means of visual criteria: 50.3% jasper, 46.3% flint, 3.4% quartzite (Table 9.4).

Assemblage analysis shows, as it has already been observed in Unit 4, the almost exclusive application of the recurrent unipolar Levallois method. A secondary *chaîne opératoire* sees the utilization of decapping flakes as cores for flakes production. The presence of some pre-cores and of plunging flakes suggests a probable occasional presence of a volumetric orthogonal debitage (Table 9.5).

Table 9.4 Raw materials

	Unit 4		Unit 1	
	N°	%	N°	%
Jasper	287	62.7	394	50.3
Flint	159	34.7	363	46.3
Quartzite	12	2.8	27	3.4
Total	**458**		**784**	

Table 9.5 Technological categories (minimum size 16 mm)

	Unit 4		Unit 1	
Technological categories	N°	%	N°	%
Cortical flakes	115	26.6	100	13.4
Core-edge cortical flakes	55	12.7	180	24.1
Core tablets	10	2.3	16	2.1
Core-edge removal flakes with plain edge	7	1.6	53	7.1
Core-edge removal flakes with prepared edge	6	1.4	10	1.3
Levallois flakes	115	26.6	198	26.5
Levallois points	17	3.9	4	0.6
Pseudo-Levallois points/flakes	5	1.2	4	0.6
Kombewa flakes	–	–	1	0.1
Knapping accidents	24	5.5	51	6.8
Other flakes	79	18.2	130	17.4
Total	**433**		**747**	

The Recurrent Unipolar Levallois Method

Optimization of the method starts by taking advantage of the pebble natural oblong shape. The striking platform is created by removal of one of the ends. Cortex removal continues by direct knapping of flakes and often flake-like-blades lengthwise (Boëda et al. 1990; Boëda 1994; Guette 2002) (Fig. 9.3(7)). Re-establishment and maintenance of lateral convexities relies edge-core flakes, with lateral cortex (Fig. 9.3(8)) or with only one scar on the edge flake. Distal convexity too is maintained by removing a flake with lateral cortex, transversal to the direction of the debitage. A more accurate preparation interests the striking platform so that butts, plain or dihedral, of totally or partially corticated flakes become accurately facetted in the *plain* debitage products. Such phase aims at obtaining flake-like-blades and blades, which tend to be flat and to have convex edges (Figs. 9.3(10) and 9.3(11)). Core surface is organized by means of convergent negatives to allow the removal of Levallois points (Inizan et al. 1995). The debitage shows, from the very early stages, a good level of predetermination and core exploitation which is re-established with minimal waste of raw material, i.e. with a quantitatively occasional presence of maintenance flakes. In the final reduction phases, it is noticeable, already in Unit 4, the tendency to change to a centripetal modality (Fig. 9.3(1)). It is probably due to this change in exploitation sequence the small number of *pseudo*-Levallois flakes present in the assemblage. Cores show an advanced stage of exhaustion.

Also in this Unit, it seems that small pebbles have been used, but not in a systematic way, to obtain small flakes through the exploitation of the natural convexity of the pebble itself, therefore without restricting it to an adequately structured surface. The presence of at least one flake both plunging and edge-core, conceptually refers to an orthogonal approach of exploitation (Fig. 9.3(2)). It is though difficult to confidently speak of a volumetric reduction method, instead of a variation of the Levallois method, especially in the absence of refittings and blanks which could be unmistakably recognized (Grimaldi 1998).

Flake Debitage

A secondary *chaîne opératoire* employs first flakes and thick corticated trimming flakes as cores (Fig. 9.3(4)). Preparation of the striking platform appears rough and from the debitage surface few flakes are removed. However, on some cores it is possible to recognize the application of a more standardized process alternately removing a predeterminating flake, which re-establishes the convexity of one side of the core, and a predetermined flake.

Transformation Phase

Among the debitage elements one can observe (Table 9.6) a higher concentration of flakes (IL = 1.0–1.5), and in general a lower incidence of laminar flakes (IL = 1.6–1.9), blades (IL < 2.0) and bladelets (Fig. 9.3(7)), whereas a selection occurs towards blades and larger-sized elements within the retouched tools (Table 9.7). Retouches, both marginal and deep, interests for the majority the entire edge and it aims at obtaining convex sidescrapers (25.9%) (Fig. 9.3(11)) followed by rectilinear unilateral sidescrapers (Table 9.8).

Table 9.6 Correlation between "widest dimension" and "laminar index" for all unretouched elements of US1 (total 266)

	0.1–0.9		1.0–1.5		1.6–1.9		2.0–2.9		3.0–5.9		>6.0	
Mm/Il	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%
1–15 mm	–		–		–		–		–		–	
16–25 mm	–		59	22.2	12	4.5	1	0.4	–		–	
26–50 mm	–		101	38.0	47	17.7	30	11.3	3	1.1	–	
51–100 mm	–		–		5	1.9	6	2.2	2	0.7	–	
>100 mm	–		–		–		–		–		–	
Total	–		**160**		**64**		**37**		**5**		–	

Table 9.7 Correlation between "widest dimension" and "laminar index" for all retouched elements of US 1 (total 56)

	0.1–0.9		1.0–1.5		1.6–1.9		2.0–2.9		3.0–5.9		>6.0	
Mm/Il	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%
1–15 mm	–		–		–		–		–		–	
16–25 mm	–		1	1.8	–		–		–		–	
26–50 mm	–		23	41.1	8	14.3	3	5.4	–		–	
51–100 mm	–		3	5.4	6	10.7	10	17.8	1	1.8	–	
>100 mm	–		–		–		–		1	1.8	–	
Total	–		**27**		**14**		**13**		**2**		–	

Table 9.8 Retouched elements

	Unit 4		Unit 1	
	N°	%	N°	%
B (burins)	–		–	
G (endscrapers)	–		4	1.8
T (truncations)	–		1	0.5
P (points)	5	5.8	16	7.4
L (sidescrapers on blade)	17	19.8	20	9.3
R (sidescrapers on flake)	25	29.1	67	31.0
L/R (fr. of sidescrapers)	20	23.2	65	30.1
A (sharp retouched)	1	1.2	3	1.4
D (denticulates)	18	20.9	39	18.0
E (scaled pieces)	–		1	0.5
Total	**86**		**216**	

Sidescrapers percentage reaches 70.4% when also fragmentary artifacts are considered; in this assemblage sidescrapers with deep retouches are little more abundant (58.0%) than those with marginal ones. Transversal sidescrapers and lateral-transversal sidescrapers represent respectively 1.3% and 1.8% of the total assemblage. Half of the denticulates group, which in total reaches a ratio of 18.0%, is composed by notches; deep retouch is more frequent (58%). Finally points, represented by a weak index (7.4%), display for the majority a deep retouch (6.7%).

Interpretation

Technological approaches highlighted so far allow placing both lithic assemblages in the same conceptual horizon. The blank production tends to obtain laminar blanks, a goal which is pursued through the standardized reduction sequences capable of taking advantage of the natural morphology of the selected pebbles, and at the same time optimizing raw material exploitation (Fig. 9.4).

Utilization of smaller pebbles (more available in larger quantities in proximity of the site) and decapping first flakes,

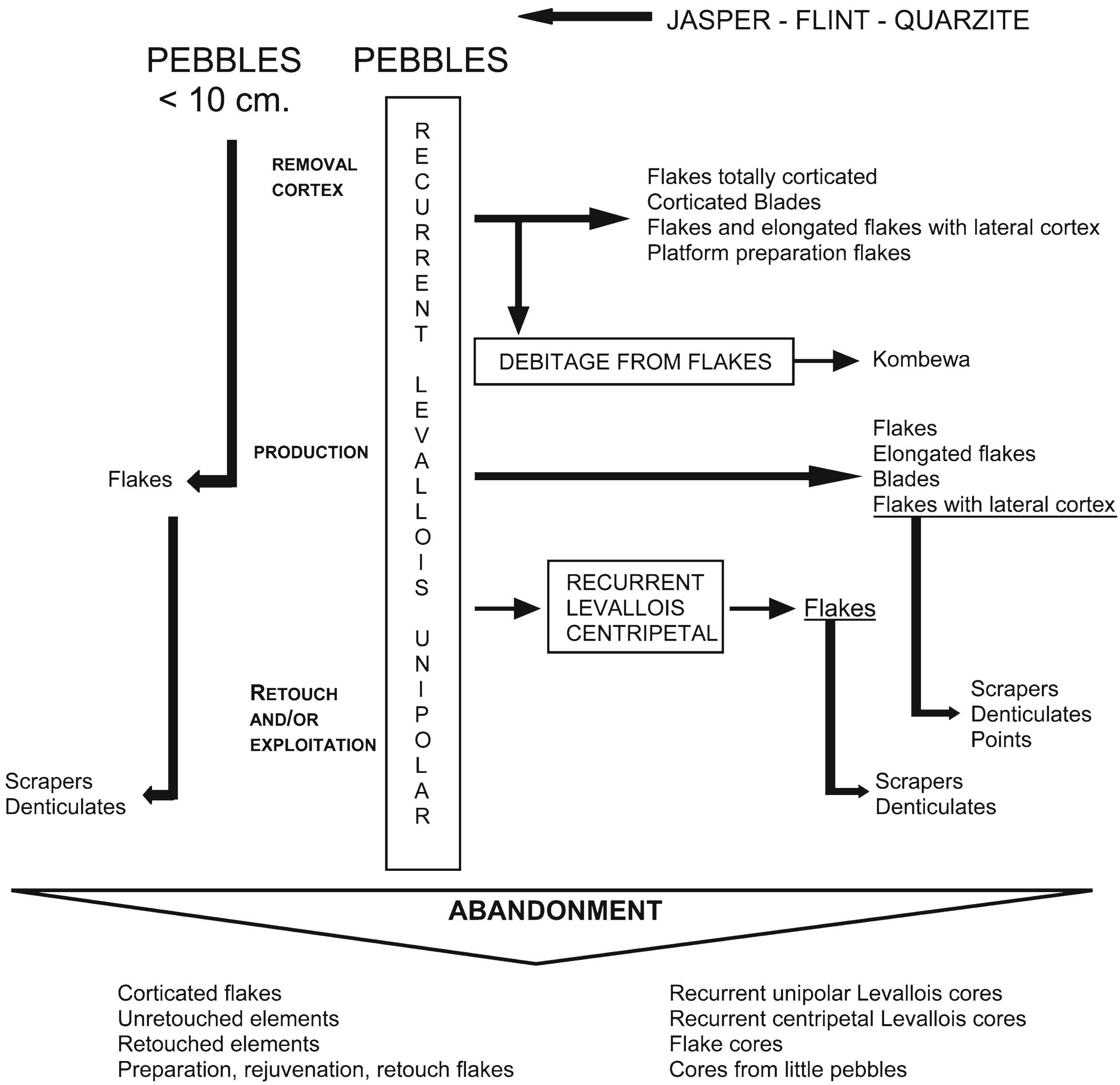

Fig. 9.4 Schematic representation of the technological system of lithic production in units 1 and 4. The secondary production of flakes from pebbles < 10 cm is associated with the principal *chaîne opératoire* (Levallois unipolar recurrent)

in order to obtain a small number of products, seems to refer to occasional exploitation rather than predetermined operational schemes.

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Part III
Neanderthal Cognition and Technological Knowledge

Chapter 10
Neanderthal Technoeconomics: An Assessment and Suggestions for Future Developments

Steven L. Kuhn

Abstract This paper reviews results from economically-oriented studies of Middle Paleolithic technologies. Findings on raw material exploitation have shown conclusively that Middle Paleolithic hominins, mainly Neanderthals, were extremely flexible, able to respond to a range of different constraints on the availability of stone and the organization of tasks on landscapes. Overall, studies of raw material economics show a remarkable level of consistency in modal and maximum distances of raw material transport and in the nature of and treatment of transported artifacts. This indicates that results are methodologically and empirically robust, and reveals important commonalities in hominin behavior. Research on raw material economy may also be limited a widespread focus on aggregate, assemblage-level observations. The next phase of methodological development should concentrate on the use of intra-assemblage variation as a means of investigating internally diversified prehistoric populations. A paradoxical feature of variation in artifact design and investment illustrate the importance of considering intra-group variation in behavior.

Keywords Lithic technology • Raw material • Economy • Mobility • Social organization

Introduction

Two perspectives dominate the study of Middle Paleolithic stone artifacts today. One centers on the characterization of *chaînes opératoires*, particularly methods of blank production. The other investigates the economic dimensions of artifact design, production and use. For the most part, studies of *chaînes opératoires* seek to elucidate choices in artifact production and use that derive from received bodies of knowledge about how to do things, filtered through the cognitive capacities of hominins. Economically–oriented studies of technology aim to understand how the time and energy budgets of hominins and the organization of subsistence and land use influenced technological behavior. Although they employ different theories and models and different methods, these two approaches are not so far apart. Researchers working from both perspectives seek to identify choices made by past humans in the context of making and using artifacts. These choices are manifest in the life histories of stone tools, beginning with raw material procurement and ending with abandonment of artifacts. The main difference is that most studies of *chaînes opératoires* examine what is asserted to be selectively neutral variation, whereas economic studies of technology are concerned with processes of adaptation.

The aim of this paper is to consider some of the things we have learned from economically-focused studies of Neanderthal stone tools, and what we have left to learn. (Other contributors to this book examine the study of *chaînes opératoires*). Economically-oriented research on Paleolithic technologies follows two main themes. The dominant one involves questions of raw material economy, strategies for exploitation, transport and conservation of sometimes-scarce raw materials. The second examines artifact diversity and complexity, and levels of investment in technology. This paper concentrates on raw material economy simply because more research has been done in this area. Results to date from studies of Middle Paleolithic raw material exploitation are generally quite consistent, which is encouraging. However, it may also indicate that we may be reaching the limits of assemblage-based analyses. Following trends in many fields, theoretical and methodological development should focus on isolating behavioral variation within groups and within assemblages. The final section of the paper briefly addresses complexity and levels of investment in Middle Paleolithic technologies. The apparently paradoxical nature of variation in Mousterian artifact "designs" further illustrates the potential importance of intra-group and intra-assemblage variation.

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Raw Material Economics: A Consensus View

A few basic principles and assumptions underpin studies of raw material economies. A central problem for users of stone tools (or any other kind of material culture) is keeping supplied with the implements and raw materials needed in their daily lives. Neanderthals were mobile foragers. Whether they were very similar to recent hunter-gatherers in the ways they used landscapes, or whether they had unique adaptations, is a matter of debate (compare Gamble 1999; Kuhn and Stiner 2001; Henry et al. 2004; Riel-Salvatore and Barton 2004). Nonetheless, Neanderthals had to solve certain problems related to keeping supplied with tools and raw materials. Foraging opportunities, and requirements for tools to assist in foraging or other activities, were scattered in space and time: sometimes they were predictable but often they were not. Meanwhile, raw materials suitable for making stone tools were distributed in a patchy manner, abundant in some places and scarce in others. Moreover, distributions of usable stone and subsistence resources could be entirely independent: the presence of usable raw materials did not necessarily coincide with needs for tools. Even when usable stone and needs for tools coincided there was not always sufficient time to make the necessary tools on the spot. The fact that needs for tools did not always arise when and where raw material was readily available requires that dedicated tool users come up with strategies to maintain an adequate stock of implements.

As of this writing, dozens of studies have examined raw material exploitation in the Mousterian or Middle Paleolithic throughout Europe and the Near East (a partial list includes Tavoso 1984; Geneste 1988a, b, c, 1990; Roebroeks et al. 1988; Wengler 1990; Turq 1992; Kuhn 1992, 1995; Féblot-Augustins 1993a, 1993b, 1997, 1999; Conard and Adler 1997; Roth and Dibble 1998; Otte et al. 2001; Porraz 2005; Slimak 2004; le Tensorer et al. 2001; Tuffreau 2001; Peresani 2001; Uthmeier and Richter 2005; and Baena et al. 2005; see also contributions to Moncel et al. 2007; Adams and Blades 2009). These studies make it clear that Neanderthals, like recent foragers, employed a range of strategies to maintain supplies of artifacts and raw materials. By moving artifacts and raw materials around the landscape, and by taking measures to extend the useful lives of artifacts, they were able to cope with vast range of situations, from the best to the worst kinds of stone, from places where lithic raw materials were abundant to places where they were exceedingly difficult to obtain. Despite the range of environments – geological and biotic – and site situations they encompass, these studies show some remarkably similar themes.

1. If stone is available in the immediate vicinity of a site, artifacts made from the local raw material are almost always numerically dominant (e.g., Geneste 1988a, b, c; Conard 2001). Artifacts from more distant sources are normally present but are seldom extremely abundant (Mellars 1995: 147–153).
2. Neanderthals habitually moved artifacts and raw materials appreciable distances. It is quite common to find artifacts made of materials that come from some 20–30 km from a site. Maximum distances of transport occasionally reach more than 100 km in Western Europe, 200 km or more in eastern and central Europe (e.g., Féblot-Augustins 1997, 2009; Conard and Adler 1997; Slimak and Giraud 2007).
3. Artifacts displaced more than 10–20 km tend to be represented by the final stages of the production sequence, as retouched tools or as Levallois products (Mellars 1995: 147–153) and references therein; Bernard-Guelle and Bressy 2001; Conard 2001; Otte et al. 2001). The more distant a source, the fewer production byproducts are found and the more extensively modified and reworked the tools are. Cores were sometimes transported substantial distances (e.g., Kurbjuhn 2005) but in a given assemblage it is the retouched tools and Levallois elements that are most likely to come from distant sources.
4. There is a recurrent relationship between the density of archaeological deposits, raw material origins, and the kinds of artifacts present in sites. Deposits with a low density of finds tend to contain higher proportions of exotic stones, retouched tools, and/or Levallois flakes and blades (i.e., end-products). Deposits with high densities of archaeological materials tend to contain larger proportions unmodified flakes, cores, and generalized production debris made of raw materials available close at hand (Hovers 2001; Kuhn 2004b; Riel-Salvatore and Barton 2004; contrast Richter 2005 with Uthmeier and Richter 2005).

While these general trends and tendencies are quite robust, the quantitative and scalar dimensions can vary. Two seminal studies of Middle Paleolithic raw material economy are the work of J.-M. Geneste in the Aquitaine Basin of southwest France (Geneste 1988a, b, c, 1990) and J. Féblot-Augustins (1993a, 1997, 1999) comparing central and western European data. Among other things, their work shows that raw material catchments and maximum transport distances can be much larger in central Europe than in southwest France although Féblot-Augustins has recently (2009) revised estimates of the scale of difference. Much of this variability may be attributable to local site formation processes, to the kinds of foraging opportunities available to hominins in different habitats, and to the actual distributions of raw material sources (Féblot-Augustins 1997, 2009).

We can draw some general conclusions about the organization of Neanderthal technologies based on these common trends. First, Neanderthals habitually carried tools and raw materials with them when they moved across the landscape. They also regularly carried artifacts for many consecutive days. Even assuming that artifacts traveled in a straight line from point of procurement to point of discard–an unlikely scenario for many kinds of implements—regular transfer distances in the range of 20–50 km exceed reasonable foraging radii from sites. What this means is that the toolmakers foresaw needs for tools in advance. Whether needs were specific or general is not often clear, though it has been argued that Neanderthals often planned around the unexpected rather than specific eventualities (Kuhn 1992; Uthmeier 2005).

Second, Neanderthals preferentially selected certain kinds of artifacts for transport. Often, but not always, these were Levallois blanks. Large, flat Levallois flakes and points offer the greatest length of edge per unit weight of typical products of Middle Paleolithic production systems. As such, they fit expectations for minimizing weight in transported toolkits (Kuhn 1994; but see Roth and Dibble 1998).

Third, it is well-demonstrated that Neanderthals were able to respond to the availability of stone. They resharpened and reworked artifacts more extensively when stone was scarce, but they could also quite profligate in their use of stone when raw material was abundant (e.g., Jelinek 1991; Dibble and Rolland 1992; Conard and Adler 1997; le Tensorer et al. 2001; Bernard-Guelle and Bressy 2001). They also took care to conserve the utility of artifacts they carried with them in face of artificial scarcity brought on by relying on transported toolkits (e.g., Kuhn 1995; Conard and Adler 1997; Soressi and Hays 2003).

Finally, it is clearly evident that Neanderthals shifted strategies according to local as well as landscape-level constraints. In very short term, ephemeral occupations (low density sites) Neanderthals relied mainly on their transported toolkits. However, as duration of occupations increased (high density sites), they began to supply locations with raw materials from nearby sources, producing larger and denser accumulations of material in the process (Hovers 2001; Kuhn 2004b; Riel-Salvatore and Barton 2004).

The overall picture obtained by studying Neanderthal raw material economics is one of remarkable flexibility. This is well illustrated by research at Kabazi II, in the Crimea (Ukraine) (Chabai et al. 2005). Different layers in this single site provide evidence for divergent technological strategies, from near total reliance of transported toolkits (Richter 2005) to on-site production for immediate consumption (Uthmeier and Richter 2005), sometimes combined in a single layer. Of course, most of what we know of Neanderthal technology comes from studies of stone tools, but emerging evidence from pyrotechnology may suggest a comparable degree of versatility (Rigaud et al. 1995; Pastó et al. 2000).

Although analytically-derived "strategies" of artifact exploitation might seem to map directly onto mental constructs, we should be circumspect in how much we conclude about the cognitive capacities of Neanderthals from these patterns. Recurrent choices from a range of alternative behaviors are construed as strategies by contemporary archaeologists, but that does not mean that they existed as similar constructs in the minds of ancient toolmakers. Moreover, null models characterized by random walk movements and opportunistic behavior can replicate many of the archaeological signatures of Neanderthal, indeed modern human raw material economies (Brantingham 2003). This does not mean that tool makers were behaving randomly: it simply shows that we cannot assume that sophisticated cognitive processes underlie apparently systematic behavior.

However, other independent facts do suggest more sophisticated strategic behavior on the part of the Neanderthals. In particular, there is evidence that they actively manipulated the economic properties of artifacts in the production process. Middle Paleolithic assemblages often contain multiple *chaînes opératoires*, with products destined for different life histories (e.g., Baena et al. 2005; Boëda 1984; Kuhn 1995; Meignen et al. 2009). This is not predicted by a neutral model. More specifically, the selection of particular kinds of artifact for transport, specifically artifacts such as Levallois flakes that present the highest utility/weight ratios (Kuhn 1994), is also not predicted in neutral models. The association between blade production and high levels of residential mobility in the early Levantine Mousterian (Meignen et al. 2005) may be another example, although in this case core productivity rather than blank portability is thought to be the factor that makes laminar production advantageous (e.g., Henry 1995).

It is common practice to contrast the Middle and Upper Paleolithic and to highlight the differences between anatomically modern humans and Neanderthals. This is a useful exercise, in so far as it provides an independent comparison for scales and patterns of variation in Middle Paleolithic techno-economic strategies. There may actually be fewer studies of raw material economy for the Upper Paleolithic than for the Middle (but see Demars 1982; Larick 1987; Geneste 1990; Montet-White 1991; Soffer 1991; Straus 1991; Turq 1993; Féblot-Augustins 1997, 2009; Blades 1999, 2001; Fisher and Eriksen 2002; Kuhn 2004a; Moncel et al. 2007). Nonetheless, it appears that the same kinds of general patterns described for the Eurasian Middle Paleolithic are also found in the Upper Paleolithic. Maximum transport distances may be somewhat greater in some regions, although the very same sources were often utilized in the two periods (Geneste 1988c; Roebroeks et al. 1988; Féblot-Augustins 1993a, 1999, 2009; Gamble 1999: 314–315). What does differ in some cases are the absolute quantities of materials from comparatively distant sources. Some late Upper Paleolithic sites contain great quantities of materials from distant sources, and sometimes it appears that the exotic materials arrived not just as well-used tools but in some bulk form (Schild 1987; Kozłowski 1990; Turq 1993; Svoboda et al. 1996: 94; Gamble 1999: 316; Féblot-Augustins 2009). The implication is that – sometimes at least – these exotic stones were intentionally brought to sites from some distance away for use or further reduction rather than being carried along as part of portable toolkits.

There are several non-exclusive explanations for the fact that some Upper Paleolithic moved larger amounts of flint around the landscape, sometimes even to places where local substitutes were available. We could be dealing with generalized differences in mobility patterns. If some Upper Paleolithic populations undertook fewer residential moves per year, but moved farther between long-term or frequently re-occupied camps, it may have been strategically advantageous to "provision places", to stockpile the best stone at residential sites (Kuhn 1992, 2004a). Another possibility is that there was greater interest in exotic raw materials because of their exoticness. For some Upper Paleolithic groups, exotic flint may have had value as an index of far-flung connections within social networks (Gamble 1999; Féblot-Augustins 2009:45). Among hunter-gatherers, trade networks tend to be isomorphic with social networks. To be clear, we should not ignore the possible role of cognitive factors in explaining the contrasts between Middle and Upper Paleolithic. On the other hand, we cannot assume they are the only viable explanations. A persistent tendency found among a group of hominids could easily reflect common conditions of life or shared history rather than some underlying biological trait.

Looking Beyond the Successes

The fact that such robust results have been obtained in studies of Middle Paleolithic raw material economies, the fact that certain patterns and associations tend to occur in case after case, should be reassuring. It indicates that current approaches are telling us something fundamental about the behavior of ancient toolmakers. Many researchers have been able to replicate the pioneering work of Geneste and others from nearly 20 years ago, and to extend it into very different biotic and geologic environments. Yet, to this writer at least, the level of consensus among studies of Middle Paleolithic raw material economies over the past decade is not entirely positive. In fact, as Torrence observed more than a decade ago (1994), there is a certain degree of stasis in economically-oriented studies of lithic technologies, regardless of region and time period.

One explanation for this phenomenon stems from the models researchers use to understand the record and the methodologies that accompany them. The approaches that we take to the study of Paleolithic raw material are based on certain assumptions. While these particular assumptions are have proven useful, they also limit where this field of inquiry can go next. (I include myself in this collective "we"). Typically archaeologists (Paleolithic prehistorians in particular) take the **assemblage** as the minimum unit of comparisons. Variation in behavior is understood mainly through examination of inter-assemblage variation in archaeological remains. Such approaches have yielded many important and useful insights. However, structuring inquiry in terms of inter-assemblage variation carries with it the tacit presupposition that assemblages are internally homogeneous (Binford 1987; Rigaud and Simek 1987; Kuhn 1994). While few archaeologists would actually support such a claim it is nonetheless inherent in the way we approach the archaeological record.

In fact, we can be certain that archaeological assemblages as commonly defined in Paleolithic sites are not homogeneous. Assemblages consist of collections of items defined on the basis of geological criteria – the characteristics of the sediments that contain them. It is widely recognized that most assemblages from most Paleolithic archaeological sites have accumulated over decades, centuries or millennia (e.g., Stern 1994; Lyman 2003). For this reason alone we should not expect that they record unchanging, uniform behavioral processes. Even the thinnest archaeological horizons may represent more than one occupational episode or event. At the same time, researchers in a range of areas have begun to focus more attention on the fact that human groups are composed of individuals with differing habits, abilities, tendencies, strategies and agendas. Whether one is referring to agency and power relations or to the foraging goals of the members of a hunter gatherer band, the internal differentiation and attendant dynamics within human groups underpin some of the most interesting and persuasive models in anthropology today. This focus on agents or agency is not exclusive to the world of social theory: it is equally important to modern evolutionary perspectives (e.g., Axelrod 2001; Dobres and Robb 2001; Hegmon 2003).

In my view, the necessary next step in studies of the economics of Neanderthal lithic technologies, or any other lithic technological system for that matter, is to develop models of internally differentiated forager groups, along with the means to test them (see also Dobres 2005; Gamble and Porr 2005). Whether such models come from social theory or evolutionary theory, whether they are rooted in the verbal calculus of power relations or in non-linear agent-based formulations is not important. Understanding intra-group variation and how it may have changed over time is as important for evolutionary studies as it is for more socially- or symbolically-oriented research agendas. Ultimately, it would be good to have models coming from a variety of theoretical directions. What is important is that models account for how internal differentiation within small groups would influence dynamics at the scale of resolution available to Paleolithic archaeologists, that is at the scales of decades, centuries, or millennia. This is not an unrealistic goal. Constraints on time, labor and mobility should vary for individuals of different ages, skill levels, genders and assigned social roles. These differential constraints should in turn have influenced how diverse individuals made and used artifacts, how they responded to the challenges of maintaining a supply of raw materials, and to what they contributed archaeological assemblages.

It is impossible to propose a comprehensive program for investigating intra-assemblage variation in the economics of artifact production and use, because the number of potential questions to be asked is so large. A hypothetical example will have to suffice. Starting almost 20 years ago, some archaeologists began to search for evidence of gender roles in lithic assemblages produced by prehistoric hunter-gatherers in the Americas (Gero 1991; Sassaman 1992). They began from the stereotypical, but still broadly valid generalization about mid- and low-latitude foragers, that men hunt and women gather. More precisely, men target large, mobile animals, and women focus their subsistence efforts on smaller but more ubiquitous food packages such as plant foods and shellfish (e.g., Halperin 1980; Kelly 2007; Marlowe 2007). These early studies of materials from the Americas rather simplistically equated bifaces (including projectile points) with male activities, and simple flake tools with women's work. However, granted that the question is of broader relevance, we can also consider the problem more generally, in terms of varying constraints on economics of artifact production and use, rather than limiting analysis to a pair of artifact classes.

In fact, the stereotypical division of subsistence labor implies that men and women had very different scales and frequencies of mobility and different labor schedules (Hurtado et al. 1985; Kelly 1992; Surovell 2000). Because they must move over larger distances in pursuit of large animals, we might expect males to behave more like residentially mobile foragers, depending to a large degree on mobile toolkits or "personal gear". By contrast, women would tend to have smaller foraging ranges, due both to the nature of resources they target and the constraints of childcare (Hurtado et al. 1985; Kelly 1992: 57; Hawkes et al. 1995; Surovell 2000).[1] This would mean that women could be able to depending more on materials stockpiled at base camps. This has direct implications for differences in technological provisioning strategies (Kuhn 1992, 1995) and raw material exploitation. There should be contrasts as well in the scheduling of activities. Conventionally, women's foraging and other activities are more constant and place greater demands on time, whereas hunters have more down time between bouts of intense activity. Thus, we could expect different tactics of artifact maintenance and discard, with fairly constant use, discard and replacement of women's tools, but more episodic "gearing up" in anticipation of male hunting trips. The combination of labor scheduling and mobility might even lead to differences in artifact design, with artifacts linked to male long-range hunting made so as to enhance portability or maximize use lives, and women's toolkits produced with the goal of minimizing time costs. Finally, because of their greater ranges, men would have access to greater variety of material, especially high quality stone.

A model based on internal differentiation in economic roles or other aspects of behavior can only be evaluated and defined using analytical approaches that help to isolating diverse components of assemblages. Such an undertaking requires methodologically consistent ways of partitioning an assemblage's different constituents. Isolating evidence diverse economic roles in lithic assemblages is not just a matter of measuring variation, of recognizing that some artifacts were completely used up while others had very short lives, or that some tools were moved long distances and others produced on site. We expect a certain degree of variability within any assemblage created by mobile toolmakers, especially when that assemblage accumulated over a long period of time, under varying conditions. What is more significant is the partitioning of variation, the degree of *independence* among artifact life history trajectories. Convincing evidence that artifacts reflected differing social or economic roles would come only from consistent *associations between* artifact forms, resharpening/maintenance, and perhaps raw material selection.

In fact, a whole battery of methods can be recruited to this task, and no single one will suffice. Some of these are obvious. Spatial patterning has been used to isolate discrete events or activity sets within archaeological levels (e.g., De Loecker 2005; Pope and Roberts 2005 for two of many such studies). Although this approach can be fruitful one, it requires extraordinary conditions of site preservation as well as extensive excavations, meaning that it is impractical in many situations. Conjoining or refitting studies have become increasingly important in recent years, particularly in the study of *chaînes opératoires*. Interestingly, despite the fact that they capture technological behavior at the very finest scale, refitting studies have most often been turned to describing general modal tendencies rather than variability within assemblages. Some remarkable studies show the method's enormous potential for evaluating variation among individual knappers (e.g., Bodu et al. 1987). Here again, the success of refitting as an analytical technique hinges on excellent stratigraphic definition and horizontally extensive excavations, conditions not always met in Paleolithic sites. Even where extensive refitting is impossible methods such as "transformational analysis" (Uthmeier 2004) or "minimal analytical nodule" analysis (see papers in Hall and Larson 2004) provide other means of identifying different episodes or linked sets of episodes within aggregate assemblages. These methods rely on isolating products associated with individual nodules. One of their strengths is that they highlight what is absent as well as what is present, thereby focusing attention on the

[1] This is not to imply an evolutionary link between mobility strategies and psychological propensities for wayfinding (e.g., Silverman et al., 2000). It is enough to postulate differences in habitual behavior, not inherent abilities.

completeness of individual production sequences and the distribution of different activities across a landscape. As is apparent from the discussion of men's and women's strategies, studies of the life histories of particular artifact forms, such as patterns of reduction or reworking, are another avenue for identifying internal variation tied to the actions of different kinds of actors or agents, especially when combined with evidence for transport and production strategies.

Similar methodological proposals have been made in the context of studies attempting to isolate the individual in the Paleolithic (see contributions to Gamble and Porr 2005). There is a subtle but important difference between studying intra-group variation and seeking evidence of individuals in prehistory. Theories of internally differentiated groups are almost always structured in terms of a few different *kinds* of person, occupying different social or economic roles or displaying different capacities, and not an infinite array of unique individuals. Both pursuits depend on isolating particular episodes of artifact manufacture and use, or the life histories of specific nodules or implements. For studies focusing on identifying individuals, these are the ultimate goal. To investigate variation in economic or social roles, to look for evidence that groups were composed of individuals playing different parts within a group, requires documenting a set of common tendencies and recurrent associations among these singular episodes or events.

This consideration of intra-group and intra-assemblage variation is admittedly abstract and hypothetical. It is difficult to point to concrete case studies where this kind of economic differentiation has been well documented. The aim here is simply to emphasize for its importance, and how it might be approached analytically. The case of broadly-defined male and female foraging roles was introduced as an example of the kinds of intra-group variation that one might want to investigate. Given that it was so nearly ubiquitous among recent foragers, the simple existence of division of labor by gender may not be a question of great interest in many situations. However, the next section of the paper shows one context where it would be well worth investigating this sort of economic diversity within ancient social groups.

Artifact Complexity and Investment: An Anomaly

The second major theme in economically-oriented studies of Paleolithic technologies focuses on questions of artifact design and investment in technology. Questions about tradeoffs between the costs of tools and the functional benefits have been a point of theoretical emphasis for behavioral ecologists interested in material culture (e.g., Bright et al. 2002; Elston and Brantingham 2002; Ugan et al. 2003; Bettinger et al. 2006). There has been much less work of the designparameters and levels of investment in Middle Paleolithic artifacts than there has been on raw material use, perhaps because of the general impression that there is not very much to study (but see Shea 2006). However, variation in complexity and elaboration of hunting weapons (or the lack thereof) illustrates the general perspective. It also presents a seeming paradox that emphasizes the importance of investigating variation within social groups and assemblages.

Economically-oriented studies of technological investment and artifact design all refer back to some degree to W. Oswalt's pioneering work on variation in the complexity of traditional technologies among ethnographically documented peoples (Oswalt 1976). Oswalt showed how the complexity and ultimately the cost of subsistence technology associated with hunting and fishing increased with latitude. Northern groups depended heavily on large game, fish and marine mammals, and they often produced extremely elaborate technological aids to the capture of these resources. Nearer the equator, where diets were broader (and people more mobile) foragers produced less diverse, less complex (and more portable) toolkits. Explanations for differential complexity and diversity in recent forager technologies assume that more elaborate toolkits and artifacts are more efficient, and that people invest in producing them when there is some in-kind economic payoff, such as increased efficiency or decreased risk of failure. The manufacture of more costly hunting and fishing tools in northern latitudes makes sense because these pursuits play a more important role in subsistence in the north, and more effective tools and weapons would eliminate some of the risks associated with such economies. Other researchers have refined and extended these observations for archaeological applications (e.g., Torrence 1983, 1989; Bleed 1986; Shott 1986; Bousman 1993; Bamforth and Bleed 1997; Elston and Brantingham 2002).

Some scholars question the relevance of evidence from early ethnographies to understanding the behavior of Paleolithic humans, and some of their criticisms are valid. However, the ethnographic literature has fundamentally influenced how we think about forgers, and we can no more reject it categorically than we can ignore the way our native languages influence they ways we categorize the world. The best we can do is keep our use of these models explicit, open to the critical scrutiny of ourselves and others. In practice, variation among ethnographically documented foragers should be a baseline for comparison with archaeological cases, not a means for filling in the blank spots in the archaeological data. We should not expect Neanderthals, or early modern humans for that matter, to behave just like hunter-gatherers of the nineteenth and twentieth centuries. In fact, the deviations from these expectations are really of greatest interest.

The same kinds of trends and tendencies that Oswalt documented among recent foragers can be observed in the later

Upper Paleolithic and Epipaleolithic of western Eurasia. There is greater elaboration of and/or investment in hunting and fishing technology in northern latitudes, particularly as concerns bone, antler and ivory components of weapons. In parallel, there is greater diversity of an investment in plant processing technology in the Mediterranean area (Kuhn and Stiner 2001). At this point in time, ambiguities with dating, taxonomic problems, and the comparatively small number of cases make it difficult to discern whether similar patterns are manifest in the early Upper Paleolithic. In any case, this comparison is explicitly not intended as a comment on behavioral continuity or disjunction between Neanderthals and later *Homo sapiens.* The reference here to the late Upper Paleolithic is simply to show that the patterns described by Oswalt and others can be observed archaeologically.

What is more surprising is that levels of complexity and elaboration in Middle Paleolithic assemblages attributed to Neanderthals them do not seem to covary with latitude or environment more generally. Investment in tools is comparatively low overall, insofar as we can know from the preserved components of Middle Paleolithic toolkits. Middle Paleolithic artifacts are simply constructed, with small numbers of component parts. Materials such as bone and antler, which require more time and effort than stone to modify (e.g., Knecht 1997: 200; Margaris 2006), are not utilized to any significant extent in the Middle Paleolithic, though they do appear in some assemblages associated with very late Neanderthals (d'Errico et al. 1998, 2003). Even among potentially functionally specialized artifacts, such as putative spear points, it is difficult to find an increase in complexity, elaboration or cost with latitude. Middle Paleolithic hominins seem to have relied on large, thrust or hand-thrown spears with simple stone points (Shea 2006). In a similar vein, a recent study shows that assemblage diversity, which should also be correlated with toolkit and activity diversity, shows surprisingly little response to climatic fluctuations in the Middle Paleolithic (Bocquet-Appel and Tuffreau 2009).

The seemingly "flat" patterns of technological investment and complexity in the Middle Paleolithic cannot be attributed to a lack of accumulated technical knowledge among Neanderthals. Arguably every technique used to make the most elaborate Upper Paleolithic weapons and implements was within the technological competence of Neanderthals. They made simple composite artifacts, showing that they could join products of multiple technological procedures in an ordered, sequential, "grammatical" way (Shea 1988, 2005; Boëda et al. 1999; Ambrose 2001; see also Wynn and Coolidge 2004). They harvested mineral adhesives and even manufactured mastics from plant materials (Grünberg 2002; Boëda et al. 1998; Koller et al. 2001; Mazza et al. 2006). Finds such as the Schöningen spears (Thieme 1997) and the wood artifacts from Abric Romaní (Castro-Curel and Carbonell 1995; Vaquero et al. 2001) demonstrate that Neanderthals and their antecedents at least knew how to work with fibrous composite materials such as wood, bone or antler. And of course Neanderthals had regular access to bone and antler from the animals they preyed upon. They simply did not put these skills and procedures together the way later populations in northern Eurasia did. Nor can one explain the low overall investment in hunting tools by asserting that large game was not important to Neanderthals. Arguments about the predatory skills and habits of Neanderthals have come full circle in the last 20 years. There is widespread agreement from zooarchaeological findings as well as evidence from stable isotopes that large terrestrial animals formed the mainstay of Neanderthal diets throughout their range (e.g., Richards et al. 2000; Stiner 2002; Bocherens and Drucker 2003; Kuhn and Stiner 2006; Bocherens 2011; Gaudzinski-Windheuser and Roebroeks 2011).

An alternative explanation for the fact that Middle Paleolithic groups did not find the same advantages in costly and elaborate technologies as did later people can be found in the organization of labor within groups. Elsewhere, a colleague and I have argued that, for most of their history at least, division of labor by gender (and perhaps age) was generally not as pronounced among Neanderthals as among recent foragers – including Upper Paleolithic populations – living in similar environments (Kuhn and Stiner 2006). We proposed that, rather than dividing into specialist task groups to harvest a range of different resources, all members of social groups participated together in many subsistence activities, the most important being the hunting of large game. Cooperation of the full group would facilitate driving, surrounding and confusing prey animals, making them easier to dispatch at close range using simple spears. Returning to the question of artifact design, what this implies is that Middle Paleolithic groups could have increased the reliability of their hunting by enlisting larger numbers of people, rather than by investing in the production of more costly weapons. Continuing with this line of argument, the increased investment in material aids to hunting during the Upper Paleolithic could reflect a trend toward greater levels of specialization within groups. Smaller hunting (or foraging) parties would have had little choice but to bear the cost of more expensive artifacts in order to make up for the lack of human helpers. In the absence of options for larger scale cooperation, the payoffs from elaborate weapons would have justified the cost of producing them (specialization in manufacture and the differential distribution of skill is another issue beyond the scope of this paper).

Returning to the theme introduced at the end of the previous section, understanding intra-assemblage variation in technological strategies could be vital to testing hypotheses about the behavior of Middle Paleolithic hominins. The proposition that all members of Neanderthal social groups participated together in hunts (and by extension, other subsistence-related activities) implies that individuals tended to spend more time together, in the same places, doing the same things, than more recent foragers. Individuals of different ages and genders would have experienced relatively uniform levels of mobility and enjoyed fairly equal access to raw materials. This would reduce intra-group variation in strategies of artifact manufacture and raw material use, and should lead to assemblages that – while not necessarily homogeneous from an economic perspective – do not contain well defined and separate trajectories of artifact design and raw material management. In contrast, members of later foraging groups with sharply differentiated roles in food collecting and other activities would experience quite different levels of individual mobility, time constraints, and access to raw materials. Highly differentiated economic roles should thus enhance intra-group (and intra-assemblage) variation in the economics of raw material exploitation and artifact use. More specific expectations for technological strategies associated with different foraging roles have already been described in the previous section. What is most important is that the hypothesis for changing subsistence roles in Paleolithic societies predicts that technological strategies should be partitioned into distinctive and independent artifact life histories or *chaînes opératoires* in assemblages created by groups with strongly differentiated foraging roles, but that variation within earlier Middle Paleolithic assemblages should be more continuous, and less clearly canalized.

Conclusion

Studies of the economics of artifact production and use have taught us a great deal about Neanderthals. They have revealed a level of behavioral flexibility that has surprised some researchers. In doing so, they have countered all older stereotype of Neanderthals as rigid and incapable of change or innovation. Overall, the pace of technological change may be slower in the Middle Paleolithic than in later periods, something that could be attributable to demographic factors (Shennan 2001; Powell et al. 2009) as well as to cognitive ones (e.g., Wynn and Coolidge 2004; Amati and Shallice 2007; Klein 2009). Nonetheless, the ways Neanderthals responded to the challenges of keeping themselves supplied with tools and raw materials on uncertain and changing landscapes are an important piece of the puzzle, crucial to understanding how these hominins managed to establish and maintain populations in such a wide range of sometimes harsh habitats.

In arguing that conventional, assemblage-based studies of raw material economics have become somewhat static I certainly do not mean to imply that they are outmoded and unproductive. Indeed, new cases accumulate and new sites are documented every day, and they will continue to produce useful and interesting results. Previous syntheses comparing time periods and regions (e.g., Roebroeks et al. 1988; Féblot-Augustins 1999, 2009) have had to rely on the limited range of information common to most primary studies: principally this has been maximum distance of transfer. As the range of detailed analyses of Paleolithic raw material economics continues to expand it will be possible to provide this sort of broad synthetic treatment for a wider range of phenomena, such as preferential selection of certain items for transport, or strategies for extending the lives of transported artifacts. If the database are not already sufficiently developed to use raw material catchments for comparative studies of environmentally-linked variation in territoriality and foraging ranges (e.g., Brantingham 2006; Hamilton et al. 2007; Grove 2008), it soon will be. The end result will be an even deeper understanding of the capabilities and limitations of Neanderthals (and other hominins) in the face of a range of ecological challenges.

At the same time, it is important to recognize that limitations on what we know about Neanderthals are not just a matter of what we haven't yet excavated, but also reflect how we construct and think about the evidence. Social scientist and evolutionary biologists alike are increasingly engaged with theories founded on the assumption that societies are composed of agents and actors pursuing differing aims and operating under different sets of constraints. These theories are already finding their way into research on the Paleolithic in such diverse areas as research on gender studies and agent-based evolutionary models (Dobres 2005; Gamble and Porr 2005). As useful as they are, the assemblage-based studies that characterize most Paleolithic research are not well suited for solving these new kinds of problems. It would be in our best interest to explore ways of testing and refining those theories based on variation in the lithic technological evidence. Clearly, this paper has raised many more questions than it has answered, and its methodological suggestions are admittedly quite broad. The hypothetical example of gender-based division of labor is also just one many kinds of intra-group variation one might seek to investigate, and perhaps not the most important one. The same principles could be applied to questions of variation linked to age or skill levels, anywhere in fact that one can anticipate varying economic constraints on behavior. This mild critique of the state of the field is intended to stimulate further discussion and certainly not to settle the question.

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Chapter 11
Blade Production in the Early Phase of the Middle Paleolithic at Bapaume-Les Osiers (Pas-De-Calais, France): Comments on the Distinction between the Early and Late Phases of the Middle Paleolithic

Héloise Koehler

Abstract Emerging already in OIS 8, the Middle Paleolithic covers a period of around 300 kyr, divided into two distinct chronological phases: the Early Middle Paleolithic from OIS 8 to 6, and the Late Middle Paleolithic, from OIS 5 to 3. It would appear that a certain technological behavior differentiates these chronological phases: non-Levallois blade production. Such reduction has been shown to be more or less clearly individualized during the late phase of the Middle Paleolithic in northern Europe. However, laminar evidence also appears sporadically starting at the end of the Middle Pleistocene, between OIS 8 and 6. What characterizes such blade production? Can it be distinguished from that seen in the late phase of the Middle Paleolithic? Do we see here the first fruits of technological activity that would be subsequently developed? In order to contribute to this discussion, we present results of analysis of the lithic industry from Bapaume-les Osiers, in Pas-de-Calais (France), which has yielded an assemblage which includes blade production, positioned stratigraphically between OIS 7a and 6, and thus in the early phase of the Middle Paleolithic.

Keywords OIS 7/6 • Non-Levallois blade production • Volumetric conception • Northern Europe

Introduction: The Increasingly Earlier Beginning of the Middle Paleolithic

In northern Europe at least, the scientific community now accepts that the emergence of Middle Paleolithic traditions is contemporaneous with oxygen-isotope stage 8 – between 200 and 300 ka (Tuffreau 1979, 1992; Callow 1986; Antoine 1990; Villa 1991), a period previously attributed to the Upper Acheulean. Many recent discoveries dating to OIS 8–6 have revealed the existence of "Mousterian" industries with well-developed Levallois methods and the production of points. These include the sites of Mesvin IV in Belgium (Cahen and Haesaerts 1981; Soriano 2000), Pucheuil, layer B in Normandy (Delagnes and Ropars 1996) and Bagarre in Pas-de-Calais, France (Tuffreau et al. 1975; Boëda 1994). These industries are sometimes associated with Neanderthal remains, as at Biache-Saint-Vaast in Pas-de-Calais, France (Tuffreau and Sommé 1988; Boëda 1994). The Middle Paleolithic has thus become increasingly older and covers an excessively long period of around 300 kyr. In consequence, it has been divided into two distinct chronological phases: the Early Middle Paleolithic of Saalian age, from OIS 8 to 6, and the Late Middle Paleolithic, from OIS 5 to 3, contemporaneous with the Early and Middle Weichselian (Fig. 11.1).

Of interest now is to determine whether technological variability can be identified within and between these two chronological groups. What differentiates these two phases of the Middle Paleolithic?

Blade Production: Technological Behavior Unique to the Late Middle Paleolithic?

It would appear that a certain technological behavior differentiates these chronological phases: non-Levallois blade production. Such reduction has been shown to be more or less clearly individualized during the late phase of the Middle Paleolithic in northern Europe. We speak of "blade production of the Early Weichselian in Northern France", mainly discovered in northern sites during OIS 5, around 90 ka (Tuffreau 1983; Cliquet 1994; Révillion 1995; Locht 2002). However, laminar evidence also appears sporadically starting at the end of the Middle Pleistocene, between OIS 8 and 6, in the early phase of the Middle Paleolithic. What characterizes such blade production? Can it be distinguished from that seen in the late phase of the Middle Paleolithic? Do we see here the first fruits of technological activity that would be subsequently developed?.

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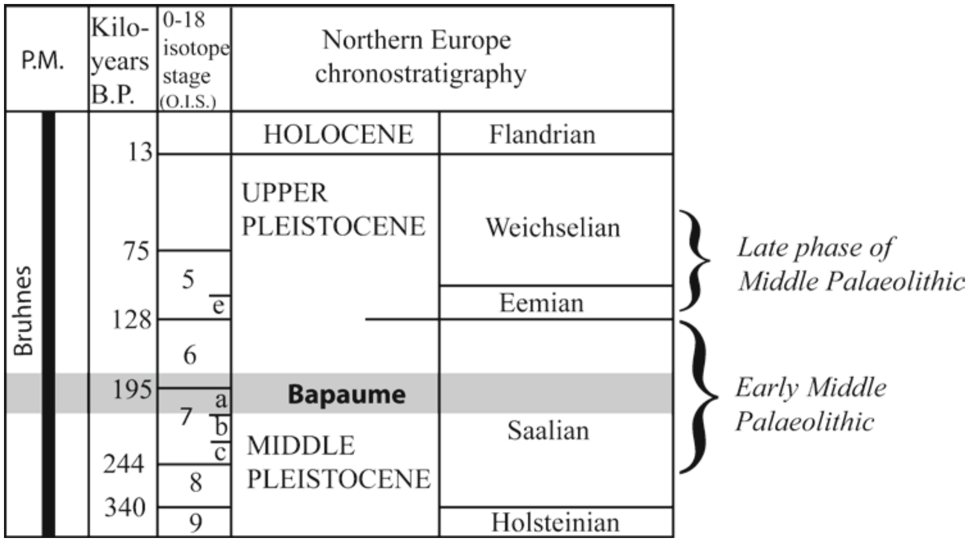

Fig. 11.1 Chronostratigraphic summary for Northwest Europe and the site of Bapaume-les Osiers (Modified after Antoine 1990)

In order to contribute to this discussion, we present results of analysis of the lithic industry from Bapaume-les Osiers, in Pas-de-Calais (France), which has yielded an assemblage which includes blade production, positioned stratigraphically between OIS 7a and 6, and thus in the early phase of the Middle Paleolithic.

The Site and Its Industry

The Site of Bapaume-Les Osiers

Bapaume-les Osiers is an open-air site in the loess region of Northern France, within the boundaries of Artois and Cambresis, on the plateau of the Seuil de Bapaume, which marks the limit between the valleys of the Somme and the Escaut (Fig. 11.2).

The site was discovered after the digging of a water infiltration basin during construction of the North A1 highway in 1966 (Tuffreau 1976). Artifacts were first collected in 1968, followed by excavation by A. Tuffreau in 1972, making it possible to recover a large assemblage and determine the precise chronostratigraphic context of the site (Tuffreau 1972). Excavation took place in a zone of around 15 m² at the base of the talus cut of the highway. The talus profile was cleaned along a length of 18 m to a height of around 7 m, exposing a sequence of Weichselian deposits overlying the Eemian interglacial soil which developed in Saalian loess (Fig. 11.3). Two strata of ancient loess are present above the substrate, separated by sporadically cryoturbated gravel that reworked a paleosoil (dark brown clayey silt). A lamina of loess probably corresponding to a paleosoil was trapped within this gravel (to the right of the profile, Fig. 11.3). Two artifact assemblages were recovered, one from the gravel layer and the other from the remnants of the paleosoil, with series B evidencing a remarkable freshness. Series B would have been deposited after the gravel and dates to the second half of the Saalian, more specifically to the end of OIS 7 (sub-stage 7a) or to the beginning of OIS 6, based on chronostratigraphic data and confirmed by recent thermoluminescence dates on the loess sequences (Tuffreau 1976; Balescu and Tuffreau 2004).

The series B assemblage has yielded a varied range of production techniques, including blade production associated with predominant Levallois reduction, significant production of points, minor discoid reduction and rare bifaces of "Acheulean" type (Table 11.1).

Production of Elongated Blanks at Bapaume-Les Osiers

The blade cores at Bapaume were prepared using a new volumetric conception of reduction with respect to the preceding period. A block was held along its length and reduction carried out along its thickness, in contrast to surface reduction as is done with the Levallois method. Thin invasive flakes such as those produced by Levallois were no longer sought, but rather elongated products, with a given thickness and a trapezoidal cross-section. Some of the cores produced

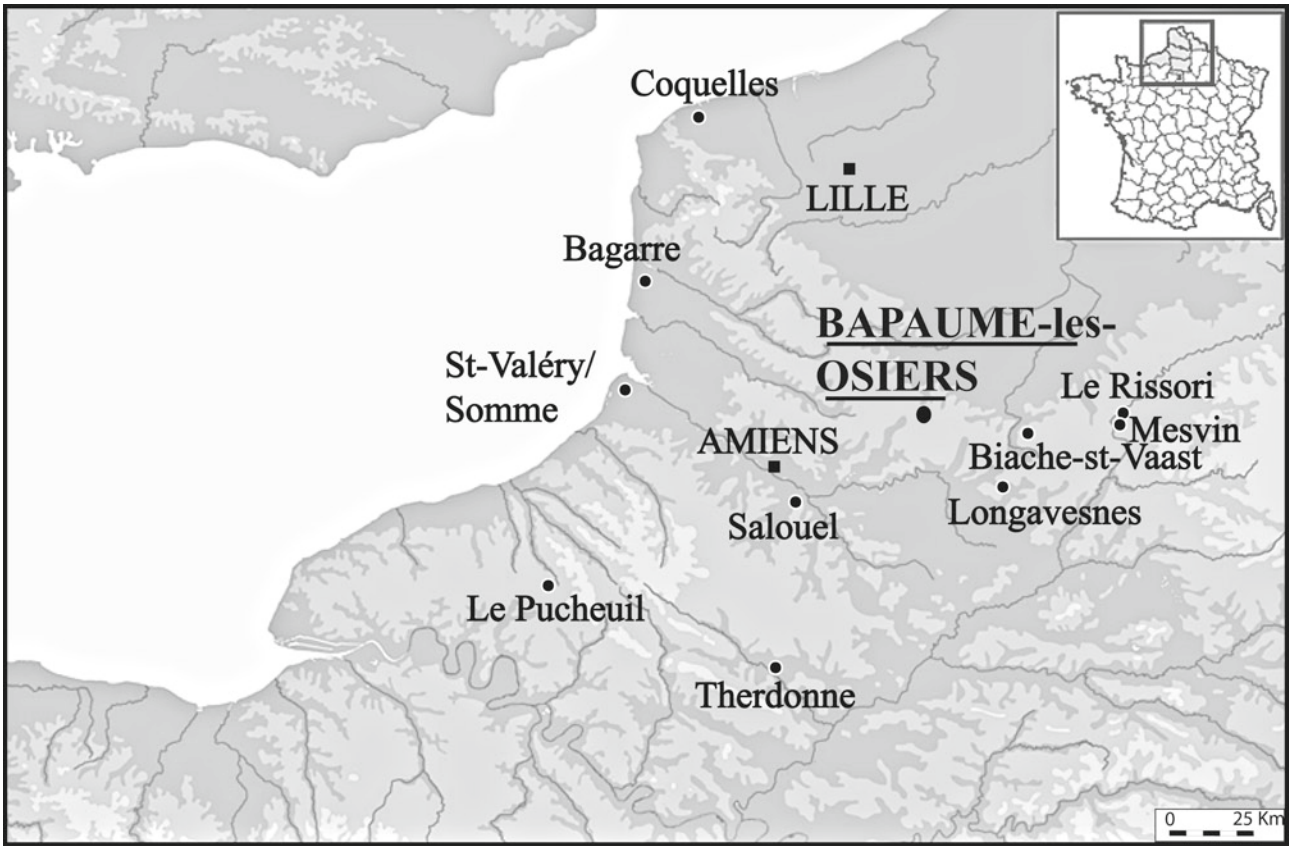

Fig. 11.2 Location of Bapaume-les Osiers and main sites of the Early Middle Paleolithic in Northern France (Modified after Locht et al. 2001)

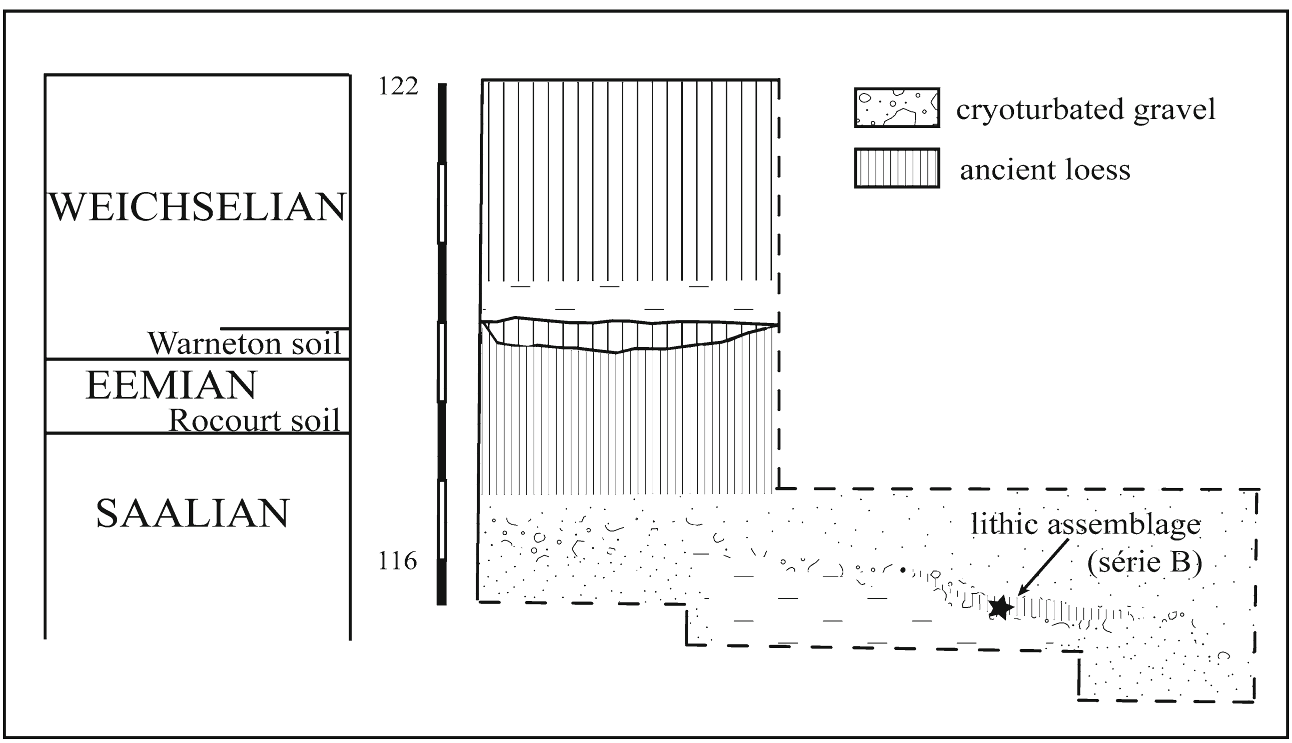

Fig. 11.3 Stratigraphical profile of the site of Bapaume-les Osiers and chronological framework (Modified after Tuffreau 1976)

Table 11.1 Series B assemblage structure from Bapaume-les Osiers

Production (cores + flakes)	*n*	%
Levallois	320	57
Points	27	4
Discoidal	16	3
Laminar	63	11
Cortical flakes	116	20
Bifaces	9	1.5
Indeterminate	21	3.5
Total	572	100

fairly thick, irregular laminar flakes that were only slightly standardized. By contrast, other cores produced regular standardized blades. Moreover, production of very small blades/bladelets is also attested. Evidence of direct hard percussion has been observed in the assemblage for blade production. Cores have deep, marked bulbar scars, a fairly open angle between the striking platform and the flaking surface (close to 80°), traces of faceting and an absence of core preparation *en éperon*. Products have thick platforms, prominent bulbs and significant faceting, without, however, isolating a spur, and a near-absence of lipped platforms.

Production of Laminar Flakes

Four cores produced laminar flakes. They were unprepared or only slightly so, sometimes exploiting natural oblong or cylindrical morphology to obtain elongated blanks from the length of the block. Some show traces of preparation of the flaking surface via transversal or bidirectional removals creating steep convexities on what could be termed the "flank" of the core (Fig. 11.4). Longitudinal removals were then extracted, following ridges created by the transversal removals. The products obtained were very thick and elongated with a trapezoidal cross-section (Fig. 11.4).

Blade Production

By contrast, two cores strongly resemble laminar volumetric conceptions from the Upper Paleolithic (Fig. 11.5). The raw blocks were clearly prepared, notably by transversal removals creating a crest and keel. Use of the crest is attested by two secondary crested blades (*lames sous crêtes*). Reduction was bidirectional and rotated around the core. Striking platforms are slightly misaligned on the two extremities of the block, making it possible to exploit the core flanks for maximum productivity. One core shows evidence of successive bidirectional reduction, meaning that blades were first removed from one direction, then a series of removals from the opposite striking platform (Fig. 11.5a). Both striking platforms were created during the initial preparation phase of the block. Another core shows the use of alternating reduction, meaning that the two striking platforms were exploited simultaneously alternating after each removal (Fig. 11.5b). Blades were removed following a crest and keel, learly created by transversal removals (crest?). Such cores would have been fairly productive, as evidenced by the numerous removal scars, and variability in the size of products obtained.

Blades are quite common in the assemblage and show significant morphometric differences ($n = 35$, or 14% of the assemblage). Large cortical blades are present, as well as blades from the active blade production phase, smaller blades and many medial and distal fragments from elongated rectilinear products (Fig. 11.5). These products have two or three removal scars on the dorsal face creating ridges that guided the shock wave. Such ridges are rectilinear and thus aided in making the removals longer. Thickness is fairly important. All of these product traits support a non-Levallois concept of reduction.

Bladelet Production?

Furthermore, a bladelet core was identified (Fig. 11.6). The core was a thin cortical nodule, possibly a flake. The flaking surface is positioned along an "edge" of the nodule or flake, permitting very narrow reduction to obtain thin, straight and very long products. A single striking platform was created by a transversal removal, although reduction was bidirectional and successive. On one end of the nodule, the core was struck directly on the scars of overpassed bladelets without preparation of a striking platform. It is perhaps for this reason that the last attempt to extract a bladelet failed due to a hinge fracture. Four very thin straight bladelets were identified. They were removed following a central ridge created by the intersection of two or more bladelet removals, which at least were three times larger than the wide (Fig. 11.6).

Summary and Comparison with Blade Production from OIS 5

Blade Production Was Mastered from OIS 7 on…

The industry of series B at Bapaume thus shows clear evidence of blade production, for which certain reduction techniques were well developed according to a volumetric

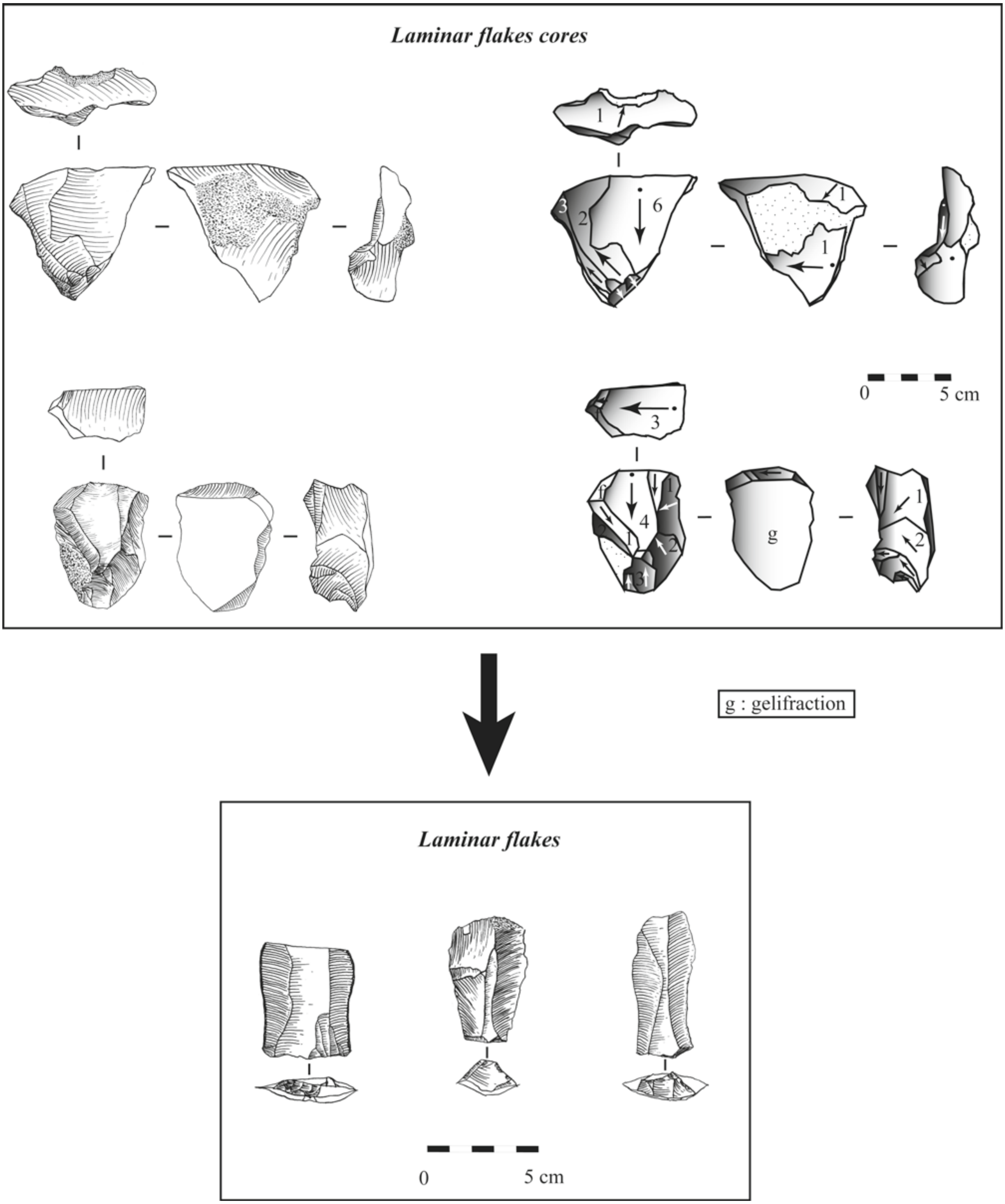

Fig. 11.4 Laminar flake production in series B of Bapaume-les Osiers: cores and products

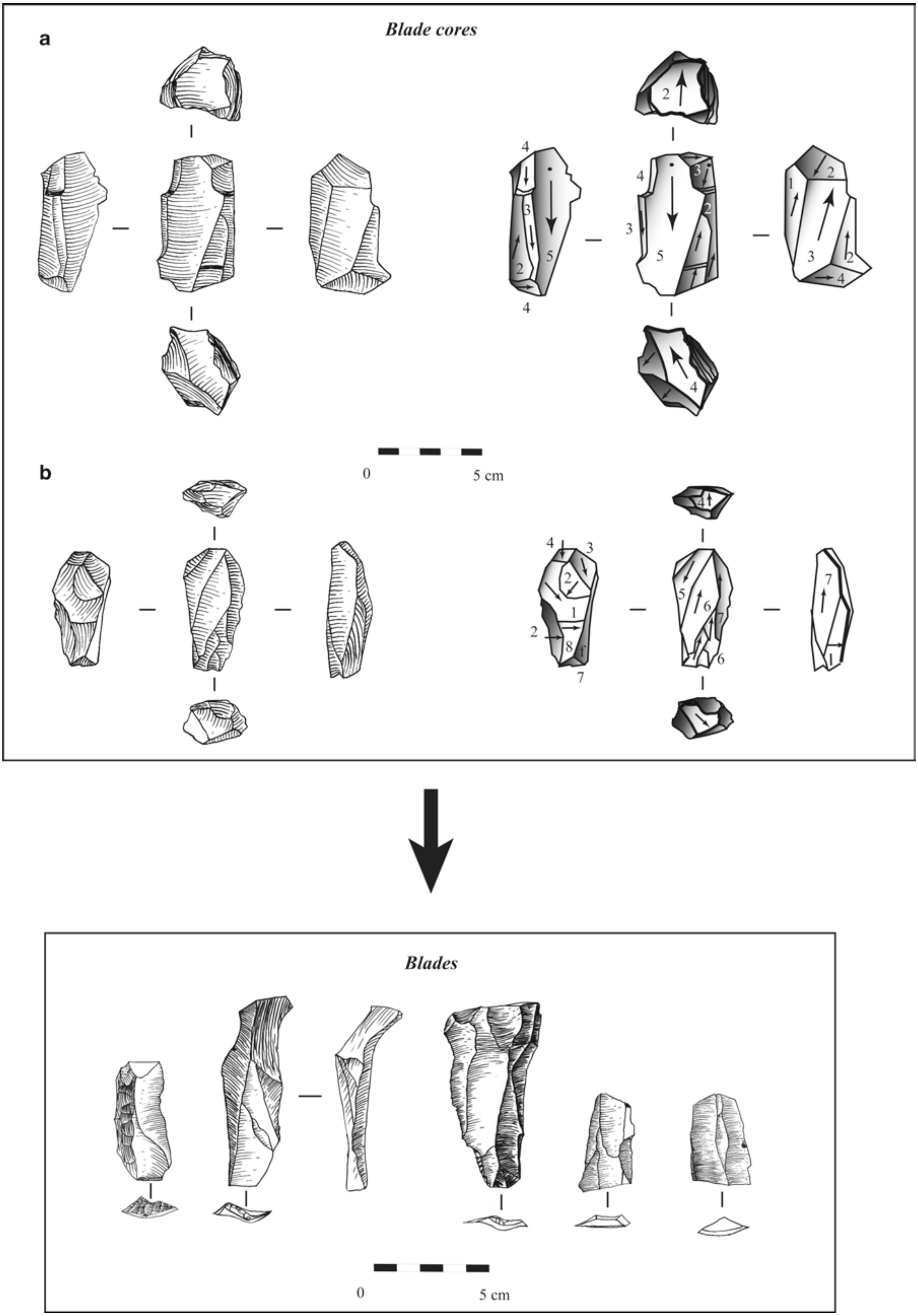

Fig. 11.5 Production of standardized blades in series B of Bapaume-les Osiers: cores and blades. (**a**) Successive bidirectional blade core; (**b**) alternating bidirectional blade core

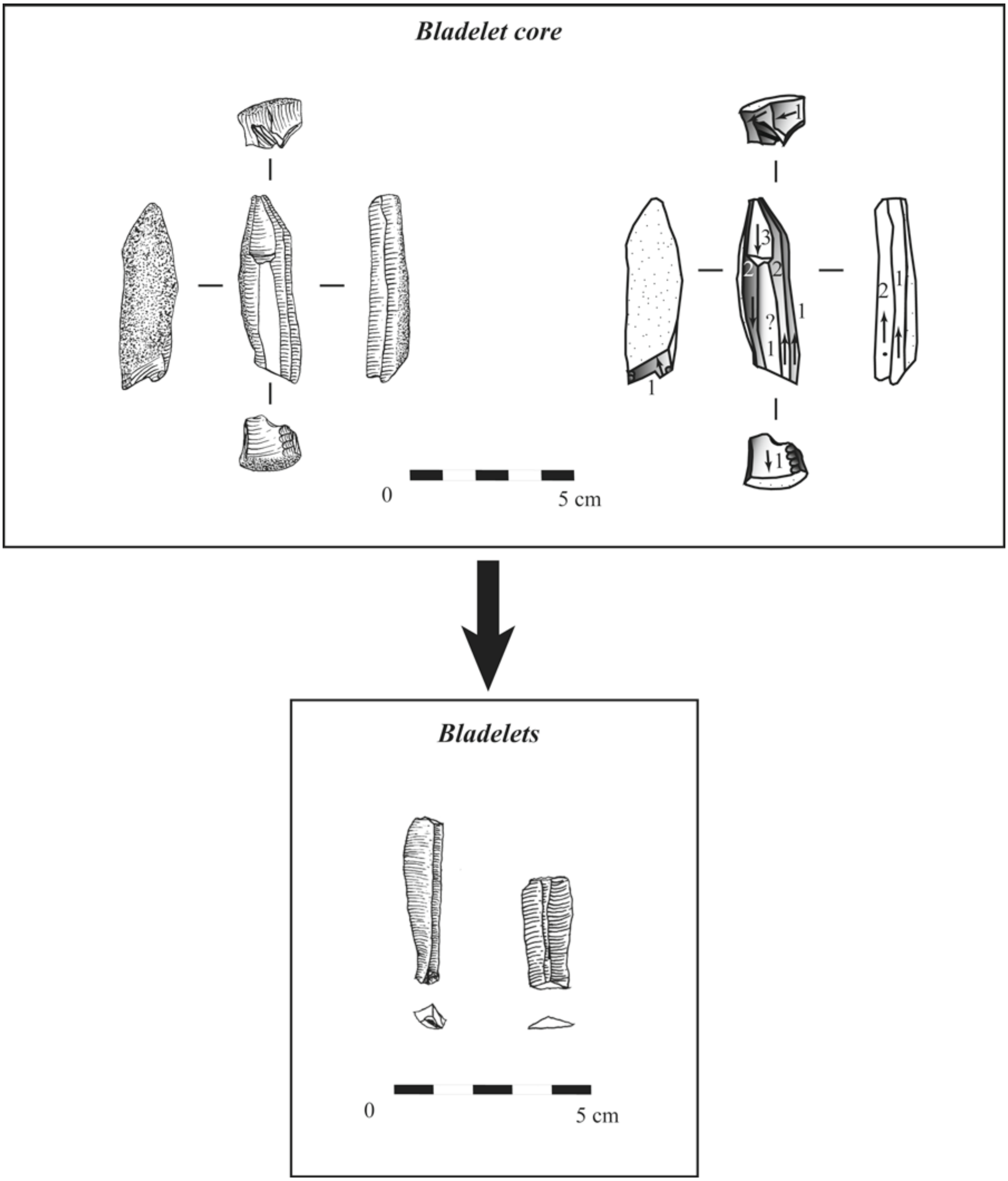

Fig. 11.6 Bladelet production in series B of Bapaume-les Osiers: cores and bladelets

conception comparable to that observed for the Upper Paleolithic. This assemblage is not unique for this period, as evidenced by refits at the site of Saint-Valéry-sur-Somme, dated to the first half of the Saalian (de Heinzelin and Haesaerts 1983: Fig. 11.7a), the industry of Rissori dated to the Middle Saalian (Révillion and Tuffreau 1995) and the prismatic cores from the recently discovered site of Therdonne in the Oise, from OIS 7 (Locht 2000: Fig. 11.7b).

… but Remained Identical up to Industries of OIS 5

These sites demonstrate that, starting in the early phase of the Middle Paleolithic, blade production was carried out according to structured volumetric conceptions identical to those observed during OIS 5. A "proto" form of blade production

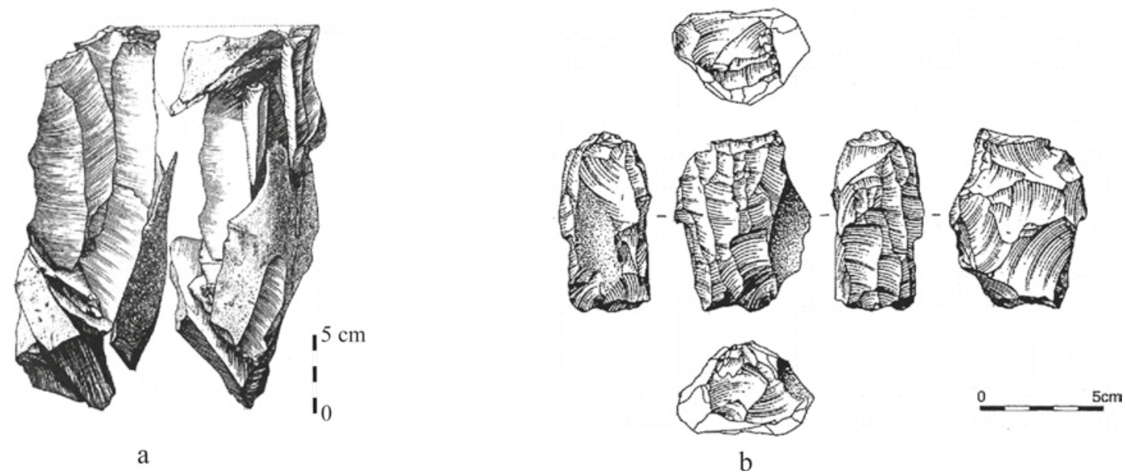

Fig. 11.7 Examples of non-Levallois blade production in the Early Middle Paleolithic. (**a**) Saint-Valéry-sur-Somme (de Heinzelin and Haesaerts 1983); (**b**) Therdonne (Locht 2000)

did not exist. The northern OIS 5 sites, including Riencourt-lès-Bapaume (level CA, Ameloot-Van der Heijden 1994), Saint-Germain-des-Vaux/Port-Racine (Cliquet 1994), Seclin (Révillion 1994) and Bettencourt-Saint-Ouen (Locht 2002), reveal the same techniques used for the production of blades, laminar flakes, and even small blades/bladelets (Fig. 11.8). Cores are also frequently bidirectional and rotated, often with two unaligned opposing striking platforms.

The Same Significance Within the Assemblage

Moreover, blade production at Bapaume, like other examples of Saalian blade production, has a minor, but non-negligible, role in the assemblage as a whole (Fig. 11.9). The same observations can be applied to Weichselian assemblages. In effect, following the example of the Early Middle Paleolithic, blade production within Late Middle Paleolithic assemblages is systematically associated with Levallois production, frequent production of points, and sometimes discoid reduction.

Conclusion: A Poor Chronological Indicator?

The series B assemblage of Bapaume-les Osiers tends to confirm the appearance of non-Levallois volumetric blade production beginning in the Early Middle Paleolithic. Such reduction may be more or less structured, but knowledge of this type of production was already perfectly mastered and identical to that observed during OIS 5. The question remains is whether such "sporadic" blade production of the Early Middle Paleolithic is anecdotal to this period or whether it is the result of the state of current research, that is, that the evidence known thus far may be the first examples of a phenomenon that in reality was much more widespread. This question should be raised because recognition of non-Levallois blade industries with "Upper Paleolithic" volumetric structuring is recent. It should not be excluded that future research may reveal new laminar evidence in the Early Middle Paleolithic. Moreover, following this re-analysis of Bapaume-les Osiers, similar analyses of other earlier assemblages may also show evidence of blade production obscured by previous approaches. The effect of such re-analysis moves back the date of the appearance of blade production, which had until now been rather the privilege of the more recent phases of the Middle Paleolithic, essentially at the beginning of the Early Weichselian glacial period (OIS 5). The chronological position of this phenomenon is no longer so clear, since it has been identified from OIS 7 to the beginning of OIS 4.

In consequence, the presence of non-Levallois blade production can no longer serve as a viable chronological marker to distinguish between the early and late phases of the Middle Paleolithic in Northwest Europe. The only technological characteristic separating series B of Bapaume from more recent industries is the presence of rare "Acheulean" bifaces. Are these strictly contemporaneous with the rest of the assemblage? Are they the result of inheritance of Acheulean techniques? These questions remain open.

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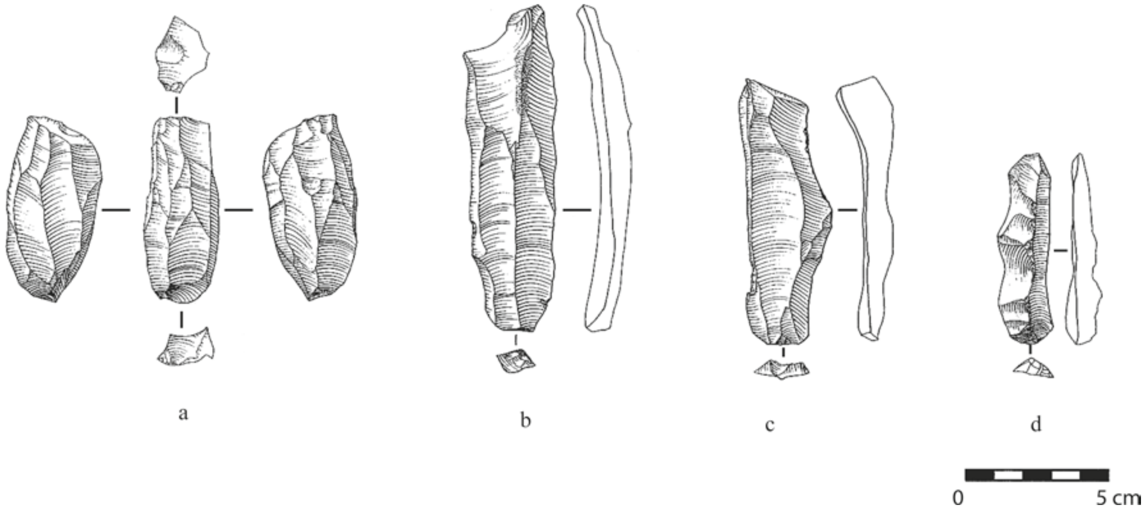

Fig. 11.8 Example of Late Middle Paleolithic blade production, the N2b2 assemblage of Bettencourt-Saint-Ouen (Somme). (**a**) Blade core; (**b**, **c**) blades; (**d**) crested blade (After Locht et al. 2002)

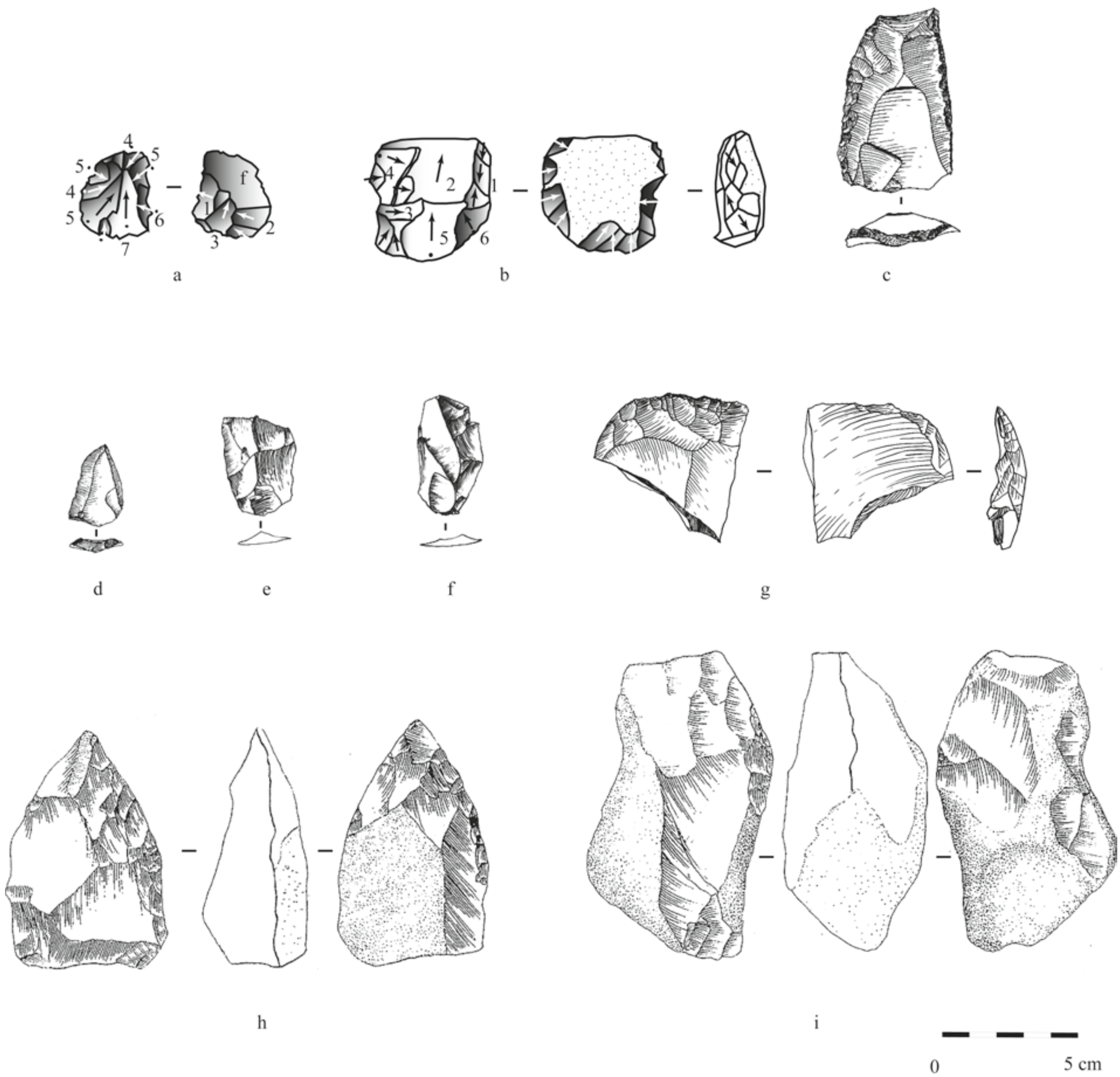

Fig. 11.9 Variability in the series B lithic assemblage of Bapaume-les Osiers. (**a**) discoidal core; (**b**) Levallois core; (**c**, **d**) points; (**e**, **f**) Levallois flakes; (**g**) sidescrapers; (**h**, **i**) bifaces (bifaces After Tuffreau 1976)

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Chapter 12
The Lithic Production System of the Middle Paleolithic Settlement of Le Fond des Blanchards at Gron (Yonne, France)

Vincent Lhomme, Elisa Nicoud, Marina Pagli, Aude Coudenneau, and Roxane Rocca

Abstract The Middle Paleolithic settlement of Le Fond des Blanchards was discovered in 1996 in a gravel quarry of the Yonne valley (Paris Basin, France). A general overview of the lithic industries allows for comparing them to assemblages of the Quina variant of the Mousterian. Thus, the Le Fond des Blanchards industries are of special interest, because the Quina variant does not exist elsewhere in the northern part of France. Therefore they do not resemble contemporaneous assemblages from the Yonne river valley or from the Paris Basin. Our study consists in a technological approach of the assemblages and a techno-functional analysis of the scrapers from level C. The understanding of these unique industries enables us to discuss the internal variability of the Quina facies and the lithic diversity of the late Mousterian. The D levels are resulting from different occupations during cold climatic conditions in an open landscape. The lithic artifacts configuration shows that all stages of the flake production in the *chaîne opératoire* are represented *in situ*. Formal tools are rare. The lithic production systems of Le Fond des Blanchards are both, classical Quina and classical Levallois. Beyond the typological and technological differences, that leads us to revise our definitions, and to look anew at the variability of the neanderthalian lithic industries.

Keywords Levallois • Quina • Internal variability • Functional variability • Rejuvenation • Fluvial context

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Introduction

The Middle Paleolithic site of Le Fond des Blanchards in the Yonne Valley (Paris Basin, France) was discovered in a gravel quarry in 1996 and excavated from 2003 to 2006. It was included in an alluvial sequence, the Gron Formation, which overlies the 3 m incision floor. The site has yielded a dozen archeological layers which are attributed to the Lower or Middle Pleniglacial substages (late OIS 4 to early OIS 3) (Fig. 12.1). The D levels are contemporaneous with the alluvial process which formed the embankment of the braided channel (Chaussé 2003; Lhomme et al. 2007). The lower levels were formed by repeated occupations on a sandy bank deposit belonging to an active channel (levels DQ to DB and D6 to D2). The upper levels consist of loamy sand from floodplain deposits (Da, D1), representing occupations further removed from the active channels (Fig. 12.2). The fauna is represented by reindeer, bison and horse, which indicates a cold climate (Lhomme et al. 2004). Level C is located 50 m to the south of the D levels. It is included in lateral colluviums which cut the alluvial formation.

More than 5,529 lithic remains were uncovered during the excavations. The raw material used at the site is a fine-grained brown cretaceous local flint. It comes from Coniacian or Santonian layers and was collected very close to the site, in the derived context of the river deposits or at the bottom of a chalky embankment.

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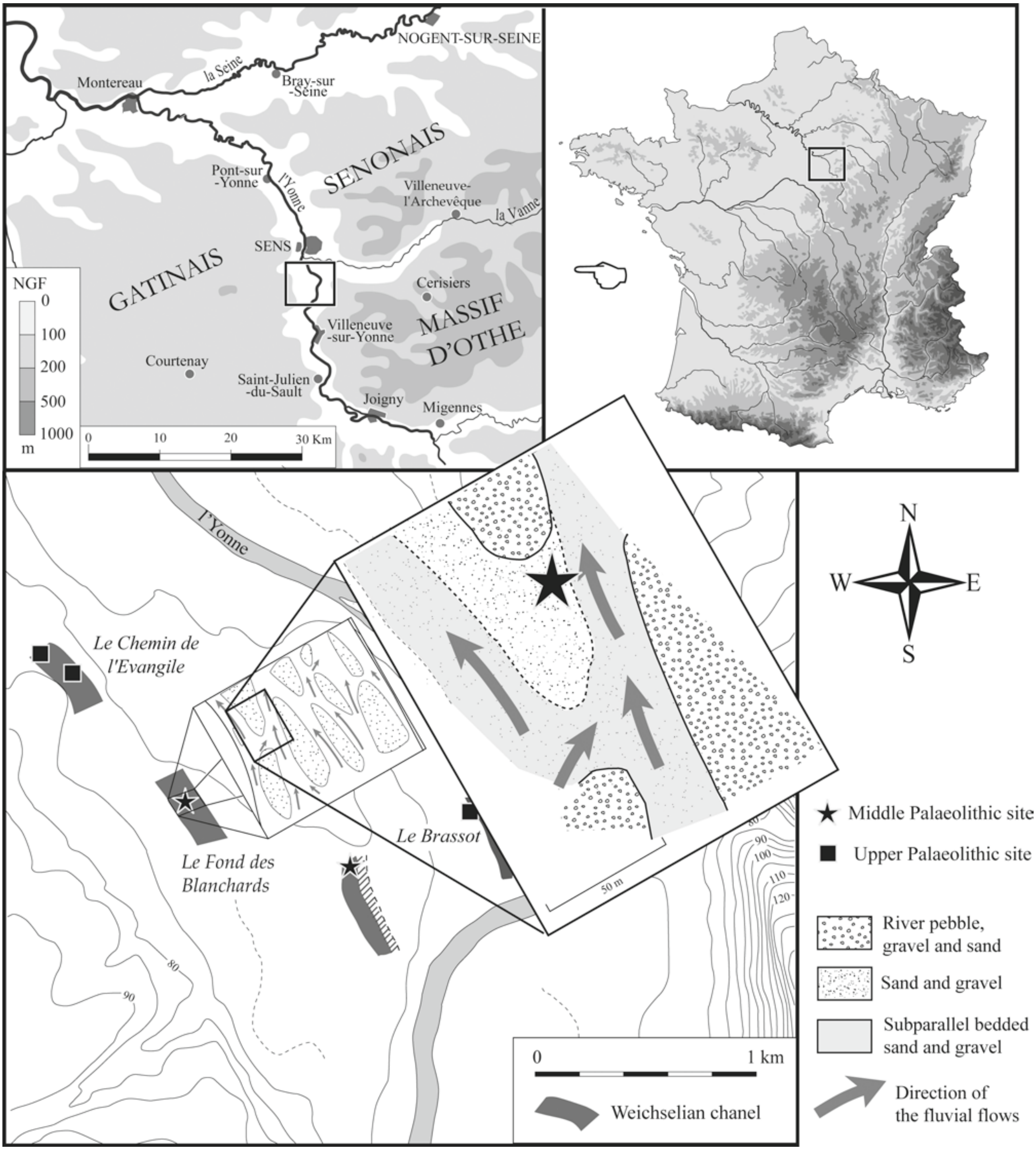


Fig. 12.1 Geographical location of the site

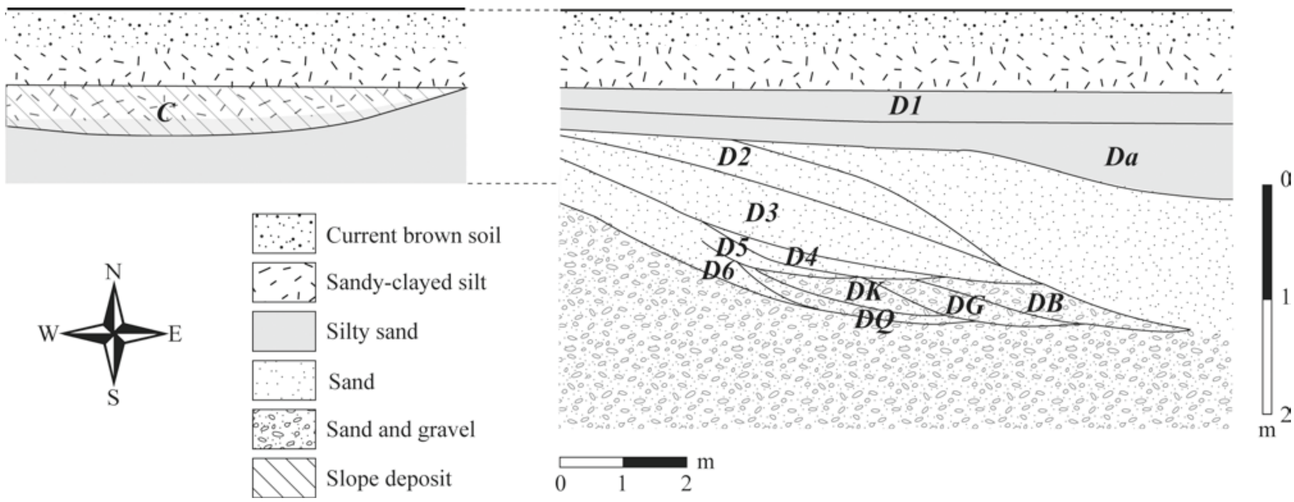


Fig. 12.2 Stratigraphic diagram and location of the different levels D and C

Levels D

Lithic Industries from the Active Channel Bank Settlements

Levels DQ, DK, DG and DB

The lithic industries from these groups appear in very well defined areas, and were reworked by energetic hydrodynamic conditions during the deposit of the pebbly level. The small number of lithic pieces (50–200 in these levels) makes the lithic remains technologically unrepresentative. Moreover, small pieces are totally absent due to the deposition context.

Most of the stages of the knapping *chaîne opératoire* are represented. Cores and knapping products are numerous. Core technology is the same as in the higher levels (Fig. 12.8). Tools are rare. All of them belong to the scraper category, one of them is made on a frost-fractured flake in tertiary flint and has Quina retouch (Fig. 12.3(1)), and the others are particularly thick scrapers.

Levels D6, D5 and D4

These levels are included in fine sands and appear in very well defined areas with no more than a dozen pieces each. These concentrations also yielded a few faunal remains. There is evidence of very little post-depositional disturbance, shown by several refittings. These may also indicate that prehistoric people discarded knapping waste in the loose sands after knapping. The techniques and methods used on local flint cores are simple and resemble those of the higher levels (Fig. 12.8). No tools were uncovered in these levels.

Level D3

Level D3 was excavated on more than 50 m^2. A total of 800 lithic remains were found in the fine sands of level D3 (Fig. 12.4(1)). Refittings are numerous and sometimes complete. An ancient technical refitting was even accomplished, namely a prehistoric occupant refitted two flakes together (Fig. 12.4(2)). This quite singular expression seems to be a deliberately anthropogenic gesture. In addition, all the elements of the knapping technical *chaîne opératoire* are represented in the industry of level D3, from hammerstones to unmodified raw material and tested blocks, formal tools, small flakes and spalls. Around 20 refitting units with 20–51 pieces each (making a refitting proportion of 50% in some areas) provide a direct illustration of how the core reduction sequences work. Indeed, some stages of the *chaîne opératoire* or even the entire sequence are present. Three main methods were used on the cores (Fig. 12.8), with a hard hammerstone. The removal of series of flakes from alternating platforms on egg-shaped blocks is predominant. Another common method is the removal of flakes by the *tranche* (*sensu* Turq 1989), flaking technique on elongated blocks. This is either a centripetal flaking associated with a consistent rotation of the block or a series of unipolar or convergent removals. Finally, there are several occurrences of flaking from the ventral face onto the dorsal face of large flakes (or natural fragments) using unipolar or convergent flaking sequences. This kind of flaking results in regular and non-cortical flakes.

We also find the sequential use on the same block of the first two core reduction methods described. The products are morphologically the same. They are thick and short, cortical or partially cortical flakes, with cortical backs and plain or cortical butts.

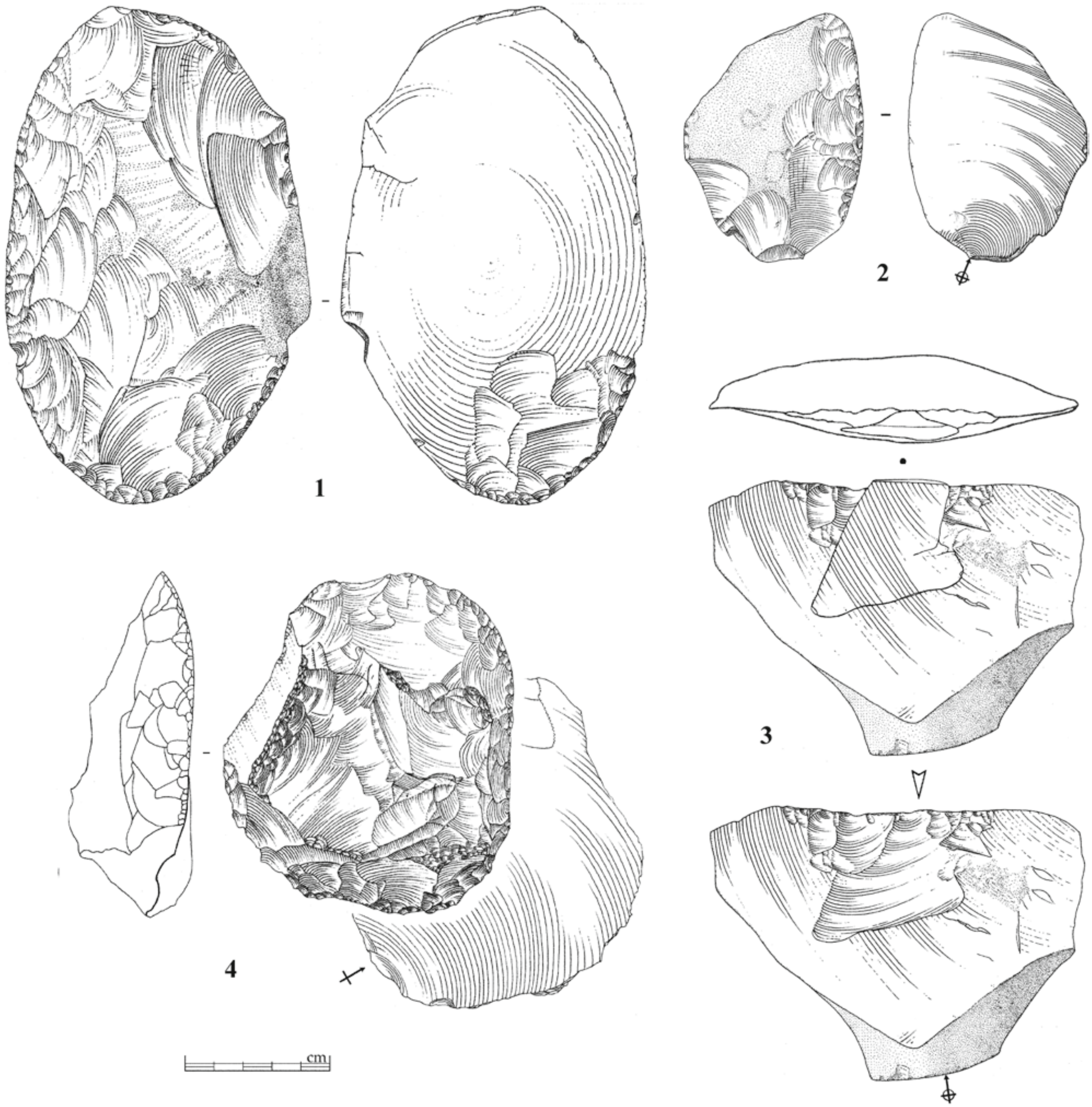


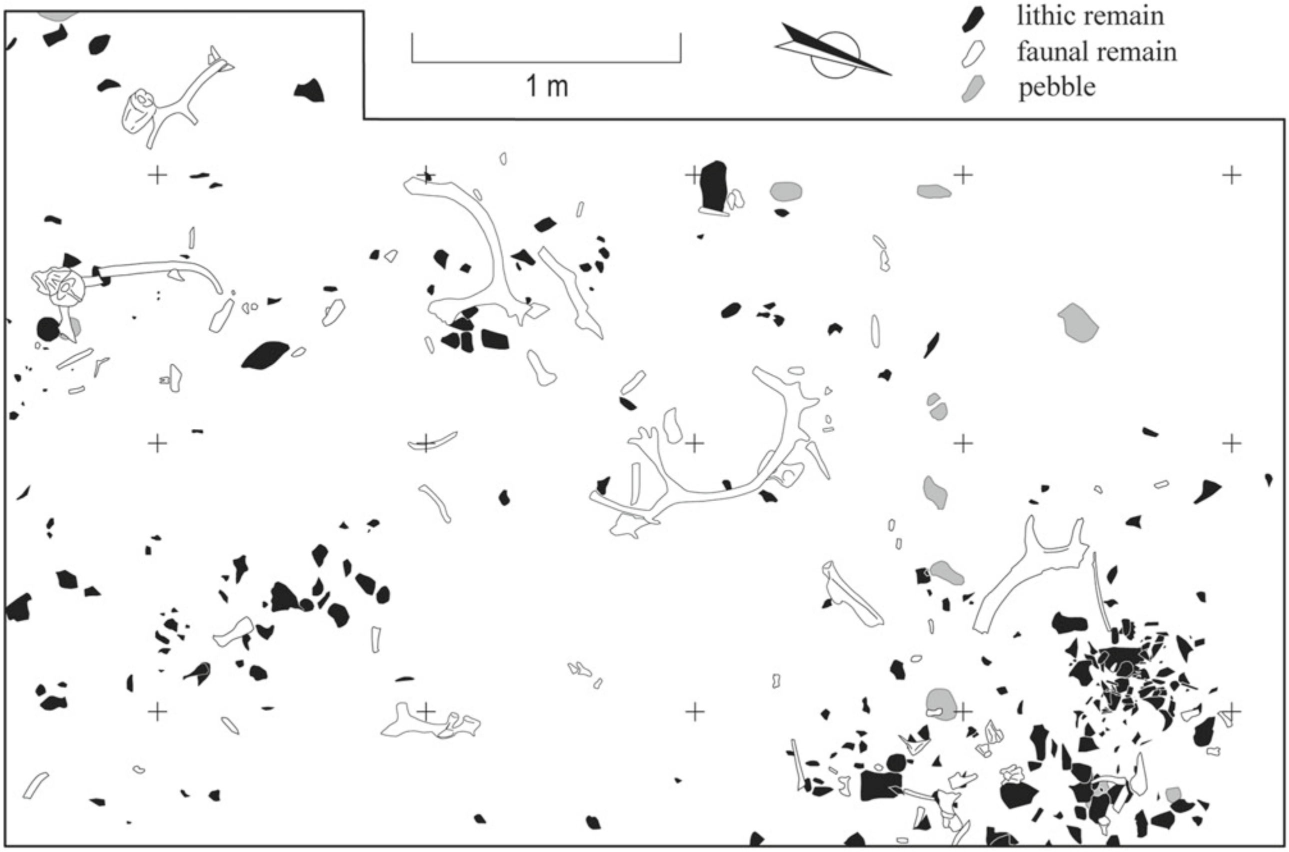
Fig. 12.3 *1*: Scraper from level DG (on a frost-fractured flake); *2*: Scraper from level D3; *3*: Conjoin of a scraper (*en fabrication*) with a hinged edge from level D3; *4*: scraper from level D2 (Drawings by V. Lhomme)

Hinged edges are frequent and were sometimes used to make scrapers. This phenomenon is illustrated by a primary retouching flake conjoining with a thick hinged flake. The knapping platform of the retouching flake is the 6 mm thick hinged edge of the flake blank (Fig. 12.3(3)). The percussion stroke was directed towards the interior. The tool was discarded during production certainly because of inclusions in the centre of the flint piece.

Scraper production is clearly present in level D3. Products from the transformation stages of the blanks are found, whereas formal tools are still rare (Fig. 12.3(2)). Very few blanks were selected to be converted into tools; more tools were produced *in situ* and removed from the site (Lhomme et al. 2007).

Level D2

Level D2 was excavated on 60 m^2. It was the last settlement during the active phase of the river system of channel A. The lithic remains studied number 750 to date and were recovered



1

2

Fig. 12.4 *1*: Spatial distribution from level D3; *2*: Illustration of a prehistoric refit in the 5 years of the excavation (Nicoud 2005). They are very fresh and refits are numerous (25% of the assemblage is contained in 22 refitting units), despite the context of the occupation. Although most of this material has probably moved since it was discarded, refittings indicate that movement was only slight and partial. Moreover, spatial distribution of the flint artifacts shows a technically logical layout of the pieces (Lhomme et al. 2010). Small pieces such as spalls are well-represented. Flakes represent 70% of the assemblage and cores only 5%. The broad morphological range of the flaking products and the scarcity of formal tools (only three pieces) are two major characteristics of level D2. There are very few retouching flakes. Tools are typo-morphologically different. There is a thick Quina-retouched scraper (Fig. 12.3(4)) and thin flakes with an irregular, discontinuous and non-invasive retouch. One block is almost completely refitted. It was knapped following the Levallois concept with a recurrent centripetal method or with preferential flake (*sensu* Boëda 1994). Whatever method was used, the removals are above all thick flakes (cortical in the first episodes) alternately produced with thin, flat and sub-oval flakes. Some of these thick flakes show a *scalariforme* retouch (Nicoud 2005; Lhomme et al. 2007). As in the D3 level, a core reduction method with short episodes of flaking (3–6 removals) was used on large flakes or block fragments. The raw materials were chosen for their natural convexities which suited the knapping method and avoided the preliminary stage of shaping the core. Sometimes a slight preparation was used to create a debitage back (*dos de débitage*). The core reduction method *en tranche* already seen in level D3 often produces blanks with an edge opposite to a cortical back. The flake production at this site may be characterized by the low technical investment in the preparation stages of the striking platform. Each knapping method produces a wide morphological range of flakes which may then be used as tools.

Settlements in a Floodplain Context

Level Da

Level Da comes from an occupation located further distant from the channels than the lower levels. 310 lithic artifacts were recovered in silty sands and are concentrated within a few square meters. The level appears much undisturbed; conjoining and refitting units are very numerous and complete (70% of the remains are contained in 11 refitting groups). Furthermore, small flakes, spalls and chips are well represented although the methods used do not produce many of these small pieces. A dozen local flint nodules were used. Formal tools are rare (Fig. 12.5(1) and (2)), so are cores (5%). Flakes on the other hand are numerous (70%).

As in the D2 level, the morphological range of artifacts is wide, though unprepared striking platforms associated with an inward-directed percussion gesture creates above all thick flakes with cortical backs. We also observe that retouched blanks consist of thin flakes (Fig. 12.5(1) and (2)). The morphological variety of the flaking products suggests that the entire flaking *chaîne opératoire* was done *in situ*, from the collection of raw material to the transformation of blanks into tools. This variety can be explained by the method of debitage: each removal predetermined the next without requiring a reshaping of the core. Most of the flakes result from a recurrent unipolar method of core reduction. They are thick with a distal dihedral edge and a cortical butt; the butt shows a "winged butt" morphology. The absence of retouching flakes and the evidence of a scraper broken during its production or its use (Fig. 12.5), shows that scrapers were brought into the site and some blanks were removed (Nicoud 2005; Lhomme et al. 2007). The knapping method *en tranche* is also used. Some blocks were knapped with an alternating platform method: alternating the function of the flaking surface and striking platforms allowed the knapper to continue the core reduction without resharpening.

Level D1

Level D1 is the most recent. It has yielded more than 400 lithic remains, in different areas distributed throughout 60 m^2. A dozen refittings contain about a hundred pieces. The complete *chaîne opératoire* of debitage is represented by unmodified raw material, hammerstones, tools and small pieces (these are particularly numerous: 65%). Cores are scarce (only 4 pieces); and show an alternating platform method) (Fig. 12.8). Knapping errors are frequent and are due to the point of percussion is too far from the edge. Flakes are short and thick, essentially with a plain butt and sometimes a cortical butt. They result from a parallel unipolar flaking method. Some refittings include fragments of tools broken during their production. The scarcity of tools holds for this level as well: there are two simple scrapers on thin blanks, two notches, three flakes with non-invasive retouch and one cleaver (Fig. 12.5(3)). This last tool has use-wear traces indicating it was used by being thrown onto a medium-hard material. Comparing these traces with experimental data shows this large artifact was used in contact with animal joints (Coudenneau 2004; Lhomme et al. 2007).

Level C

The C level has delivered a lithic industry characterized by a dominant production of large-sized flakes on local senonian flint cores. Contrary to the D levels, the major part of the tool assemblage is formed by retouched blanks converted into numerous scrapers often obtained by several retouches in a row, which affect in an important way the edges and the

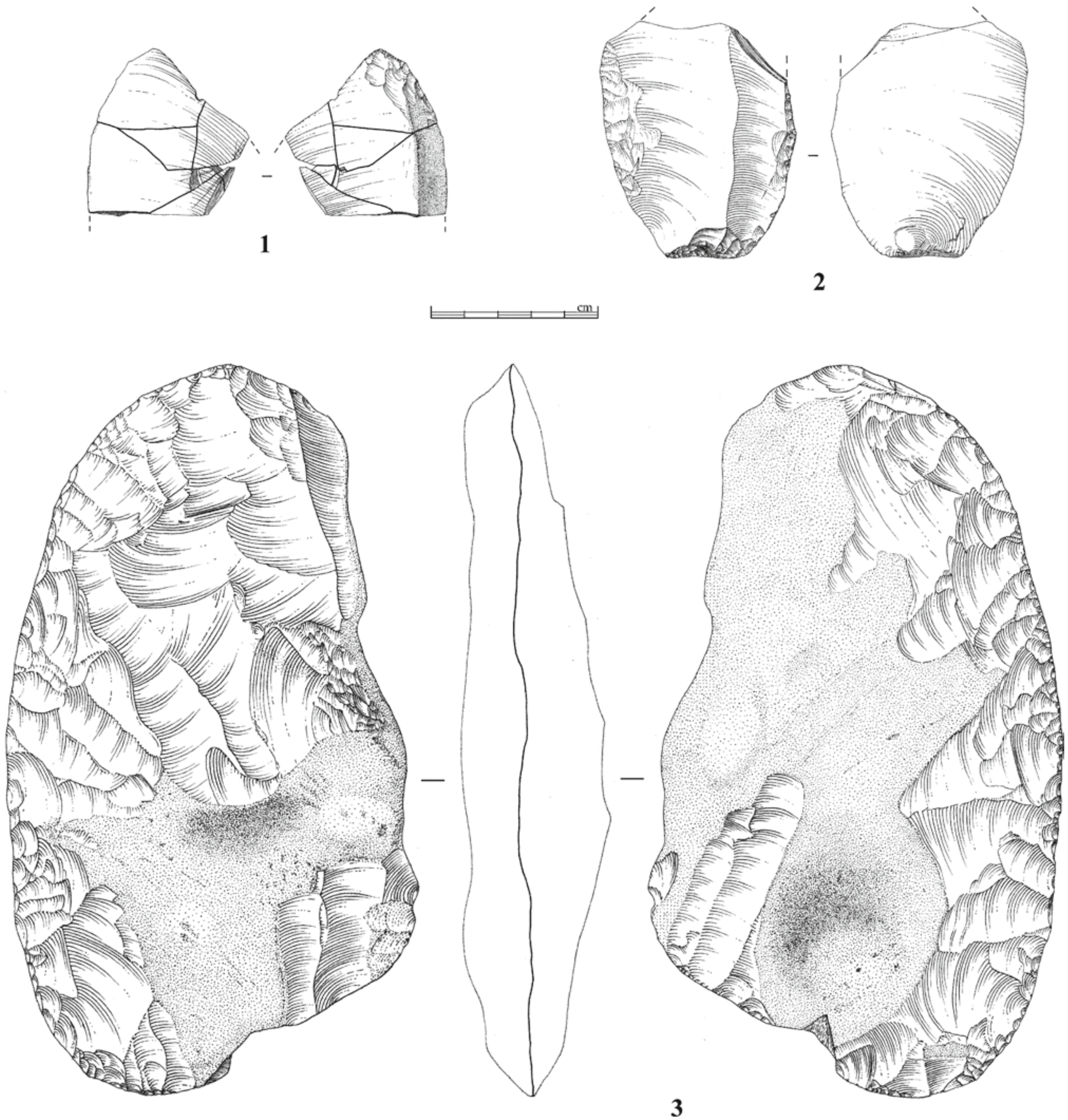


Fig. 12.5 *1–2*: Broken scrapers from level Da; *3*: *Hachoir* from level D1 (Drawings by V. Lhomme)

surfaces of the tools. A small number of imported tertiary flint natural blanks and flakes have also been transformed into scrapers. Because of the typological and morphological characters of the tool assemblage, this level has been closely related to the Quina variant of the Mousterian. Nevertheless this industry aroused immediately a particular interest because of its specificity. This specificity is related to the feature of tools, which are definitely different from those of the "traditional" Quina industries of south-west of France, in spite of a general similarity due to the retouch intensity (Fig. 12.6).

The C Level Sample: Methodology and Chaîne Opératoire

A dimensional and qualitative comparison between the tool assemblage and the unretouched component from the excavation of 2004 (373 flakes) was carried out in order to increase data concerning reduction strategy and to assess the existence of a possible selection of blanks at different stages.

The tool component was analyzed in a techno-functional way (Lepot 1993; Bourguignon 1997; Soriano 2000;

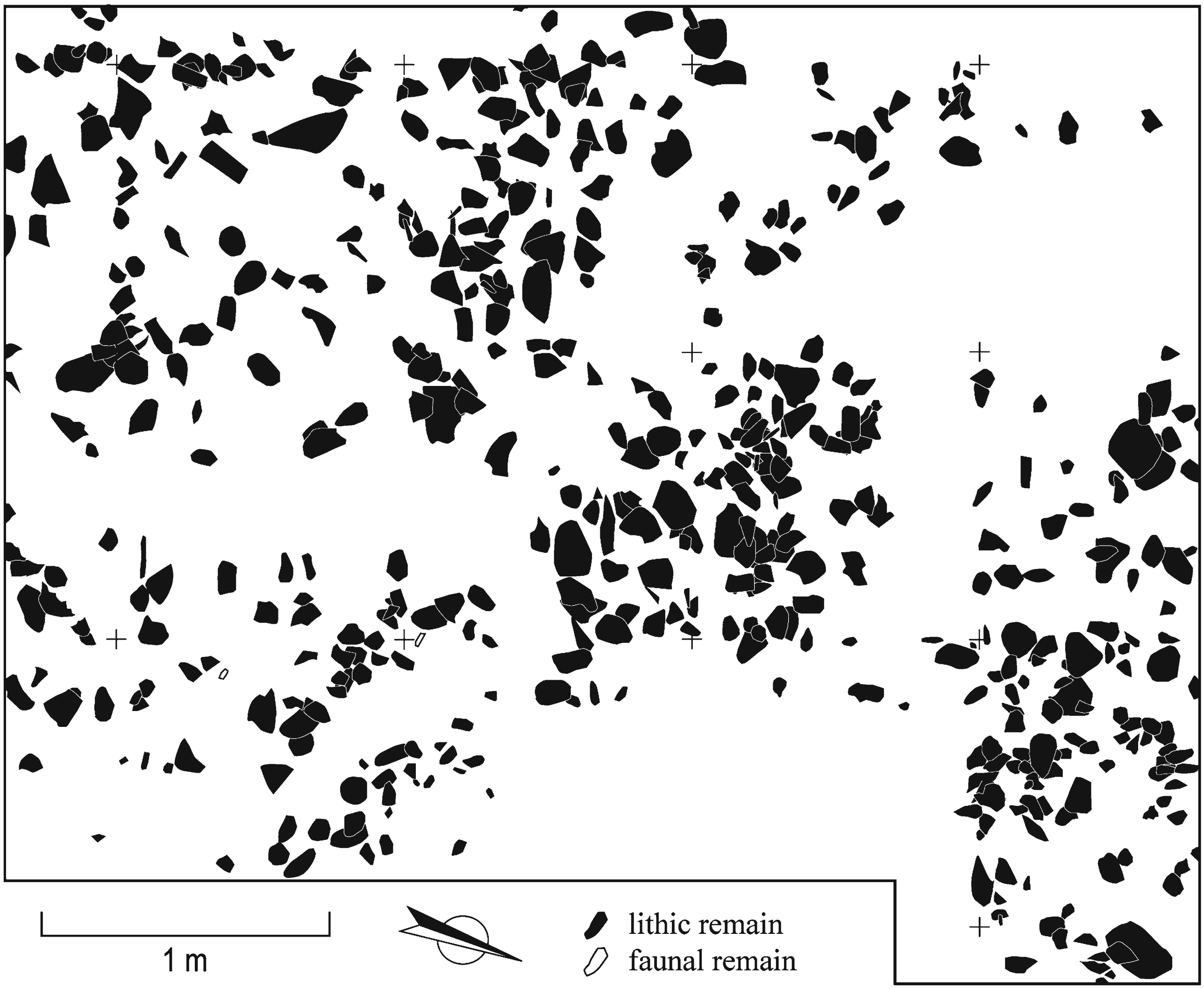


Fig. 12.6 Spatial distribution of remains in the level C

Boëda 2001; Boëda et al. 2004), which allows understanding the functional objectives of the lithic production, represented by tool structures which occurred in an assemblage, defined by technical and morphological features. Differently from typology, this methodology combines the blank production methods with technical characters of tools and of their actives edges, in order to assess regularities in tool features. This approach considers that there is a systemic relation between the technical objectives and the individual who has produced them. Namely, this person inherited a technical culture, shared with his cultural group. This is the ideological element that brings out the cultural value of some structural characters of the technical objects, and allows distinguishing them from environment and raw material influences. In spite of the dimensional and typological variability, some kinds of tools occur several times, with a restricted number of morphotechnical features, each one corresponding to a particular design.

Cores

Cores from Level C are characterized by an important morphological and dimensional variability (from 5 to 6 cm to more than 40 cm). Three kinds of blanks were exploited as cores: blocks, frost shattered block fragments and large cortical flakes. All cores show the same kind of core reduction technology and their morphological variability depends on different stages of the reduction sequence. None of the cores shows a preliminary preparation of the volume before flaking: the reduction sequence begins from convex and cortical platforms of the core and then, investing the arises of previous removals. The initialization phase of knapping is thus represented by the selection of surfaces presenting the suitable characteristics. Knapping, always with stone hammer, consists in one or more striking series of removals on one or more flaking surfaces of the core. The simplest series of removals is a group of three unidirectional removals starting from a cortical striking platform or from the negatives scars of the previous series. Each removal or short series of removals can be repeated with different dimensional ranges from one platform or from different alternating platforms. The organization of the reduction sequence frequently delivers alternate products: on the one hand the fracture surface is parallel to the flaking surface whereas on the other hand the fracture surface is oblique. There is no hierarchy between the flaking platform and the striking platform: both can alternate at any moment of the reduction sequence, or one of them can be used to exploit other platforms of the core. All these characters show that there is no sequential phase division during the reduction sequence, which is continuous.

Flake Production

The morphological variability of the blanks depends on the core morphology and dimension, as well as their own flaking scheme inside each series of removals. Flakes obtained from this core reduction are very often cortical and semi-cortical with an important dimensional variability and the recurrence of homogeneous morphotechnical features. Cortical tool blanks are well represented in the sample (35% of the tools, $N = 41$). They are dominated by thick flakes and those, which are shorter than long with wide and thick butts. Thin and small flakes occurred in this category in less important proportions. Semi-cortical and non-cortical tool blanks often have only one or two dorsal scars of removals. Directions of removals scars show predominantly the use of a unidirectional method to remove series of flakes, in accordance with the reduction sequence as reconstructed by our analysis. For semi-cortical tool blanks (46% of the series, $N = 56$) several characteristic flakes occurs repeatedly: there are cortical backed knifes, cortical pan flakes, *en tranches* flakes (resulting from the knapping method of the same name) (Turq 1989), all linked with specific knapping gestures. Non-cortical tool blanks are less represented (17%, $N = 20$) in the tool assemblage and show a higher dimensional variability, with both small and larger tools and morphological features similar to the semi-cortical tool blank group. Kombewa flakes occur as well in the assemblage.

A preliminary comparative study between sizes of tools and unretouched components shows a trend-setting selection to convert broad and thick cortical blanks into tools. In the sample there are also four scrapers where the retouching phase involves a total reinvestment of the volumetric structure of the original flake. Thus, they correspond to the definition formulated to describe a tool volume created by a shaping pattern (*façonnage*: Boëda 1991; Soriano 2000).

The C Level Sample: Functional Techno-Types and Tool Design Patterns

The study of the reduction sequence organization allows for recognizing a range of technical gestures that leads to repeated volumetric structures of tools. Every volumetric structure shared by each group of tools, contain different and specific functional potentials. The complexity of the techno-functional classification would require a considerable space to be entirely exposed (Pagli 2006; Lhomme et al. 2007). So, we will only describe, in a synthetic way, the main results of this analysis.

The 121 tools analyzed from level C have been divided in several groups (tool *techno-types*). A first level of variability depends on technical, dimensional and morphological characters of blanks. They allow for definition of four kinds of tool blanks. The technical elements, their location and organization, lead us to distinguish two main structures.

The first volumetric structure is formed by a cutting edge on the opposite side of a prehensile system consisting of a back/backed element (*élément à dos*) sometimes associated with one or two adjacent backs (Fig. 12.7(1)–(8)). The second volumetric structure is made up of two opposite cutting edges (Fig. 12.7(6)). The dimensional characters distinguish three classes in the tool assemblage:

- very large-size and thick tools (Fig. 12.7(1), (2), (3), and (5));
- small-size tools always with a high thickness (group II tools) (Fig. 12.7(7) and (8)); Small-size but still thick tools;
- small-size and thin tools.

Morphological components show three trends in tool blanks:

- a group of more broader than long tools (Fig. 12.7(1), (2), (3), (5), (7), (8));
- a group entirely made up by more long than broad tools (Fig. 12.7(4) and (6));
- a group where the morphology of the blanks is undifferentiated.

Some of these groups show an internal structural variability. A second level of variability depends on tool surfaces morphology (ventral and dorsal curvature, according to their cross-section), and on the layouts of the different technical elements they are structured by. These are called Techno-Functional Units (UTF). A Techno-Functional Unit (Boëda 2001) is an association of technical and morphological elements that constitute a homogeneous set on the tool edge. In every tool there is at least three Techno-Functional Units: a prehensile unit, the active edge unit and a unit, which is conveying energy from the first unit to the second. These techno-morphological aspects lead us to

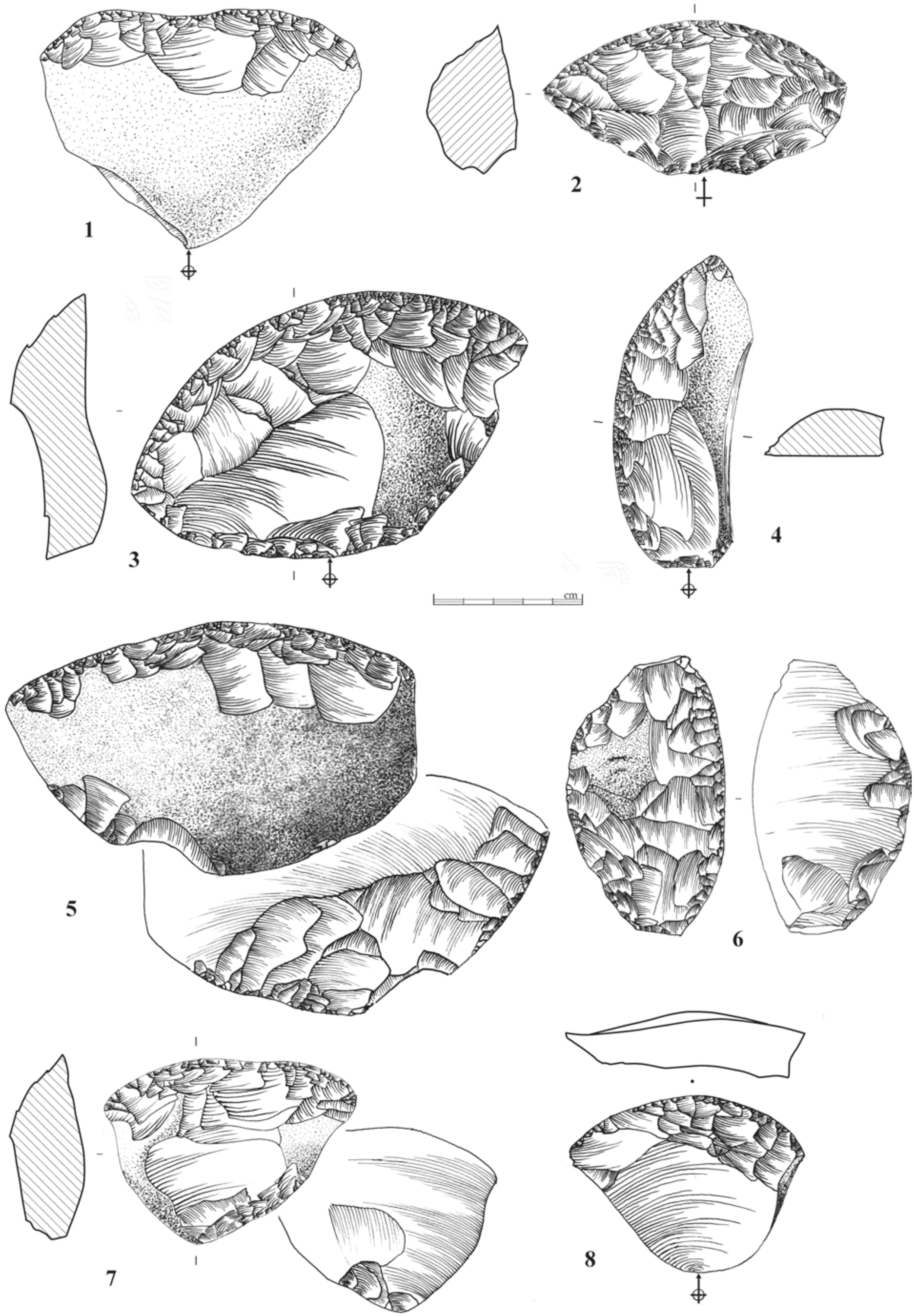


Fig. 12.7 Scrapers from level C (Drawings by M. Pagli)

individualize seven techno-morphological categories in the tool assemblage.

The last issue of the study is the morphometrical analysis of the cutting edges. In the C Level tool assemblage, ten different groups of edges (cutting edge techno-types) occur. Each one is defined by three criteria: cutting edge surfaces, angles and delineation. Each volumetric structure is combined with one or several cutting edge techno-types by specific relationships, which allow us to conclude that each volumetric structure is planned to support a specific cutting edge's set. Crossing all these data (tool blank volumetric structures, modes of production and cutting edge techno-types), this analysis reveals both the knapping method and the retouch sequence utilized to create these different kinds of tools. From an initially varied morphology of blanks, a differential integration of retouch phase lead to obtain the required tool in specific way and with different intensities in every group. In this way, each tool blank, with its specific cutting edge set, shows a different organization of the knapping and retouching phase and so a diversity of the intentions underling its manufacture.

With a tool design pattern perspective, data from techno-functional analysis are a step in the understanding of the C level lithic industry position in the cultural context of the recent Middle Paleolithic of Western Europe.

Three elements in this lithic assemblage show strong similarities with the "type Quina" Mousterian and let us consider it as belonging to this technical complex: knapping methods, morphological characteristics of tool blanks and the occurrence on several scrapers of an intensive retouch in several rows, which form sometimes a slightly scalar profile on the cutting edge. This kind of retouch corresponds to the typological definition of the "type Quina" retouch defined by F. Bordes (1961). Although this similarity, the intensive retouches of Level C tool assemblage are however different from those attested on the Quina tools from South-western France.

A techno-functional analysis of the Quina type industries from the south-west of France, has tried to reconstitute the functional objectives represented by a "Quina type" tool. The thickness and the intensive retouch have shown an important standardization in the morphotechnological characteristics of the tool blanks and in cutting edge features (Bourguignon 1997).

On the other hand, the techno-functional analysis of scrapers from level C lead to assess the presence of a different functional objectives showing a greater variability in techno-morphological characters of tool blanks and cutting edges. This variability takes on two forms. The intensive retouches (typological "Quina type" retouch) of level C tools are combined with a huge range of cutting edge techno-types, without creating a specific or standardized cutting edge. Such retouches are associated with different tool volumetric structures, with varied morphological, dimensional and technical characters. Between these characters the large size and important thickness of tools are an evident objective of the production, but they characterize different tool blank types, and varied supported kinds of cutting edge. In the C level of Le Fond des Blanchards the intensive retouch is used as a blank transformation process in order to obtain not a particular cutting edge but to reach a much diversified tool assemblage, according to volumetric structure and cutting edge characteristics.

Conclusion

The Middle Paleolithic site of Le Fond des Blanchards has been occupied many times during the second part of the lower Pleniglacial and the beginning of the middle Pleniglacial stage of the Weichselian. Numerical dating is in progress to precise the chronologic range of the site. The faunal association, which includes horse and reindeer, indicates an open environment and relatively cold climatic conditions.

Lithic productions from Levels D and C seem morphologically very varied, but the technological analysis shows different methods of debitage, producing in reality only few types of blanks (Fig. 12.8). Big and cortical flakes then backed flakes are predominant. In fact, different methods are used to obtain few types of similar shape blanks. In level C, formal tools are numerous. Selected blanks are characterized by their great sizes and specific edges. Rejuvenation is applied on these edges following different means. This difference between classic Quina Mousterian and this one must have a functional meaning. Since its discovery in 1996, a parallel has been established between the lithic industry from Le Fond des Blanchards and the Quina Mousterian from the southwest of France. New studies now permit to reconsider this cultural assignation. If few typically Quina tools really appear in the industry (Fig. 12.3(1), (4), 12.5(3), 12.7(2), (3), (8)), the study of scrapers from Level C shows differences in the conception of the tool compared with scrapers from the classic Quina Mousterian of south-western France. These differences concern the blanks and the rejuvenation of the edges. Indeed, both are more varied, from a morphological point of view or from the effect of rejuvenation on the edges.

So, how to conceive these lithic collections in a cultural meaning, knowing that this industry is sharing the chronological range of the Quina industry of south-western France and its typo-technological major characteristics, but, however, with structural different elements? Even if it is too soon to be sure of it, we can imagine that the lithic industry of Le Fond des Blanchards is older than the classical Quina industry of South-Western France, namely, it may appear when the scrapers production system is not yet completely dedicated to the transformation of blanks with important backs by the technique of the Quina retouch. Assuming that, the Paris Basin, which is at a crossroads between Eastern and South-Western Europe, may have taken a central place for the spreading of neanderthalian cultures.

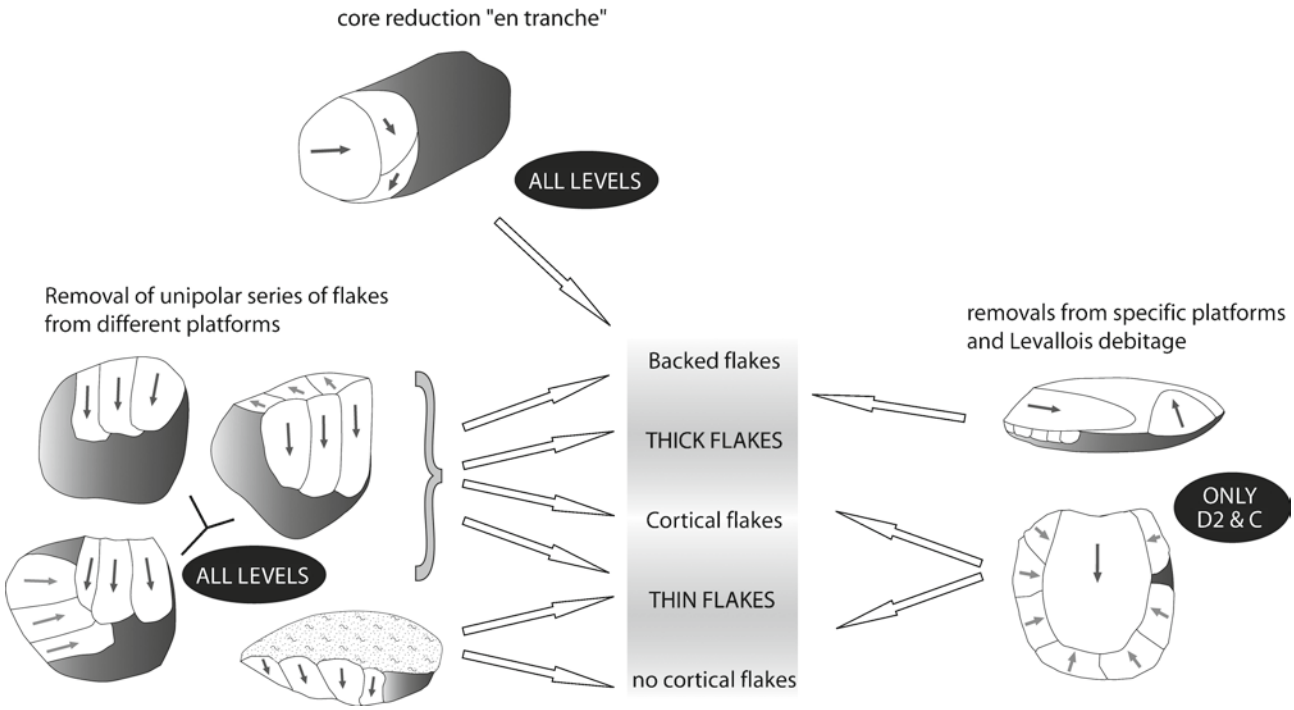


Fig. 12.8 Methods of blank production in the lithic industry of Le Fond des Blanchards

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Chapter 13
Technological Analysis of the Bifacial Tools from La Micoque and Its Implications

Gaëlle Rosendahl

Abstract Layer 6 of La Micoque was used to create the term "Micoquian", but its content is badly defined and the layer itself was destroyed. A technological analysis of the bifacial items from this layer has shown that two concepts are present: the "handaxe concept", with a symmetrical repartition of the techno-functional units along the length axis, and the "bifacial backed knife-concept", opposing an active edge to a passive back. The presence of bifacial backed knives enables La Micoque 6 to be placed in relation to the Central European assemblages belonging to the *Keilmessergruppen*, but raises questions concerning the definition as well as the chronological and geographical limits of those *Keilmessergruppen*. Micoquian can presently only be considered as a classification category.

Keywords *Keilmessergruppen* • Micoquian • Bifacial backed knives • Handaxes • Techno-functional units

Introduction

The layer 6 of La Micoque (Dordogne, France) led to the term "Micoquian". This "culture" has been at the center of an enduring discussion since Bosinski (1967) linked it to Central European assemblages characterized principally by bifacial items such as bifacial baked knifes (*Keilmesser*), certain handaxes and small bifaces (*Fäustel*). The term "Micoquian" was introduced by Hauser (1916) to describe an industry characterized by "microlithic" and irregular shaped tools. Closer to our understanding of the word today, Obermaier (1908) spoke about "Micoquian bifaces", meaning small elongated bifaces. As Bosinski applied the term to Middle European assemblages, he automatically included Krukowski (1939–1948) *Prondnikian Cycle*, created to describe similarities in the assemblages of Okiemnik and Ciemna and the *Prondnikian* of Kowalski (1967). The enlargement of the Micoquian's meaning led to quite different understandings of the term between Western, Central and Eastern Europe. Unfortunately, the layer 6 of La Micoque was completely plundered between 1914 and 1929 (Peyrony 1933; Rosendahl 2006), and a technological analysis of the lithic production has never been undertaken, making a comparison with the Central European assemblages difficult. The lack of specificity in the definition of the Micoquian led German scientists (Mania 1990; Veil et al. 1994) to favor the name *Keilmessergruppen* (KMG) for the middle European assemblages instead, whereas the Eastern European scientists still refer to an "East European Micoquian". Independent of the name, the position of La Micoque 6 in regard to those groups of assemblages is unclear, from a chronological as well as a technological and, to a lesser extent, typological point of view. The question of a west European extension of this type of assemblages remains unsolved since the meaning of the "Micoquian" varies strongly between the authors (e.g., Richter 1997; Gouédo 1999; Jöris 2001; Molines et al. 2001), some French authors understanding this term as an Upper Acheulean with unusual bifacial items (e.g., Bordes 1984; Gouédo 1999). Furthermore, the Near-Eastern Yabroudian was firstly considered as Micoquian, and the meaning of the similarities between Micoquian and Yabroudian is still discussed (Ronen and Weinstein-Evron 2000a, b). One could even wonder whether the Acheulean industry of Tabun agrees with the definitions of Micoquian or the KMG (McPherron 2003).

This paper deals with the question of the technological and typological characteristics of the bifacial items from La Micoque 6 and the attribution of the assemblage to a "Micoquian/KMG" *sensu lato*, i.e., each Lower or Middle Paleolithic European assemblage containing at least one of the *Leitformen* defined by Bosinski (1967) or Bordes (1984) or bifacial items unusual in the Acheulean context, as done often in France. The name "Micoquian/KMG" *sensu stricto* is applied to assemblages of the last glacial (for some authors is the time range even smaller) containing at most important common attribute *Keilmesser* or several of the *Leitformen* described by Bosinski (1967). These assemblages are referred to as KMG, M.M.O. (Richter 1997) or Micoquian in the literature.

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The attribution to "Micoquian/KMG" depends only on the presence of certain bifacial items. The focus is not based upon the flake production, which is briefly characterized here: The Levallois and discoid methods are present but very rare, and the most frequent knapping technique is represented by "ingot-shaped cores" (Luttropp and Bosinski 1971). "Ingot-shaped cores" are elongated cores with a more or less triangular section, one surface building the flaking surface and both others being striking platforms. The blanks are removed mainly perpendicular to the elongation of the core from both long sides. The flakes obtained are short and quite thin. Another important group is build by the globular cores (Bordes 1961) in all states of reduction. The blanks are produced in short unidirectional or converging series from cortical or plain platforms without preparation of the flaking surface, the striking platform changing frequently. The products of this technique are flakes with unidirectional, bidirectional or converging scars on the dorsal surface as well as around 25% *éclats débordants*. All those products have an irregular shape; the *éclats débordants* have not been retouched as often as the flakes (15–8%). The characteristics of the blank production are also present in two other layers containing only very few or no bifacial items.

Analysis

The bifacial items of La Micoque were principally characterized by typological definitions, the Micoquian bifaces being considered as the most typical pieces. Even the definition of these Micoquian bifaces has not always been the same. While Obermaier (1908) considered "lanceolates" as such, Bordes (1961) emphasized on a massive, crude basis, axial asymmetry and curved edges. Since, however, the form of such pieces depends to a larger extend on the form and the quality of the raw material (White 1998) as well as on the ability of the stone knapper and the duration of the use and the frequency of sharpening or reworking (Jöris 2001), the characteristics of the edges alone (i.e., straight or curved) and the relation between basis and tip, which can vary during the lifespan of a piece, this cannot be considered as discriminative *a priori*. Within the background of the discussion about the *Keilmessergruppen*, a technological approach allowing the concepts underlying the bifacial production, independently to the form, was needed.

The artifacts from La Micoque are currently spread throughout all of Europe and North America, but representative collections are concentrated in France (Les Eyzies, St. Germain en Laye, Poitiers) and Germany (Cologne, Mannheim, Erlangen, Berlin, etc.). A total of 31 bifacial items collected by Hauser and conserved in the Reiss-Engelhorn-Museums in Mannheim were analyzed in detail using the concept of techno-functional units or TFU of Boëda (2001) and the different stages of production still documented on the pieces. This allowed identification, on one hand, of the concepts underlying the production and, on the other hand, the steps of the production and the life span of such a bifacial tool (e.g., Bourguignon 1992; Jöris 2001; Pastoors 2001; Soriano 2001).

Two concepts were identified. The first one leads to the production of handaxes *sensu stricto* with a roughly symmetrical organization along the length axis (Fig. 13.1a). Two active TFU with similar lengths and characteristics form the point of the piece (Fig. 13.2a). Those TFU can cover the total length of the long sides up to the base, but additional TFU can be placed between the top and the base (Fig. 13.2b). TFU are usually organized symmetrically, can be active or passive and their use can require the piece to be turned in the hand. The base usually carries a passive TFU, but this is not obligatory. If the base can be used as active tool, its handling requires a rotation of the piece, so that it becomes active, while previously-active TFUs serve as grips and become passive. A piece with the "handaxe concept" can, therefore, be held and used in several ways and all TFUs can be, at least potentially, active.

The second concept produces bifacial knives, characterized by the asymmetrical organization of their TFUs along the long axis (Fig. 13.1b). The main active TFU is localized on one of the long edges, opposed to a back that is always passive on at least a part of the other edge (Fig. 13.3a). A further active TFU can be situated at the top of this edge and form a point with the main TFU (Fig. 13.3b). The base usually carries an active TFU, shifted towards the main active TFU. A piece with "bifacial knife concept" can therefore be held a maximum of two ways and always has an absolutely passive TFU.

The characteristics "splinted biface" (*Halbkeil*) as well as "alternant one-directional working of the edges" (*wechselseitig-gleichgerichtete Kantenbearbeitung*: Bosinski 1967), often considered as typical for the "Micoquian", did not show any pattern of repartition or preference. Their presence or absence could not be linked to any characteristics of the TFUs, nor to the one or the other concept. The form of the piece is independent from the concept, i.e., that "lanceolates" or other bifacial forms can be handaxes as well as backed bifacial knifes, and irregular items are present in both groups. Typological considerations reach their limits quite quickly, as they cannot be used to discriminate the concepts since the symmetry or asymmetry of the TFUs' organization is not necessarily reflected in the form of the piece. The objects that belong to the concept "handaxes", however, can be most easily classified in the traditional types, whereas the backed bifacial knifes correspond only to a very restricted extent to the classes defined for such pieces. The consistency of the two concepts can be read on the pieces themselves: once the structure of organization of the piece was set in place, the concept was

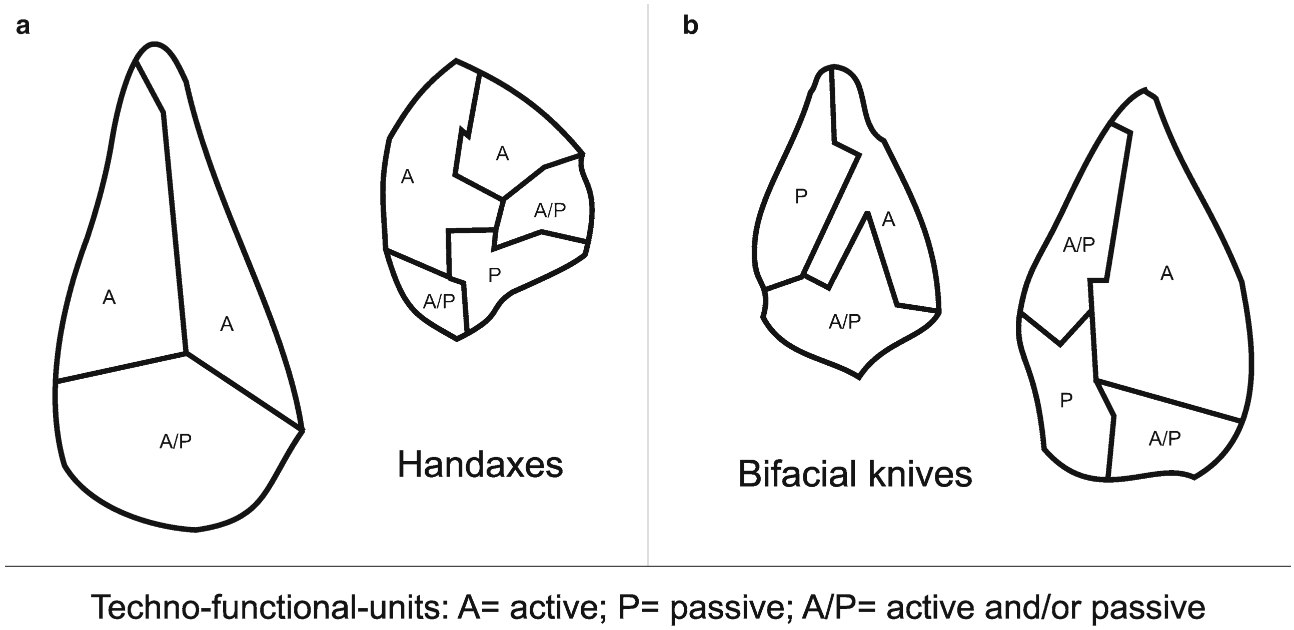

Fig. 13.1 Comparison between the organization of the techno-functional units on handaxes (**a**) and bifacial backed knives (**b**)

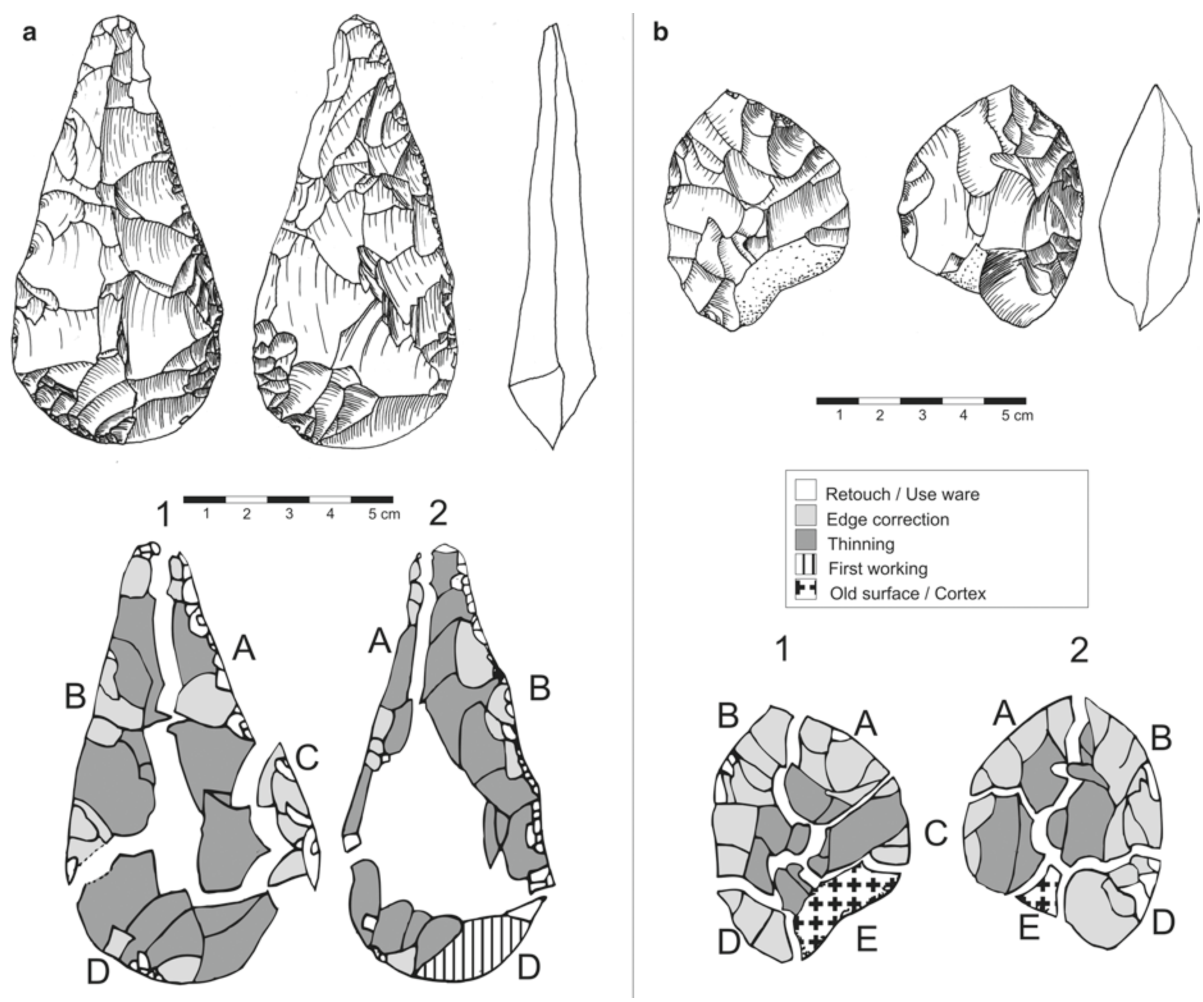

Fig. 13.2 Examples of the organization of techno-functional units on handaxes from La Micoque

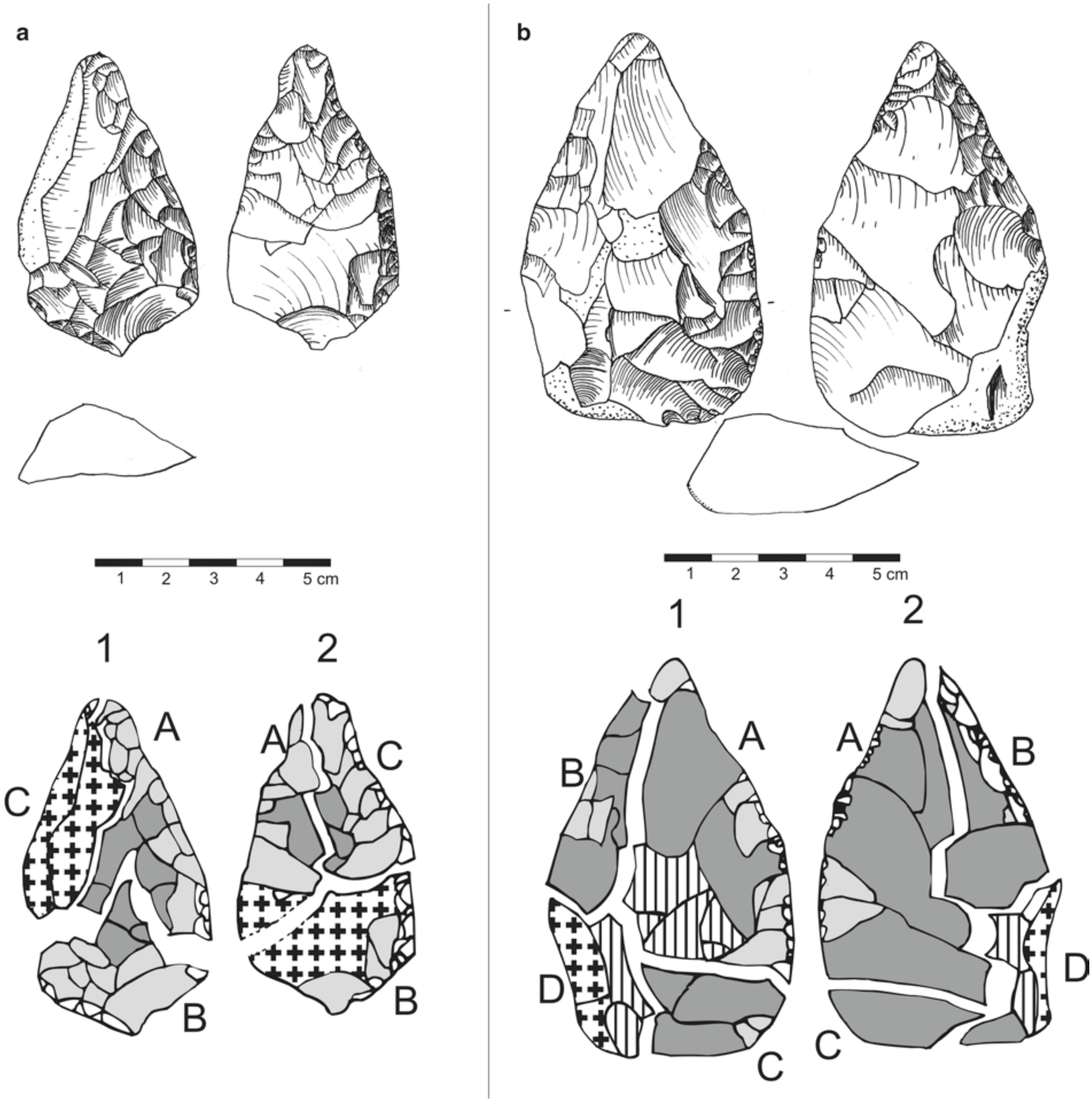

Fig. 13.3 Examples of the organization of techno-functional units on bifacial backed knives from La Micoque

never changed, i.e., there is no case where a previous handaxe became a backed bifacial knife or inversely. It could nevertheless happen that supplementary TFUs were added during the use of the tool, changing the characteristics of the edge to create a new tool (e.g., sharper scraper) or elongate the passive zone of the basis (Fig. 13.2a). The biggest problem related to the function of the different units is to determine if the basis was active or passive. Usually, blunt edges are considered passive, but the possibility remains that the massive end has been used to crush material, as quoted in Albrecht et al. (1984), Hahn (1991) and Boëda (2001). This question cannot be resolved for the material from La Micoque, since the state of conservation is too poor to undertake microwear analysis. A possible difference in use of handaxes vs. bifacial backed knives cannot be analyzed for the same reason. The life span of the bifacial items seems to have been relatively short compared to other sites (e.g., Buhlen: Jöris 2001). The edges of numerous pieces were sharpened until they became nearly blunt, but there are only four cases where a more invasive reworking, i.e., a correction of the steepness of the edge, took place. The value attributed to the tools seems to have been only limited to of the restricted time and work invested to maintain their functionality. Further possibilities for such a rapid discarding of the bifacial tools can be the presence of abundant raw material at the site, the briefness of the stay at the site, or the limit of the need for the tool.

The question of bifacial tool production on the site could not be answered with the material available. Some unfinished pieces suggest that at least a part of them were hewn *in situ*, but not to what extent production took place at that location.

Discussion

As seen above, the material of La Micoque 6 contains bifacial items that can be identified as bifacial backed knives, allowing relating them to the Central European *Keilmessergruppen* (KMG) *sensu lato*. By doing so, however, several problems arise, all closely related to one another.

The first one touches the definition of the KMG: to what extend can assemblages including bifacial backed knives be considered systematically as belonging to the KMG? Even only in Europe, such pieces occur in Acheulean (Galeria Pesada: Marks et al. 2002; Trinkhaus et al. 2003; Mesvin IV: Cahen 1984; Cahen and Michel 1986; Van Neer 1986; La Cotte de St. Brelade: Callow and Cornford 1986; Tuffreau and Vandermeersch 1992; Pombonne: Chadelle et al. 1996) as well as in Mousterian (Sesselfelsgrotte: Richter 1997) context, covering huge periods of time, and not necessarily all assemblages have been studied in this regard. What are the diagnostic elements, specially the discriminating ones, allowing relating an assemblage to the KMG or not? A clear definition of the KMG is still missing, and a typological description of the different *Keilmesser* is problematic, since the reasons for their shape and characteristics depend on numerous factors (see above). Furthermore, the final shape of the bifacial items have very little to do with the original one at some sites, whereas at others, as La Micoque 6, only minor modifications have affected the shape, making comparisons difficult.

The second problem is related to the geographical expansion. The KMG were first thought of as a middle European group of assemblages, but west European sites have already been related to the KMG, like the Abri du Musée (Bourguignon 1992), Champlost (Farizy 1985, 1995; Farizy and Tuffreau 1986) or Mesvin IV. The relationship between the Central European (*Keilmessergruppen*) and the Eastern European assemblages (East European Micoquian) is still unknown.

The third issue is the question of the chronological extension of the KMG. While German authors (e.g., Richter 1997; Bosinski 2002; Jöris 2002) discuss a limitation of the KMG to different parts of the last glacial, increasing data point to an earlier beginning of this type of assemblages even in Central Europe, for example in Pietraszyn 49 (Fajer et al. 2001) or in Dzierżisław I (Foltyn et al. 2000). La Micoque 6 itself is not dated, but lower layers are. La Micoque 3 (E) has been dated by ESR and U/Th to 400 ka, La Micoque 4 (H) to 340 ka, La Micoque 5 (J) to 340 ka (Falguères et al. 1997), and La Micoque 5′ (L) to 280–300 ka (Schwarcz and Grün 1988; Falguères et al. 1997). La Micoque 6 was dated on the grounds of the characteristics of the sedimentation probably deposited during the isotope stage 8 (300–250 ka) or slightly later (Rosendahl 2006) and would, together with Mesvin IV, be one of the oldest witnesses for this type of sets. Even the pseudo-burin blow, which has been considered as a diagnostic element for the late MIS 5 - MIS 4 (Jöris 2002), is also present in La Cotte de St. Brelade and in Mesvin IV, both clearly older.

Conclusion

The presence in La Micoque 6 of two different concepts that do not mix shows clearly that both forms of bifacial tools, handaxes and bifacial backed knives, were deliberately wanted and produced. In the actual state of knowledge, it is therefore legitimate to relate La Micoque 6 with the KMG, due firstly to the presence of bifacial backed knifes and, to a lesser extent, to the vicinity of the site Abri du Musée, also attributed to the KMG, for which the chronological position is still discussed (for different views see Gouédo 1999; Jöris 2002).

The different problems discussed above make a delimitation of the KMG to Central Europe and to the last glacial difficult. Sites cannot be ignored just because they are too old to fit in the framework or outside of the determined region. Even if a peculiar concentration of KMG-assemblages seems to occur in that region at that time, much more research has to be undertaken to clarify the phenomenon of KMG. The KMG-concept has therefore to be considered provisionally only as a working hypothesis and cannot be used to date typological assemblages that aren't otherwise dated.

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Chapter 14
Handedness in Neanderthals

Natalie T. Uomini

Abstract The question of manual laterality in extinct hominins has long interested archeologists and paleoanthropologists. It is possible to approach this question using the fossil and archeological records. By drawing on several different categories of evidence, a more complete picture of Neanderthal handedness emerges. This shows that Neanderthals produced lateralized use-wear on stone and bone tools, made asymmetrical retouch patterns on artifacts, had strongly asymmetrical upper limbs, and display tooth striations consistent with right-handedness. The diverse categories of evidence all indicate a bias to the right side, which suggests that the Neanderthals were right-handed in high proportions just as are living people. It is the most robust and reliable evidence for prehistoric handedness out of all hominin species and it indicates the Neanderthals showed the population-level right-side bias that is a characteristic feature of humankind.

Keywords Manual laterality • Lateralized use wear • Asymmetrical retouch patterns • Skeletal/endocast asymmetries

Introduction

When reconstructing specific aspects of Neanderthal lifeways, it is often useful to take a multi-disciplinary approach. One question which is amenable to such an approach, and which has fascinated archeologists and paleoanthropologists since the nineteenth century, is whether the Neanderthals were lateralized, namely, what proportion of individuals was right-handed. This is related to the larger question of when our rightward-biased pattern of hand use emerged in the hominin lineage. The current data on hand preference and performance for living *Homo sapiens sapiens* suggests that we have a 70–90% population-level bias to right-handedness (Annett 1970; McManus 1979; Annett 2002). When measured by direct observation of spontaneous behaviors, people in traditional societies show a pooled frequency of 84% right-handedness for tool use (Marchant et al. 1995). Behavioral observations on the other living great apes (chimpanzees, bonobos, gorillas, and orang-utans) show that this strong population-level bias is not shared by our nearest evolutionary cousins (McGrew and Marchant 1997; Fletcher and Weghorst 2005; Papademetriou et al. 2005; Mosquera et al. 2007; Cashmore et al. 2008). By implication, species-level right-handedness must have emerged sometime after the divergence from our last common ancestor(s), which is thought to have occurred sometime between 5 and 10 million years ago (Wood and Constantino 2004). The search for the emergence of this trait therefore focuses on hominin species prior to *Homo sapiens sapiens*.

The worldwide interest in determining handedness in ancestral species has often been motivated by the question of whether these hominins had language. Linguistic capacity is currently thought to be a defining feature of humans (Greenberg 1959; Peters 1972; Hewes 1973; Montagu 1976; Burling 1986; Gibson and Ingold 1993; Armstrong et al. 1995; Knight et al. 2000; Corballis 2002; Wray 2002; Burling 2005). This much-debated topic has been driven, historically, by a desire to assert our superiority in the animal kingdom (Corballis 1989; Corbey 2005). Manual laterality is sometimes used as a proxy for language lateralization in the brain, and as such it has been invoked as an argument for or against the presence of language in prehistory (e.g., Falk 1980; Falk et al. 2005; Frost 1980; Annett 1985; McManus 1985, 1991; Rogers 1993; Aiello 1998; Corballis 2005; Llorente et al. 2008). However, the exact nature of their relationship still remains theoretical (Harris 1991; Provins 1997; Michel 1998; Bradshaw 2001; Vauclair and Fagot 1993; Jürgens 2005; Woll and Sieratzki 2005; Uomini 2006).

There are several contenders for the first claim to a common origin for language and handedness. The most well-known and most frequently cited is Pierre Paul Broca (1861a, b). It is said that Boca's later publications popularized the idea of this link (but see Harris 1991). However, it

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seems that some notion of a connection was already in circulation, through Bouillaud (1825) and later Hughlings Jackson (1868, 1880). The anthropologist Daniel Wilson (1885, 1886, 1891) explored, through archeological artifacts, the links between handedness, aphasias, and the manipulative skills of prehistoric people. Current theories are based on the assumption that handedness and language arise from a single brain mechanism related to brain asymmetry (Crow 1998). For example, Levy and Nagylaki (1972: 119) propose that "since the above data establish that a correlation exists between hemispheric dominance and handedness, the most reasonable inference is that both are under genetic control and that the genetic mechanisms controlling the two are in some way related". Similarly, Frost (1980: 448) states "The co-occurrence of these asymmetries in the hominids is perhaps too much to be a coincidence".

A clearer neuroanatomical hypothesis is found in suggestions of a specific ability which is common to both handedness and language. For example, the sequential processing hypothesis (Bradshaw 2001; Aboitiz and García 1997); proposes a common temporal aspect to language and handedness, while the adjacent motor areas hypothesis (Falk 1980, 1987) suggests that motor areas for speech and hands are connected due to their proximity in the brain. Others postulate a common factor of general cognitive abilities (Alter 1989; Krifka 2005; MacNeilage 1986), symbolism (Vandervert 1997, 1999), tools (Steele et al. 1995), or other unrelated activities (LeDoux et al. 1977; Sieratzki and Woll 2002). A link is made through any one of various abilities or activities, or combinations of them. This is the crucial point in exaptation hypotheses of language evolution.

Even without relating it to language evolution, the study of handedness continues to generate interest in its own right, since it can provide valuable insights into the motor skills and technological behaviors of prehistoric people. This chapter addresses the particular issue of manual laterality in Neanderthals. A brief overview of some historical references to laterality in hominins will set the stage for a review of the current evidence. This consists of data from archeology, fossil skeletons, and clues from other behaviors for which there are ethnographic parallels in living humans. By combining several different categories of evidence, a more complete picture of Neanderthal laterality emerges.

Background

In the historical literature, some mentions of laterality in prehistory have appeared since the nineteenth century. However, none have focused directly on Neanderthals. In his literature review of prehistoric handedness, Daniel Wilson (1885 and 1891) concludes that "… any strongly-marked examples of the left-handed workman's art thus far observed among paleolithic flint implements appear to be exceptional". Wilson's references are those of Cushing (1881) on the direction of pressure flaking scars in Native American arrowheads, the directionality of animal heads in French cave art (see also Alter 1989), and Evans' (1897) remarks on the Z-shaped profile of twisted handaxes (see also White 1998). These diverse sources of research into prehistoric handedness were already well-known at the time of medical doctor Daniel Brinton, who wrote over 100 years ago: "Archeologists have not neglected to study the relics of primitive man with the aim of ascertaining his dextral or sinistral preferences" (Brinton 1896). However, although "Neanderthal Man" was known since 1856, none of these earliest proposals refer directly to Neanderthals; in fact, the concept of Mousterian artifacts did not exist at the time, and the term "Paleolithic" was used as an umbrella term for all prehistoric people. It was not until the middle of the twentieth century that archeologists began again to look for handedness in artifacts. The remainder of this chapter will focus primarily on the data that has specifically been presented as evidence for handedness in Neanderthals and their material culture.

Currently the Neanderthals have the most abundant and most reliable handedness data of all extinct hominin species. The fossil and material culture evidence for handedness in other hominin species has been reviewed elsewhere (Steele and Uomini 2005; Uomini 2006). A major problem is that many of these data come from poorly-dated contexts, are not directly associated with hominin remains, or are based on unreliable methods (Uomini 2006). Some of these data from non-Neanderthal species consist of single instances, which are only useful as anecdotal examples of laterality. Knowing the handedness of only one individual does not tell us anything about the laterality of that person's community or species. Examples are the Nariokotome Boy's (WT-15000, *Homo ergaster*) right-sided skeletal bias (greater development of the clavicular area of attachment of the right deltoid muscle and greater length of the right ulna, consistent with right-handedness) (Walker and Leakey 1993) and the right-skewed knapping scatter (a triangular concentration of flakes bounded by the outlines of the legs consistent with a knapper seated on the ground) preserved *in situ* at the 500 ka old site of Boxgrove, UK (Wenban-Smith 1997; Roberts and Parfitt 1999). Other types of data are assemblages of artifacts which may reflect a group-wide bias but fail to discern individuals. These are equally uninformative because they may reflect either the repeated actions of one individual, or the single actions of many people. In both cases, the minority users (such as left-handers) leave so little evidence compared to the majority that the minority's signatures may become invisible. The data proposed by Toth (1985) and by Rugg and Mullane (2001) may fall into this category (Patterson and Sollberger 1986; Ludwig and Harris 1994; Pobiner 1999; Uomini 2001). In still other cases, data come from palimpsest assemblages or groups of sites with an extremely coarse temporal resolution spanning hundreds of thousands of years. Such data are found in the predominant Z-shaped profile of twisted ovates found in France and the UK between OIS 12 and OIS 8 (478 ka–242 ka) (Evans 1897; White 1998) and the circa 1 million-year-old handaxes and cleavers from surface collections at Kariandusi, Kenya, whose macroscopic use-wear suggests they were held predominantly in the right hand (Phillipson 1997). In these last two cases, although the methods may be reliable, the data points do not represent related individuals from a single population.

In contrast, the evidence that is associated with Neanderthals, either directly or indirectly is somewhat more robust and reliable. Most importantly, there are some data sets from groups of Neanderthals in which the laterality of related individuals can be assessed. These give us a glimpse of the proportion of left-handers that may have existed in a typical group of contemporaneous Neanderthals.

Lateralized Use-Wear and Lateralized Knapping

The first detailed studies of laterality in Neanderthal artifacts were done by Semenov in Russia from the 1930s onwards, although his work did not reach the English-speaking community until several decades later (Semenov 1964). He combined ethnography, use-wear analysis, and experimental trials to reconstruct the holding positions for specific tools. From these holding positions and the use-wear traces, Semenov (1964) identified the direction of motion for the tools during use: “traces of work as a whole regularly reflect the kinematic action of the hand, and striations represent parts of the path of the tool in its movement.” Semenov’s particular interest in determining the handedness of prehistoric flint knappers and tool users is evident in his 1964 volume (Uomini 2008). He recognized the importance of asymmetrical processes and used these to reconstruct the laterality of the users, for example on flint blades: “The striations (very fine scratches and lines) are sometimes at right-angles to the working edge, but more usually somewhat inclined towards the working end of the knife, caused by the pressure of the human hand, which pushes the blade in a parallel direction to the whittling surface” (Semenov 1964). Among the Paleolithic artifacts reviewed in the volume, laterality was determined for bone retouchers and endscrapers.

Bone Retouchers

The kinematics of pressure flaking were proposed by Semenov (1964) to cause lateralized use-wear on bone retouchers: “In some cases traces of pressure retouch have the form of broad grooves one on top of another, in others very slight dents hardly detectable with the naked eye. From these run almost microscopic grooves like very tiny scratches, which show the tearing of the blade when worked by extraordinarily careful and fine retouch”. The retouchers presented by Semenov (1964) have clusters of dents on their convex side (i.e. the working side) which are oriented at an angle of 75–85 degrees to the long axis of the tool (Fig. 14.1). Replication experiments by Ahern et al. (2004) showed that the dents caused by pressure retouching are “short linear channels with a U-shaped cross-section”.

According to Semenov’s (1961, 1964) experimental trials, the ideal holding position for retouching flint with bone is in this angle range, with the right hand holding the retoucher and the left hand holding the flint piece (Fig. 14.2). The pressure is applied upwards from the right hand to remove spalls from the upper (visible) surface of the flint. In Semenov’s ideal configuration, the long axes of both pieces meet not at 90°, but at a more acute angle. This may be related to biomechanical efficiency, where the position of the forearms in front of the body are most effective for applying force when the elbows are closer to the body. Fortunately, this means that leftward and rightward acute angles are different (a perpendicular angle would be the same for right- and left-handed configurations). Semenov’s argument is

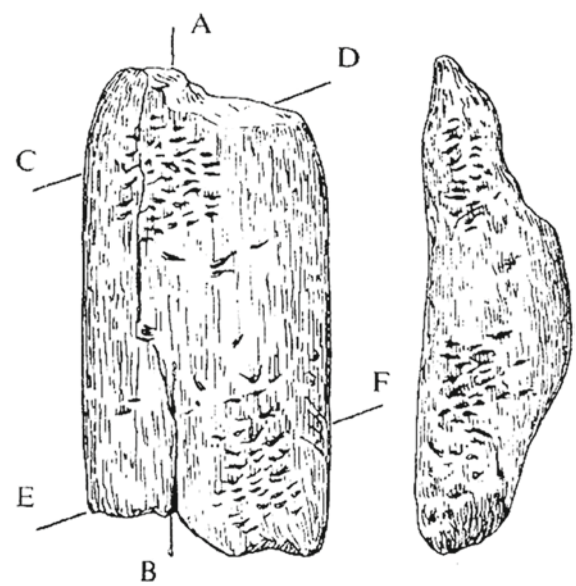

Fig. 14.1 Retoucher from Kiik-Koba showing diagonal right-handed use-wear marks (From Semenov 1964: 177)

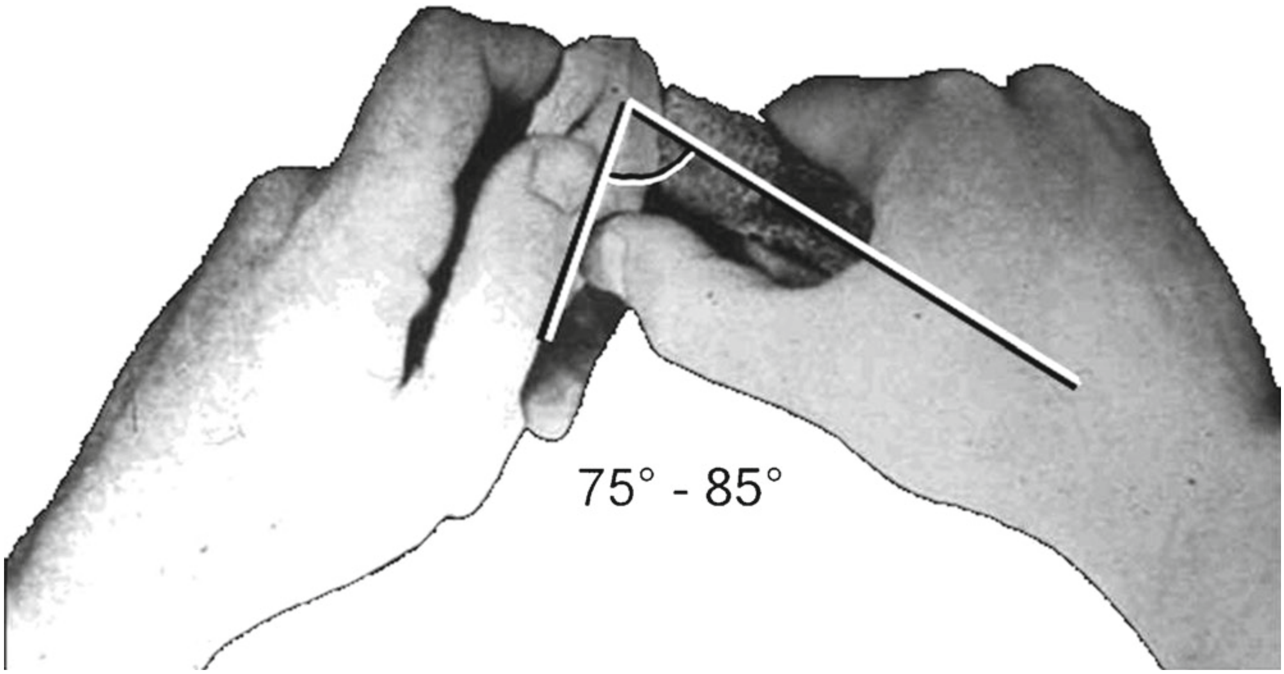

Fig. 14.2 Ideal holding position for retouching flint with bone (Modified after Semenov 1964: 177)

based on the assumption that right-handed and left-handed users tend to use opposite bimanual configurations, causing different orientations of the traces.

Figure 14.2 illustrates Semenov's reconstructed bimanual configuration. More recent experiments confirm that an area near the distal end, but not at the tip, of the bone is ideal for pressure retouching (Ahern et al. 1994). Assuming that the working end of the bone retoucher is near the distal end, the bone can be inverted to provide a second working end. This dual use is demonstrated by the frequent presence of two clusters of dents, one near each end of the retoucher (this is also the case on the Vindija retoucher from Gd illustrated in Ahern et al. 2004). The frequent occurrence of two parallel clusters means that the relative working angle was the same for either end of the bone. When the traces occur clearly oriented in one consistent direction, we can infer that each tool was only used by one person, or by several people using the same configuration. The retouching tools that Semenov lists as showing consistent right-oriented use marks are made of equid long bone diaphysis from Middle Paleolithic (Kiik-Koba, Teshik-Tash) and Upper Paleolithic (Kostenki 1) cave sites in the former USSR, but he does not detail numbers of artifacts (Semenov 1964). A slight angle was also noticed in the orientation of at least one retoucher from Vindija Cave, Croatia (Ahern et al. 2004). Seven bone retouchers were found in the Mousterian "G" levels of Vindija, which also yielded several Neanderthal fossils. Figure 25 on page 59 of Ahern et al. (2004) shows clearly diagonal striations on one of these retouchers.

Overall, Semenov (1964) suggests that the right-handed pattern was the most frequent in bone retouchers, although he does not give numbers. However, even if there were enough findings to be statistically significant, the dispersion in time and space of the various sites means they can only be treated as independent occurrences over a wide time range.

Endscrapers

Additional data are also presented by Semenov (1964) on endscrapers from Mousterian and Upper Paleolithic sites. In these artifacts, Semenov proposes a mechanism for asymmetrical scraper wear on hand-held scrapers that were used to work hide. Semenov begins with the assumption that these tools, made on retouched flakes, were used with the ventral face of the flake moving towards the user (Semenov 1964). The optimal working angle is similar to that for the bone retouchers, but with very different biomechanical implications. The tool is held "with its axis at an angle of 75–80 degrees to the skin surface" (ib.), rather than at 90°, with the thumb pressing against the ventral face of the flake as the tool is pulled towards the user. Similarly, Gunn (1975) found an optimal working angle of 70° for similar uses with burins. This position leads to greater use-wear on the right lateral side of the scraper's distal end, owing to a bias of the right forearm (Fig. 14.3).

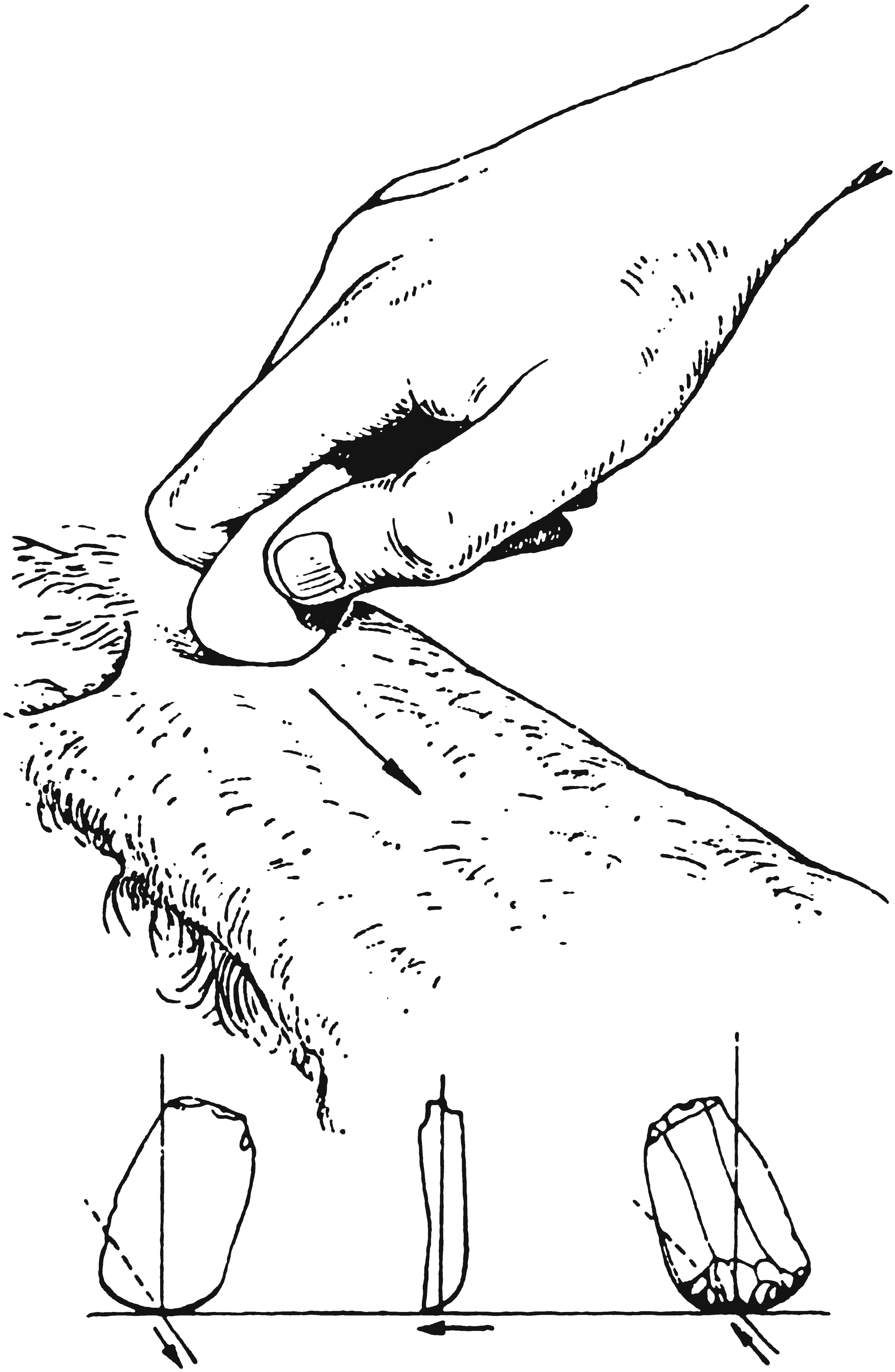

Fig. 14.3 Ideal working angle for endscrapers (From Semenov 1964: 88)

Based on asymmetrical "secondary trimming" on one edge of the scrapers, which is taken to reflect their usage, Semenov counted that "about 80% of endscrapers are worn on the right side. Not only material from sites at home (Kostenki I, Timonovka, Mezin, Suponevo, Sakajia cave) but also published abroad testify to this" (ib.). Although Semenov writes this figure with confidence, he once again fails to provide any numerical data or statistics. He lists data from European publications of sites from the Caspian Sahara (Breuil and Clergeau 1931), namely Wadi Diffel (end- and disk scrapers worn on the right side) and Wadi Mengoub ("not all worn on the right side"). Semenov adds that "the greater part" of endscrapers from Przedmost (Moravia) and from Magyarbogy (Transylvania) are also worn on the right side (Breuil 1924). Semenov also lists other publications of material from Gorge d'Enfer, Font-Robert, El-Mekta, Lespugue, Ercheu, Seriniá, and Campigny, claiming that "these and many other sites have yielded endscrapers with signs of wear on the right-hand side" (Semenov 1964).

Once again, the reported high proportion of right-handed use on the endscrapers may indicate a right-handed bias either synchronically or diachronically. Unfortunately the data as it stands can only reflect laterality in a broad sense, over a vast time range covering the Middle and Upper Paleolithic. The lack of detail in the data gives no information about lateralization at the level of community groups.

Asymmetrical Retouch

A handedness-based interpretation of asymmetrical retouch is proposed by Weber (1990), who studied artifacts from Gröbern, a Middle Paleolithic site in Germany. This method begins with the assumption that the edges of flake tools would show different retouch depending on what the function of the edge was, namely as a working edge or as the edge to be gripped in the hand. Weber measured the cutting angles of three edges (left, distal, and right, with the flake butt oriented towards the observer and ventral face down) on 25 retouched flake tools. While the left edge angles have a range from 24 to 31 degrees, the right angles have larger values, between 37 and 44 degrees. Weber (1990) suggests that the more acute angles indicate that the working edge was the left edge, and hence a preference for the artifacts to be used in the right hand. This is based on the assumption that the tools were used "with the bulb towards the user and the ventral face down" (ib.). To complete the study, Weber (1990) examined use-wear traces on ten of these same artifacts and found a preference for the left side. In conclusion, combining the use-wear data with the retouch angles, these artifacts show a tendency for the wear traces to occur on the distal end of the left edge and the left side of the distal end, which is consistent with right-handed use. Unfortunately, the small number of artifacts precludes the use of statistics in this sample.

Production Techniques of Resharpening Flakes

Further evidence for handedness in Neanderthal artifacts is suggested by Cornford (1986). The site of La Cotte de St. Brelade (Jersey, Channel Islands) has a long stratigraphy spanning the last two interglacials (from 240 ka to 122 ka). The typology of the lithic assemblages contains a Levallois component and all but the two earliest layers "fit very readily into an early Middle Paleolithic technocomplex" (Callow 1986), thus confirming their place in the time range of Neanderthal occupation. Neanderthal remains were recovered in the 1910–1911 and 1915 excavations; the surviving specimens consist of ten teeth plus three casts of teeth that are now missing, and one fragment of a child's skull from the left occipital squama (Stringer and Currant 1986).

Cornford (1986) proposes a method based on the production techniques of specific types of resharpening flakes at La Cotte de St. Brelade. These flakes served to rejuvenate used edges and were knapped from retouched flake tools (mainly sidescrapers but also endscrapers and unidentified scraper types). The removal is a *coup du tranchet*, struck along the working edge, which "creates a new edge of the greatest possible length and sharpness on the parent tool" (ib.). The resulting flakes are termed either longitudinally struck flakes (LSF) or transversely struck flakes (TSF). As Cornford (1986) describes, transverse sharpening flakes "are struck from the edge of a retouched tool by a blow more or less at right angles to it and delivered on the ventral surface" (ib.). They are wide and short. Long sharpening flakes are also struck from a point of percussion on the ventral surface, but their length extends along the edge of the scraper and they are usually longer than they are wide. Both these types of sharpening flakes have parallels in North America; the TSFs correspond to Shafer's (1970) Retouch Method B ("striking the ventral surface of the scraper near the edge in such a way as to remove a section of the trimmed edge"). A small proportion of LSFs (21.5%) was also struck from the dorsal surface of the parent tool, and thus correspond to Schafer's (1970) Retouch Method C ("the trimmed scraping edge serves as the striking platform which is struck at an angle to remove a flake from the ventral surface of the dull scraper").

The interpretation of the knapper's handedness is based on an underlying assumption about biomechanical constraints on holding positions when knapping the long and

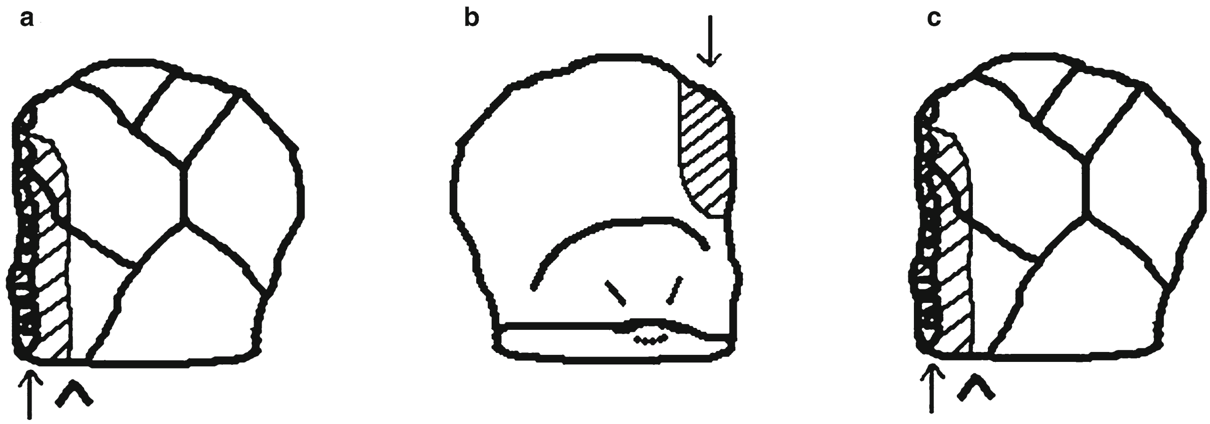

Fig. 14.4 Preferred removal locations for Long Sharpening Flakes, shown on a schematic scraper. *Striped area* shows future negative (flake scar) of LSF to be removed in the direction of the *arrow*. (**a**) distal right end of dorsal surface; (**b**) proximal left end of dorsal surface; (**c**) distal right end of ventral face

transverse sharpening flakes. Cornford (1986) noted that most of the LSFs at the site were removed from the same corner of the tool, regardless of the tool's orientation. This is illustrated in Fig. 14.4. Cornford's replication experiment showed that a right-handed knapper was unable to make LSFs when striking on the opposite edge, meaning that the removal location chosen by the La Cotte knappers was the preferred one for a right-handed knapper. Out of 1,302 unbroken LSFs, 79% were removed from the right distal end of the dorsal or ventral surface and from the left proximal end of the dorsal surface (Fig. 14.4). However, by far the most frequent removal location was the distal right end of the dorsal surface (Fig. 14.4a), accounting for just over 50% of the assemblage. All of these removal locations are achieved with the same holding position. The proportion of 79% is taken as representing a right-handed preference among the population of Neanderthal knappers at the site (ib.).

Cornford (1986) proposes a slightly different argument for transverse sharpening flakes. The biomechanical constraints for TSFs are different from LSFs. These can be struck with a blow that is either perpendicular to the edge of the tool, or oblique to it. A perpendicular blow results in the TSF showing its point of percussion located at the center of the butt. An oblique blow results in a point of percussion located at one end of the TSF's butt. This shift can be achieved by changing the relative positions of the tool edge and the striking arm (Fig. 14.5). Combined with the holding constraint that the struck edge must be opposite to the gripped edge, this leads to Cornford's interpretation that a point of percussion located at the right end of the butt represents a right-hander's knapping, and vice versa. Out of 288 TSFs, about 53% were struck with an oblique right-handed angle, 32% with a perpendicular angle, and 15% with an oblique left-handed angle (ib.).

Summary of Material Culture Data

The material culture evidence for laterality in Neanderthals is currently limited to these few studies. Semenov (1964) estimates a proportion of 80% right-handed use in Middle Paleolithic bone retouchers, and Weber (1990) infers a right-handed preference for wielding flake tools at Gröbern. With statistical significance, the knapping techniques for long sharpening flakes at La Cotte de St. Brelade suggest that right-handers occurred at proportions between 77% and 91% (Cornford 1986). If the assumptions behind the methods are correct, then these data are robust indicators of stronger signals for right-handed tool production and use than for left-handedness. Nonetheless, it is important to note that caution must be taken when applying the methods reviewed here to different assemblages. An attempt to replicate Cornford's (1986) methodology for tranchet removals on Lower Paleolithic bifaces found a high proportion of right-handed knappers according to Cornford's classification, but it was argued that the La Cotte sharpening flakes were technologically distinct from tranchet flakes on these bifaces (Uomini 2006). Furthermore, a knapping experiment showed that there were no biomechanical constraints on knapping tranchet flakes on handaxes, since knappers can achieve different striking angles by varying the core support on the leg (Uomini 2005). In addition, the use-wear methods of Semenov are now being revised and improved with new technologies. Although traceology can now reliably determine the direction of movement and the working angle of hand-held tools (e.g., Fritz et al. 1993), little attention is paid to the differential traces of right and left hands. More work in recent years has been done on another category of information, the skeleton itself; this is described next.

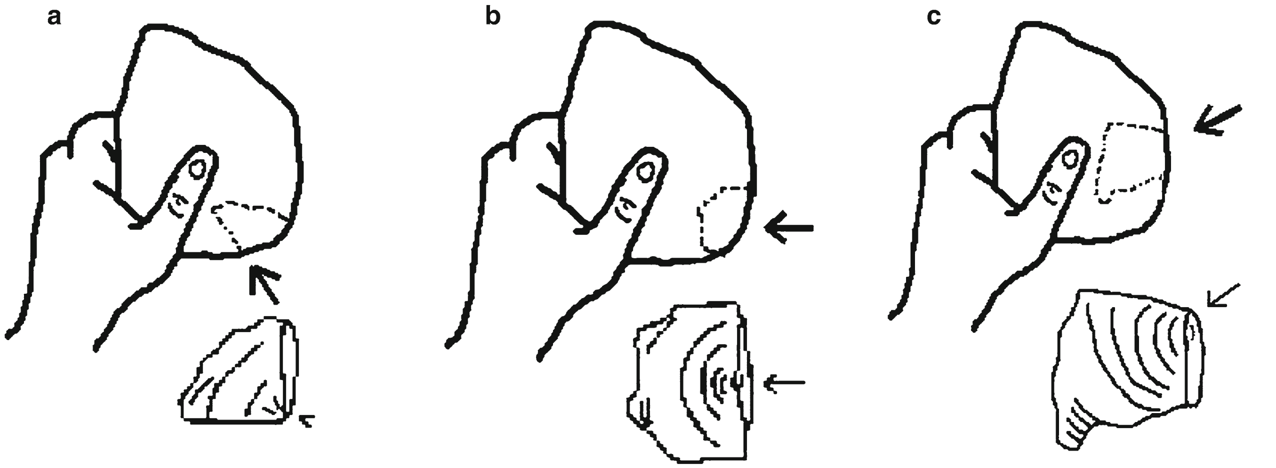

Fig. 14.5 Possible hand configurations for knapping Transverse Sharpening Flakes, and resulting TSFs, shown on a schematic parent tool. *Dotted line* shows future TSF located on the underside of the parent tool. (**a**) left-oblique blow; (**b**) perpendicular blow; (**c**) right-oblique blow

Skeletal Asymmetries in the Upper Limb

There are suggestions that humans are the only primates to show a right-biased asymmetry in arm bones. For instance, Schultz (1937) measured paired humeri and radii in skeletons from 130 gorillas, 82 chimpanzees, 8 orangutans, 21 gibbons, and 722 humans; although he found more chimpanzees with longer left limbs, the human skeletons were about twice as asymmetrical and biased to larger right arms. A more recent study examined skeletons from wild-caught chimpanzees: a 66% left-biased asymmetry was found in the sample of 58 chimpanzee humeri, based on length and cross-sectional area (Sarringhaus et al. 2005). However, the same study also found a weak right-biased asymmetry in the paired metacarpals of 45 individuals. These mixed results suggest that the biomechanics of chimpanzees during locomotion and arm-loading postural support are still poorly understood compared to humans (Sarringhaus et al. 2005), while reinforcing previous indications that the human pattern of upper limb asymmetry is unique among great apes.

The relationship of upper limb asymmetries to handedness has been demonstrated. Because the skeleton grows and adapts itself according to the way it is used (i.e., the mechanical pressures it experiences from muscles and tendons) in a person's lifetime, the differential loading of paired hands, arms, and shoulders necessarily causes asymmetrical adaptations in the skeleton. It must be noted that the effect of asymmetrical muscle strength and mechanical loading on bone mineral formation is localized to the specific site of muscle-bone interaction; the skeleton's response is directly related to the actions of the muscles. The bone's response to loading can include increases in bone strength through increased bone mineral content, density, and/or cross-sectional area (as in the playing arm of tennis players; Haapasalo et al. 1996), increases in mechanical efficiency by shape change (such as the scapula and clavicle allowing a greater range of motion in the gleno-humeral joint on the side of the preferred hand; Bonci et al. 1986), and resistance to avulsion by increasing the surface area of the attachment sites of muscles and ligaments on the bone's surface (Carter 1987). One example of this is found in a recent archeological individual from Rota, in the Mariana Islands, whose right scapula has a beveled joint extension facet, possibly due to habitual slingstone throwing (Heathcote 1995). The effects are not restricted to long bones and large joints, however; in right-handers, the fingers on the right hand are several millimeters thicker than those on the left hand, as well as the hand volume being larger (McLeod and Coupland 1992; Purves et al. 1994).

Steele (2000) and Steele and Uomini (2005) have reviewed the fossil evidence for handedness in Neanderthals and other species. Right-arm dominance exists in all *Homo sapiens sapiens* populations studied to date. These include recent hunter-gatherers, Medieval British, Roman British, German Neolithic farmers, and Northern European Mesolithic people (Schultz 1937; Thould and Thould 1983; Constandse-Westermann and Newell 1989; Reichel et al. 1990; Trinkaus et al. 1994; Steele and Mays 1995). In contrast, very few studies of arm bone asymmetry have been reported for non-*Homo sapiens* fossil hominins. This is often due to the poor preservation of paired upper limbs, or to a total lack of postcranial material for some species. Species that are defined solely on cranial characters are *Sahelanthropus tchadensis*, *Kenyanthropus platyops*, and *Australopithecus* (*Homo*) *rudolfensis*. Others have only unpaired arm bones, such as *Orrorin tugenensis*, *A. garhi*, *Homo floresiensis*, and *A. anamensis*. *A. afarensis* is best represented by Lucy, whose fragmentary paired humeri and ulnae (Senut 1981) have not been studied for laterality.

Nonetheless, well-preserved Neanderthals specimens do provide important information. The data from Neanderthals showing greater humeral robusticity in the right arm has been suggested to result from hunting with thrusting spears (Schmitt et al. 2003). The Neanderthal individual buried at

Le Régourdou shows several markers for right-handedness, notably as greater diaphyseal diameters in the clavicle, humerus, medio-lateral ulna, and radius, as well as greater radial neck diameter, proximal clavicular curvature, radial interosseous crest development, and ulnar radial facet height (Vandermeersch and Trinkaus 1995). Trinkaus et al. (1994) quantified the asymmetries in the paired humeri of eight individuals: La Chapelle 1, La Ferrassie 1, Neanderthal 1, La Quina 5, Spy 2, Shanidar 1, Tabun 1, and Kebara 2. The measurements taken in these individuals were humeral length, distal articular breadth, and the cortical and medullary areas both at 35% and 50% of the length from the distal end of the humerus. All but Shanidar 1 are right-biased; this can be attributed to this individual's pathological right arm and associated disuse atrophy on the left arm (ib.). The arms of Neanderthal 1 also show pathologies, in the form of left-arm lesions which may have partly contributed to the strong rightward asymmetry in this pair of humeri. A possible left-arm trauma can be attributed to a third fossil, La Quina 5, despite the absence of visible lesions. The remaining five individuals are considered as having nonpathological asymmetries, indicating they were subjected throughout their lifetimes to differential loading patterns which favored the right arm (Trinkaus et al. 1994).

The results from the fossils studied by Trinkaus et al. (1994) are listed in Table 14.1 below, incorporated with the

Table 14.1 Summary of laterality results for Neanderthals: humeral asymmetry, dental striations, and endocast petalia patterns

Individual	Humeri	Teeth	Endocast
Cova Negra	–	R (one tooth)[a]	–
Djebel Ihroud 1	–	–	R[a,b]
Engis 2	–	–	R[c] but distorted
Gibraltar 1 – Forbes' Quarry	–	–	R[b]
Gibraltar 2 – Devil's Tower	–	–	R[b]
Hortus 7	–	R[a]	–
Hortus 8	–	L[a]	–
Hortus 9	–	R[a]	–
Hortus 11	–	R[a]	–
Hortus 12	–	R[a]	–
Kebara 2	R[d]	–	–
Krapina – KDP[i] 5	–	R (five teeth)[e]	–
Krapina – KDP[i] 6	–	R (12 teeth)[e]	–
Krapina – KDP[i] 17	–	R (five teeth)[e]	–
Krapina – KDP[i] 18	–	R (three teeth)[e]	–
Krapina – KDP[i] 29	–	R (two teeth)[e]	–
Krapina – KDP[i] 'Q'	–	R (two teeth)[e]	–
Krapina – KDP[i] 4	–	L (seven teeth)[e]	–
Krapina – six individuals (KDP[i] 10, 13, 19, 23, 26, 30)	–	no predominant pattern[e]	–
La Chapelle-aux-Saints 1	R[d]	–	L[b,f]
La Ferrassie 1	R[d]	–	R[b]
La Quina H5	R[d] but possibly pathological	R (two teeth)[a,g]	no asymmetry[f]; weakly R[b]
Le Moustier 1	–	–	R[c]
Le Régourdou	R[h]	–	–
Neandertal 1	R[d] but pathology partly responsible: L arm lesions; L arm is hypotrophied/atrophied and R arm is hypertrophied	–	R[f]
Saccopastore 1	–	–	R[i]
Shanidar 1	L[d] but pathological: atrophy on arms and trauma/disease on whole skeleton	–	–
Shanidar 2	–	R (two teeth)[j]	–
Spy 1	–	–	R[b,k]
Spy 2	R[d]	–	R[b,k]
St. Brais	–	R (one tooth)[l]	–
Tabun 1	R[c]	R[a,g]	–
Teshik Tash 1	–	–	R[c]

Notes: [a] data from Bermúdez de Castro et al. 1988 (R indicates right-handed striations); [b] data from Holloway and Delacoste-Lareymondie 1982 (R indicates predominant pattern of right-frontal and/or left-occipital petalias); [c] data from Grimaud-Hervé 1997; [d] data from Trinkaus et al. 1994 (R indicates right-biased asymmetry); [e] data from Fox and Frayer 1997, each KDP (Krapina Dental People) or 'tooth set' is from a single individual; [f] data from LeMay 1976; [g] data from Lalueza and Pérez-Pérez 1994 (reported in Fox and Frayer 1997); [h] data from Vandermeersch and Trinkaus 1995; [i] data from Bruner et al. 2006; [j] data from Trinkaus 1983; [k] data from Holloway 1981; [l] data from Koby 1956 (cited in Bermúdez de Castro et al. 1988) data from the dental use-wear study by Bermúdez de Castro et al. (1988). The humeral asymmetry results are shown as R (right-handed) or L (left-handed) according to the individual's asymmetry bias as judged by greater values on one side. The teeth results are shown as R or L according to the direction of striations; striations oriented downward to the right correspond to right-handed users and vice versa, as described in the text.

Dental Striations

Another possible dataset for determining hand preference is found on teeth, particularly in the orientation of diagonal striations. The presence of these traces on the anterior dentition of many Neanderthals has often been interpreted as the result of a specific, lateralized eating activity (Martin 1923; Semenov 1964; Trinkaus 1983). This involves holding a piece of meat in between the teeth and with one hand, and cutting off pieces with a knife held in the other hand. A photograph showing one hand configuration used for this action is found in Weyer (1959), shown in Fig. 14.6.

Ethnographic observations by Semenov (1964) and others since the last century confirm that this practice was not only widespread among Arctic peoples, but was also common for traditional peoples in other parts of the world (South Africa, East Africa, North America, and the Amazon). Importantly, the universal pattern is to hold the meat with the left hand and the cutting implement in the right hand; this is true for all references that mention hand roles (Uomini 2008). A number of published mentions of this behavior were found in the e-HRAF Collection of Ethnography (HRAF 2003), and their geographical distribution is summarized in Fig. 14.7.

Despite the widespread ethnographic parallels for cutting meat held in the mouth, there are no data from recent hunter-gatherers to support the hypothesis that this behavior causes the diagonal striations identified in Neanderthals. Bermúdez de Castro et al. (1988) tested this hypothesis with an experiment. The procedure involved wearing a prognathic mouthguard with fake porcelain Neanderthal teeth, holding pieces of meat between the teeth, and cutting off bite-sized pieces with flint flakes using the right hand. The experimenter made striation patterns on the anterior teeth oriented downward to the right (from the individual's point of view).

The experimental meat-cutting results are consistent with the fossil dental striations, in which the marks predominantly extend from the upper left part of the buccal surface to the lower right part of the tooth (Fernández-Jalvo and Bermúdez de Castro 1988). The Neanderthal teeth measured by Bermúdez de Castro et al. (1988) include two teeth from La Quina 5, one isolated tooth from Cova Negra, and several anterior teeth from five individuals at Hortus (France). In addition they report data from one isolated tooth from Saint Brais (Switzerland), and two teeth from Shanidar 2. All but one of these fossil samples show striations oriented downward to the right, as in the experiment. The teeth from Hortus VIII have inversely oriented striations, suggesting this individual was a left-hander. These are summarized in Table 14.1.

Other data support the universal Neanderthal pattern of right-oriented dental striations. Fox and Frayer (1997) studied 82 teeth from individuals at Krapina. Thirteen individuals with ages estimated between 13 and 27 years show consistent patterns within their own tooth sets. Six of these Neanderthals have predominantly right-handed striations, while one shows the opposite pattern. The remaining six individuals have no predominant pattern, but rather combinations of marks in different orientations. Pooling all teeth from Krapina, the rightward pattern is more than twice as frequent as the left-handed pattern (ib.). Additional data reviewed by Fox and Frayer (1997) include Tabun 1, and La Quina 5, all of which show right-handed patterns; these are also included in Table 14.1.

Endocast Asymmetries

One final category of evidence from fossils that has been proposed to relate to handedness is cerebral asymmetry. The coarse morphological asymmetry in the human brain, shown by the association of frontal and occipital petalias, is likely to be associated with hand preference. Specifically, the combination of right-frontal and left-occipital petalias is linked with right-hand preference, while the inverse pattern (right-occipital and left-frontal petalias) is more common in left-handers (Galaburda et al. 1978). However, LeMay (1976) and Holloway and Delacoste-Lareymondie (1982) were reluctant to accept a strict connection between petalias and hand preference, as are Amunts et al. (1996) who highlight how little is known about the relationship between brain morphology and neurological function. If the petalias are indeed linked to handedness, their study is valuable in providing a further source of data for laterality in Neanderthals.

Endocasts of fossil skulls can show petalias, although the expression of circumvolutions is reduced in fossils (Bruner 2003). Some data are presented here for their relevance to Table 14.1. Holloway (1981: 387) reports that three Neanderthal endocasts (Djebel Irhoud 1, Spy 1, and Spy 2) show the right-handed pattern of petalias. Holloway and Delacoste-Lareymondie (1982: 105) report that seven large-brained hominins out of nine (Spy 1 and 2, La Quina, Gibraltar 1 and 2, La Ferrassie, and Djebel Irhoud) show either or both of the left-occipital and right-frontal petalias, while two show the inverse petalia pattern. While this publication does not specify which these latter two fossils are, these may be inferred from the data. The 1982 sample contains the Rhodesian (Kabwe or Broken Hill) and Swanscombe

Fig. 14.6 Ethnographic example of eating meat held between the teeth, with a knife in the right hand (From Weyer 1959: 42)

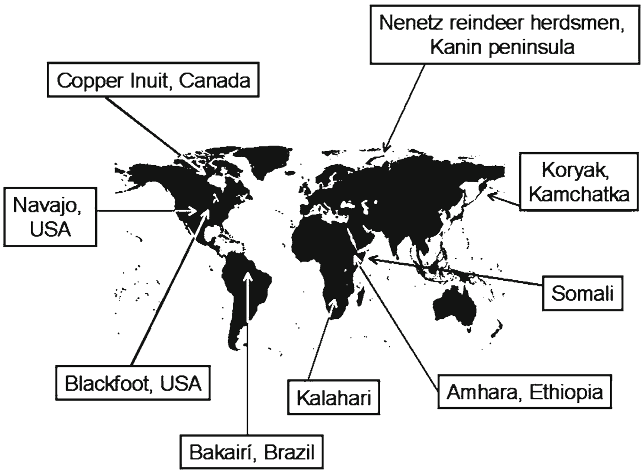

Fig. 14.7 Geographical distribution of ethnographic examples for eating meat held between the teeth with a knife in one hand

endocasts, being included as large-brained hominins although not Neanderthal. Previous observations have attributed an inverse petalia pattern to the Swanscombe skull (Smith 1925; LeMay 1977): "Attempts have been made in the past to determine whether extinct members of the human family were right- or left-handed by a study of the implements made by these people. But so far as I am aware no one has attempted to solve this problem directly by a consideration of the fossil remains of man himself." Smith (1925: 1107).

On the contrary, Grimaud-Hervé (1997: 182) reports a left occipital petalia for Swanscombe. The second fossil in the 1982 sample with inverse petalias is Neanderthal: LeMay (1976) previously reported La Chapelle 1 as showing a slight right petalia in the occipital lobe, confirmed by Grimaud-Hervé (1997) and consistent with the left-handed pattern.

Most of the fossils that yield endocast data have no paired postcranial material. Contrary to LeMay's (1976) report that La Quina showed no asymmetry, Holloway and Delacoste-Lareymondie (1982: 104) find "a weak left-occipital and right-prefrontal pattern". Gibraltar 2 only preserves the frontal lobes but the right is more prominent (Holloway and Delacoste-Lareymondie 1982; Grimaud-Hervé 1997: 196). A further three endocasts studied by Grimaud-Hervé (1997) show left occipital petalias: Teshik-Tash 1, Le Moustier 1, and Engis 2, although this latter shows great distortion.

Unfortunately, no endocast data are available for the Krapina individuals that show dental striations. Krapina 3 and 6 are the best-preserved specimens, but it is not possible to assess asymmetry in the Krapina 3 and 6 endocasts because only the right side of the skulls are available (Holloway et al. 2004; Bruner et al. 2006). However, some of the other Krapina cranial fragments preserve portions of paired frontal and/or occipital regions (Krapina 1, 2, 6), which may offer partial data on petalias in future studies.

While the most frequent petalia pattern and other asymmetry patterns are consistent in living humans and in fossil endocasts since at least 2 ma (Bruner, pers. comm.), they are not unique to hominins. The other living great apes share the human combination of right-frontal and left-occipital petalias (Grimaud-Hervé 1997; Semendeferi and Damasio 2000; Pilcher et al. 2001), although they are less frequent and less prominent. Therefore brain asymmetry patterns can be considered as shared features of hominoids which provided a pre-adaptation to hemispheric specialization in hominins (Bruner 2003). The predominance of the common right-handed petalia patterns among Neanderthal brain endocasts is consistent with the right side dominance seen in the humeral and dental data.

Summary of Fossil Data

The fossil data for humeral asymmetries, dental striations, and endocast petalias are combined in Table 14.1, with the existing results for both types of data shown for each individual. The table is largely incomplete. This is partly due to preservation biases, because many fossils only retain unilateral cranial or postcranial material. Only one individual has data from all three categories, which allows a correlation of features: La Quina H5. Five individuals have data for two categories of evidence: La-Chapelle-aux-Saints 1, La Ferrassie 1, Neanderthal 1, Spy 2, and Tabun 1. All but one are in agreement as to the side of the laterality (right-handed). La Chapelle shows a right-arm dominance but a left-handed petalia pattern. The three possibly left-handed individuals listed are attributed as such from only one category of evidence (Shanidar 1, Hortus 8, and Krapina KDP 4). Pooling all data, the humeral and dental categories of fossil evidence total 28 right-handers, three left-handers, one with discordant features and six individuals of unknown laterality, out of 38 studied. If we assume that the proportion of right to left is the same in the indeterminate samples as in the known samples (90%), then at most one of the six Krapina individuals can be attributed to the left-handed group. In addition, the constrained time range of the Krapina fossil ages (Rink et al. 1995), suggesting that these individuals may have been part of a contemporaneous group, makes it possible to establish that roughly 11 of 13 individuals were right-handed according to the fossil data.

Conclusion

The high proportion of right-handers in the skeletal data agrees with the artifact evidence suggesting an overall figure of 80–90% right-handedness. Although the Neanderthal evidence for handedness is the most reliable and abundant of all non-*Homo sapiens species*, it is far from complete. The wide time spans and geographical ranges, the paucity of sites with associated fossils and artifacts, and the lack of detail in the existing data prohibit calculating the percentage of right-handers in a given population. More studies are needed, in the form of comprehensive analyses which combine several different categories of evidence. Unfortunately, there is still a mismatch between sites yielding Neanderthals with fossil asymmetries and the sites yielding material culture evidence for handedness.

Furthermore, evidence for the hand use patterns of hominin species prior to the Neanderthals indicates that right-handedness is not necessarily a derived feature of *Homo sapiens sapiens*, as it may have emerged much earlier than previously thought. Anecdotal reports of similar evidence for lateralized behaviors in *Homo heidelbergensis*, *Homo ergaster*, and possibly Australopithecines support the early emergence of handedness. For example, right-handed striations were found on the teeth of several individuals from Atapuerca, as well as on the two teeth from Boxgrove (Fernández-Jalvo and Bermúdez de Castro 1988; Pitts and Roberts 1997). Similarly, right-handed petalia patterns on Australopithecine and *Homo erectus* brains (Holloway 1981) shows that their presence in Neanderthals is not a new feature of this species.

With a variety of data from different sources, the evidence for right-handedness in Neanderthals is firm and unanimous. The presence of skeletal and brain endocast asymmetry features in Neanderthal fossils deriving from stratigraphic deposits of varying ages, and the occurrence of Neanderthal artifacts from a wide geographical range showing right-handed production and use, suggest that right-handed lifestyles were a long-standing behavioral pattern in this species. If, as many people believe, right-biased manual activity and morphological brain asymmetries are connected to language lateralization in the brain (Hécaen and de Ajuriaguerra 1964; Bradshaw 1988; MacNeilage 1992; Corballis 2002), then the data make a strong case for the existence of modern linguistic capacities in Neanderthals.

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Part IV
Neanderthal Social Organization and Land Use

Chapter 15
The Social and Material Life of Neanderthals

Clive Gamble

Abstract While it is a commonplace to state that every age gets the Neanderthals it either deserves, or wants, there has recently been a sea-change in these just-desserts and needs. It has taken 150 years for Neanderthals to emerge as humans with a difference and this difference depends not on the shape of the skulls or tools but rather in their competence as social actors. Here, I set out an approach that supplements the rational analysis of their behavior with a relational understanding of their lives. Using the social brain hypothesis I argue that the differences between these perspectives have important implications for the development of Paleolithic archaeology, and in particular the role of artifacts as material metaphors based on the experience of social life.

Keywords Paleolithic society • Material metaphors • Social interaction • Rational/relational perspective

Birthday Celebrations

The Neanderthals of 2006 are very different to those of 1956 and 1906. One hundred years ago the preferred means for hypothesizing about their settlement and society was by direct comparison with Australian Aborigines (Sollas 1911), while 50 years ago the contributors to "Der Neanderthaler und seine Umwelt" (Tackenberg 1956) restricted their discussions to descriptions of bones, stones and physical environment. The form of Neanderthal society was not considered.

Following the centenary of *Homo neanderthalensis* in 1956 there was an infusion of social thinking into archaeology (Renfrew 1973; Redman et al. 1978; Meskell and Preucel 2004; DeMarrais et al. 2004). Modern humans were now classified according to the four stage typology of social evolutionists such as Service (Earle 1994, Service 1962) and models of band societies were applied to Paleolithic and Mesolithic data (Williams 1974; King 1978; Newell and Constandse-Westermann 1986; Constandse-Westermann and Newell 1991). But Neanderthals did not feature in these developments. Instead the emphasis was on the origins of Band Society (Wobst 1974; Gilman 1984), the modern form of hunter-gatherer society with its open and closed networks of affiliation and their implications for patterns of information sharing and the geographical distribution of artifact styles. These data were used to investigate the different spatial scales of Modern Human and Neanderthal society (Stringer and Gamble 1993: Figure 82) and reinforced the importance attributed to a symbolic revolution based on novel artifacts which had wide ramifications for all aspects of society (Pfeiffer 1982; Knight 1991). Such approaches favor the evidence of the European Upper Paleolithic (Conkey 1985; Mellars 1985; Soffer 1985; White 1997) and indeed, before art and ornaments appeared there seemed little evidence on which to base a reconstruction of social life during the Pleistocene (Gamble 2004).

As a result while primatologists forged ahead in their studies of ape and monkey societies, archaeologists accorded hominins whose brains were two or three times larger an almost asocial existence (Gamble 1999: Chapter 1). There were exceptions, most notably in Washburn's (1961) "Social life of early man", which forged a new synthesis from ethnographic, primate, anatomical and archaeological data. Neanderthals figured prominently in this landmark interdisciplinary synthesis. But their social life remained indistinct from *Homo sapiens*. For example, in his review of the anatomical evidence set against a framework of ethnographic data, Vallois (1961: 229) concluded that, "All evidence suggests that the Paleolithic bands were not territorial units, that they were capable of large migrations, and that sexual relations must have existed between them". His last point refers to the isolated populations of both Neanderthals and Crô-Magnons

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in France and Italy. Washburn's synthesis would be applied instead to much older human ancestors in East and South Africa, most notably in the work of Isaac (1989). As a result a gap opened up between studies of early hominin society - based on Washburn's comparative approach - and the evolution of modern Band Society, using models from cultural ecology. Neanderthals, along with *Homo heidelbergensis* and *Homo erectus*, vanished into that black hole of chronology, behavior and culture that Glynn Isaac (Butzer and Isaac 1975) once memorably dubbed "the muddle in the middle". And if Paleolithic archaeologists are not looking for traces of social behavior, is it surprising that those studying later prehistory continue to regard the origins of society as a Neolithic achievement (Renfrew 1996; Watkins 2004; Runciman 2005; Bellwood 2005)?

I will argue in this paper that locating the origins of society in either the Neolithic or Upper Paleolithic is unhelpful (Gamble and Gittins 2004). Hominids, hominins and humans all had social lives, although these varied greatly. The heart of the matter lies in their diverse skills as social actors (Strum and Latour 1987), and their involvement with material culture through cognitive structures that are distributed outside the body (Clark and Chalmers 1998). If this is accepted then a social brain perspective (Dunbar 2003) opens fresh vistas for Paleolithic investigation, and in particular for the currently asocial Neanderthals.

What Do We Mean by a Paleolithic Society?

"Society" is a contentious topic defined in many ways - most of them unhelpful when it comes to investigating the social life of Neanderthals (Gamble 1999). The slippery nature of the term was well appreciated by Wolf (1988) who regarded the notion of society as representing a claim to construct a state of affairs that previously did not exist. It is an imaginative exercise brought to life through enactment. Following Wolf's lead we can narrow the problem down by approaching definitions of society as competing claims based on either *rational* or *relational* perspectives of how and why people associate. Paleolithic archaeologists have traditionally favored the former, rational approach, even though by comparison with the study of society in later prehistory the data have resisted such analysis (Gamble 2004). In this approach the unit of analysis is the institution and the group, and the focus on how these originated and what influenced their persistence and change. This perspective is often supported by a Cartesian model of Paleolithic cognition that is internal. Thinking takes place within the brain and is applied to solving problems in the world outside. Such solutions might include changes to technology, patterns of mobility and the timing of when to use resources. Examples of this approach can be found among the optimal and central place foraging models that have been applied to Paleolithic data in the last 40 years (Gamble 2007: 74).

By contrast, a relational perspective offers an alternative that focuses on individuals as social actors and how they enact social life using limited resources, both bodily and material. Cognition is here conceived as distributed, both internal and external to the individual, rather than stopping at the skin as in the rational approach (Hutchins 1995). In this way individuals are re-united with, rather than separated from the world (Clark and Chalmers 1998).

The important difference between the two social claims, rational and relational, lies in their differing understandings of how material culture is involved in creating social life. In a rational approach material culture reflects status and position. It is an external badge that archaeologists interpret according to a variety of models that, for example, link energy investment to social prestige. An example is the recent classification of the Lateglacial female internment from Saint-Germain-La-Rivière, France, as a person of high status (Vanhaeren and d'Errico 2003). This assessment was based on comparisons with individuals in the complex ranked societies of the Northwest Coast of North America (Ames 1985). In contrast, according to a relational approach to the same evidence (Gamble 2007: Chapter 6) the burial, found within a stone container with its necklaces and shells, reflects neither social position nor institution or even the category of an individual. Instead the collection of materials, including the woman's body, were part of a larger social project that harvested resources over a wide geographical area in order to create sets of materials at this place. These sets included ornaments, bone tools, animal parts and stone tools. Their collection and accumulation created nets of relationships between widely dispersed people and places and between objects and people. The burial was not a statement about hierarchical ranking in a society based on inequality (Vanhaeren and d'Errico 2005). It was instead an ongoing project in a hybrid, or heterogeneous, network where objects and people had equivalent properties as social actors; a material example of a distributed cognition.

Social Life in the Paleolithic

Before exploring these differences in more detail, it is necessary to consider how these approaches are underpinned by rather different versions of what constitutes social life. A *socio-ecological* perspective examines Paleolithic society through its component institutions such as hierarchies, marriage rules and kinship systems, viewing them as evolutionary adaptations (Wrangham 1987; Foley 1989, 2001; Foley and Lee 1989; Steele and Shennan 1996). They persist because of the selective advantage they confer. Moreover, they are seen as just one set of solutions among hominins where aspects of life-history, diet and evolutionary history play important roles in determining outcomes that are ultimately evaluated by reproductive success. Such a model of society allows the comparative examination of issues such as reciprocal altruism, group fission-fusion and coping with free-riders that face any social animal as it adapts to a changing environment.

The alternative approach is less concerned with such universal social problems. While the ecological approach takes the community as its unit of analysis, an *interactional* perspective begins with the individual (Gamble 1999; Gamble and Porr 2005a). Such approaches do not deny the existence or importance of communities and groups but rather offer a bottom-up perspective on their construction in preference to the top-down model of society whereby institutions precede both the community and the individual. We are born into them and they determine our social lives. The bottom-up approach emphasizes the individual as negotiating her/his social life through more fluid networks based on the rules of social interaction, including cognitive load (Bernard and Killworth 1973; Killworth et al. 1990) and the stipulation of physical co-presence (Rodseth et al. 1991).

While in practice top-down and bottom-up approaches to social construction run in tandem (Hinde 1976), the adoption of either has important implications. The former facilitates investigation of the appearance of institutions such as law and marriage, while the latter looks for evidence of connection and social extension. This might be indicated archaeologically, for example, by evidence for the release from social proximity that determines the rules of interaction for all hominids except humans (Rodseth et al. 1991). It is the human ability to stretch social relations across time and space that has resulted in a global distribution and a very wide ecological tolerance. This has co-evolved with changes to technology; for example the importance of many forms of material containers (houses, clothes, boats, pots, graves etc.) and composite tools in the last 100 kyr and in particular after 20 ka. These new technologies have made many things possible; for example ocean voyaging, the storage of foodstuffs and urban living; changes that have both separated and concentrated people in larger social networks. And this is the issue. Neanderthals also had a distributed cognition and a complex involvement with material instruments (Gamble 2007). But they achieved neither a global distribution nor the move to a container dominated technology. They adjusted population by fission and fusion to seasonal fluctuations in resources but to what extent were they released from the hominid requirement of maintaining spatial proximity in order to negotiate social life?

Neanderthal Society

We can now understand why the study of Neanderthal society has not flourished since 1956, when elsewhere in prehistoric archaeology a flood of social interpretation based on gender, symbolism and materiality has been unleashed. In an ecological approach, with a top-down perspective, we require the archaeological record to furnish evidence for social institutions. But in the absence of art and ornament, architectural data, far-flung trading networks and the accumulation of materials only in some burials and sites, there does indeed seem little scope for a social analysis.

This problem faced those interested in the study of how Band Society originated and explains why before the Upper Paleolithic there is little discussion of social matters. Even when the time depth for such evidence is pushed back (McBrearty and Brooks 2000), the interpretations offered concern only adaptive behavior such as planning depth and the social implications are ignored (McBrearty 2007). The same difficulty also confronts those adopting a socio-ecological approach as described above. For example, Foley (2001: 183) admits to the difficulty of putting together a coherent story for human social institutions in the period from 400 to 50 ka that comprises much of Isaac's "muddle in the middle". He suggests that this period saw the appearance of male kin-bonded groups that represented a significant departure from older forms of social living; multi-male, multi-female communities where the females dispersed at maturity. The difficulty arises from the lack of convincing artifactual evidence to support this shift in residence and dispersal that is an essential feature of the modern human social pattern. It is reasonable to suggest that it took place at this time but the material correlates are absent.

Elsewhere (Gamble 1999) I have argued that we will never trace the development of institutions through Paleolithic evidence. But it is not the data that are at fault: rather, the concept of society being employed. A different notion of the social is required that invests the individual with agency (Wobst 2000). The interactional approach that I have explored in some detail depends on relationships being created through the resources available to the actors. These consist of their bodies and material culture. For such an approach to prosper it is also necessary to change a fundamental precept that has dominated Paleolithic analysis since its inception: that an analytical division exists between people and artifacts, such that the latter represent externalized mental constructs applied as adaptive solutions on an outside environment.

An alternative, relational approach to the same data, but based on a different concept of human motivation, places the social in the foreground (Gamble and Porr 2005b). For example, Gamble and Gaudzinski (2005) add to the rational account of Neanderthal hunting at the locale of Salzgitter-Lebenstedt by considering the relational context of the same faunal data. In their analysis they show how the locale stands at the start of the chain of relationships - what Binford (1978: 248) in his ethnographic study of reindeer butchery called a "maze of pathways" - that initiates the movement and distribution of food. These Neanderthal hunters related to reindeer, stone tools and each other as well as the locale and landscape through the commonplace social actions of consumption and fragmentation. As the evidence from body parts (Gaudzinski and Roebroeks 2000, 2003), bone and stone tools (Gaudzinski 1998; Pastoors 2001) and even the five fragmentary hominin remains indicates (Gaudzinski 1998: 169), these social actions led to the accumulation of a number of sets of material at this locale. Moreover, evidence that those same social actions created nets that enchained people and things throughout a larger social landscape is scarce. By contrast, the Upper Paleolithic record of Western Europe points to a greater emphasis on social actions that led to enchainment and an increase in fragmenting material culture that, for example, is the underlying philosophy behind the production of blades (Bar-Yosef and Kuhn 1999; Coward and Gamble 2010). Furthermore, accumulation and consumption are still common social practices at locales such as Gönnersdorf (Bosinski and Fischer 1974; Bosinski 1979; Jöris and Terberger 2001) with its sets of engraved slabs, horse bones and huts. But added to these expanded sets of materials are the nets of relationships created now by the commonplace movement of human body parts around the landscape (Orschiedt 1999) and the comparable interest in selected flint parts from the *chaîne opératoire* (Floss 1994). This difference is shown in Table 15.1, where among Middle Paleolithic technologies only retouched tools and blanks, those elements at the end of the *chaîne opératoire*, are found on raw materials that came from distances greater than 20 km. This is in marked contrast to the pattern among Upper Paleolithic technologies where all stages of the *chaîne opératoire* are widely distributed.

Table 15.1 Technological modes

	Modes							
Late Middle Paleolithic	1	2	3	4	5	6	7	8
Western Europe								+
Central Europe	+							+
Upper Paleolithic								
Western Europe	+	+	+		+	+	+	+
Central Europe	+			+	+		+	+

The occurrence of technological modes made on raw materials that have been transferred more than 20 km from source. Data and description of modes from Féblot-Augustins (1997: Table 1). Mode 1 represents all stages of artifact manufacture. Mode 8 is represented by only retouched tools and blanks, no manufacturing debris (see Gamble 1999: Tables 5.14 and 7.3 for discussion)

Material Metaphors

Such studies of enchainment and accumulation are significant for a relational approach because they elide the division between person and object and bring us to a fresh understanding of the role of technology in hominin evolution. The separation of object and person, so basic to the rational approach, can be replaced with the concept of hybrid culture, where objects are simultaneously the targets of and instigators for human agency (Gell 1998; Gamble 2007). In hybrid culture there is no sensible distinction to be drawn between person and object, animate and inanimate (Knappett 2005). Instead there are networks of relationships, as with the Salzgitter bones, through which social lives are created and expressed in imaginative ways. Importantly, these relationships require metaphors since they involve the experience of one thing in terms of another (Lakoff and Johnson 1980).

The rich imaginative worlds that metaphor opens up are usually conceived as the product of language. But as several archaeologists have pointed out (Tilley 1999; Chapman 2000; Chapman and Gaydarska 2007), there are also material, or solid, metaphors. One example is provided by metonymy and where a part stands for a whole as is the case with passport photos.

A Social Brain Perspective

An emphasis on material metaphors may be too drastic a departure for most Paleolithic archaeologists, so let me reexamine Isaac's muddle in the middle with a comparative approach based on brain size. Aiello and Dunbar (1993) proposed that increases in hominin encephalisation were driven by social factors. In particular they drew attention to the strong correlation among primates of brain and community size. Larger brains result from the expansion of the neocortex that is associated with social memory and was required for group size to increase in order to manage the higher cognitive load of interaction. Since fission-fusion characterizes most extant hominids, and by inference ancestral hominins, the social problem that faces larger community size is how to integrate more, smaller units at the level of local group and family (Zhou et al. 2004). Community size itself is neither the major problem nor the evolutionary measure. Rather it is a proxy for the increasing cognitive complexity facing hominins as they attempt to integrate the competing claims of smaller demographic units into a coherent, and stable social whole.

Furthermore, Aiello and Wheeler (1995) argue that the benefits of living in larger communities provided the strong selection needed for such an energetically expensive

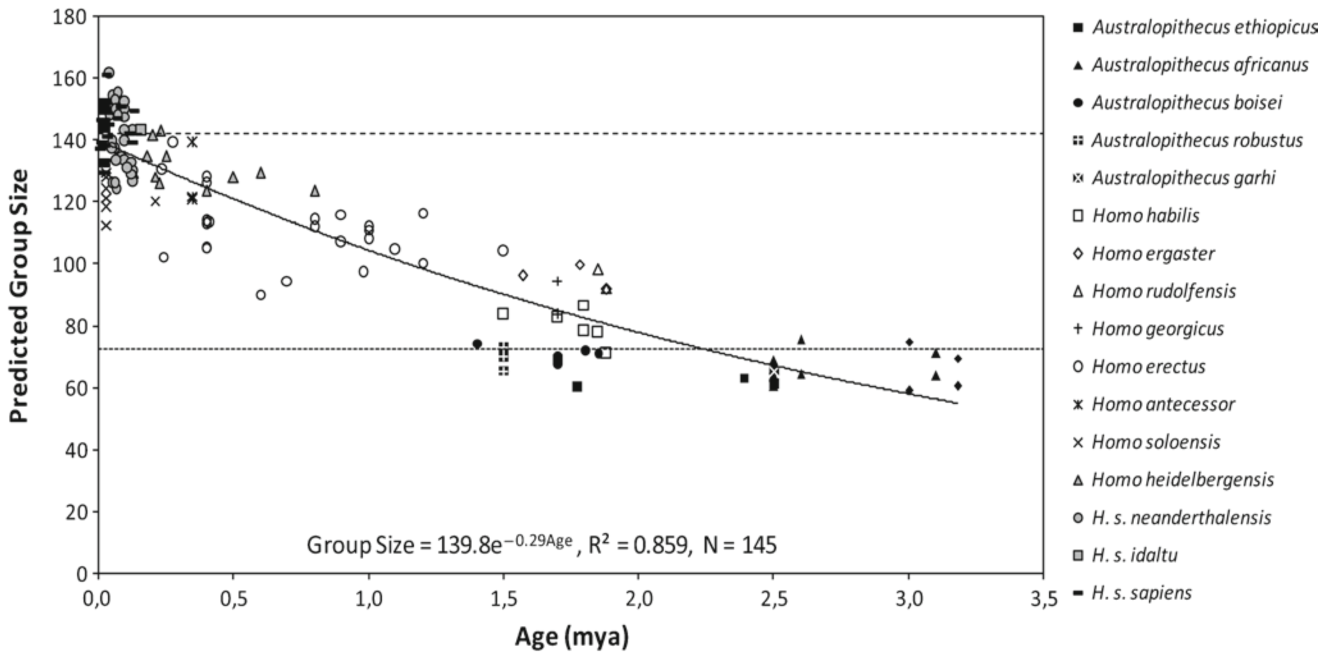

Fig. 15.1 The development of community size as predicted from increases in Neocortex ratios of fossil skulls. The squares plot the changing cranial volumes from which group size is interpolated (Aiello and Dunbar 1993; updated by Matt Grove). The *horizontal lines* indicate threshold group sizes that require 20% (*lower line*) and 40% (*upper line*) of the time budget to be devoted to integration by social grooming. The *fitted line* is an exponential relating group size to age

Table 15.2 Community size predictions and language outcomes

Age millions of years	Representative taxon	Community size	Communication
<0.1	Modern humans and Neanderthals	150	Metaphor and technical
0.5	*Homo heidelbergensis*	120	Socially focused "gossip"
<2	*Homo ergaster*	100	Vocal chorusing
5	Australopithecines	70	Primate grooming

After (Aiello and Dunbar 1993; Dunbar 2003)

organ as the brain to expand to three times the size expected for a primate of our size. Fossil skulls can be positioned on the same graph since their internal cubic capacity provides a measure of the size of the neocortex, and when these are plotted we see a marked increase in brain size 500 ka, accompanied by an indicative community size of 120 (Fig. 15.1: Table 15.2). Such a figure is considerably greater than those known from even the largest primate groups. These findings led Dunbar and Aiello to conclude that alternative forms of cohesion were needed by these enlarged communities, since the ancestral solution of finger-tip grooming would prove too costly in terms of time spent. They suggested that spoken language might have provided an alternative means to "groom" significant relationships between a larger number of network partners (Dunbar 2003).

Neanderthals, as is well known, had brain sizes equivalent to or in excess of *Homo sapiens*. Their predicted community size would therefore be equivalent to the 150 for *H. sapiens* extrapolated from the comparative data provided by the primates. These were not communities in the sense of residential bands that formed a mating network. Rather they reflect the limits of cognitive loadings in person-to-person interaction. These are networks negotiated by individuals which in a wide cross-cultural sample produce modular sizes of 3–7 persons (Intimate network), 10–25 persons (Effective network) and 100–400 persons (Extended network) (Gamble 1999: 58–60; Zhou et al. 2004). These three networks depend on different levels of commitment and resources, being dominated by emotional, material and symbolic capital respectively. As a result the bonds that are created differ significantly in their strength and duration. We are familiar with the constant changes to all three personal networks that arise because we live in demographic universes of millions of people closely packed together. At much smaller population sizes, it is not surprising that networks based on interactions by individuals and groups/communities have a much greater correspondence.

Time Lags and Paradoxes

The implications of the social brain graph (Fig. 15.1) are considerable. It is widely acknowledged that a time-lag occurs between the genetic, anatomical and cultural indications of *Homo sapiens* in Africa, and a radiation out of the continent to other parts of the Old World (McBrearty and Brooks 2000; Henshilwood et al. 2002; Henshilwood and Marean 2003). However, the time span involved ranges from 200 ka to 100 ka with the appearance of *Homo sapiens* in East Africa (McDougall et al. 2005) and their arrival in the Near East (Grün et al. 2005). The social brain graph suggests a much greater duration for this time-lag; from the encephalisation/group size saltation c. 500 ka to the beginning of the global radiation of *Homo sapiens* 60 ka. Therefore, the appearance of *Homo sapiens* outside its geographical area of origin is a delayed event. It is however one closely matched by other Old world hominins, of which Neanderthals are the most obvious example. Large brains, and by inference more complex social networks very possibly supported by language as a means of communication and integration, were for many hundreds of millennia not part of any significant dispersal either as a hominin adaptive radiation (Foley 2002) or a human diaspora (Cavalli-Sforza and Cavalli-Sforza 1995).

Foley (2001: 187) explains the time-lag between the appearance of *Homo sapiens* and the full expression of social institutions in an enhanced material record by climatic and ecological effects. This is an argument directed primarily at the European evidence, and recognizes complexity in the Upper Paleolithic; but without the ecological conditions that occurred later in the Mediterranean to convert such changes into sedentary, permanent societies. Renfrew (2001) agrees with this in his identification of a sapient paradox; here it is the sedentary revolution associated with cereal agriculture in the Near East that changed people's symbolic engagement with the material world and led both to the modern mind (Watkins 2004) and to the institutions necessary to underpin society (Runciman 2005). Away from Europe these concerns have been characterized as Eurocentric (McBrearty 2007). There was no obligation on African *Homo sapiens* to immediately colonize the world: it happened when it happened. McBrearty argues that people did not become human just because they left Africa. Much the same argument has been put forward for a late, independent development of Neanderthal culture (d'Errico et al. 1998), regarded by others as an impossible coincidence (Mellars 2005).

Neanderthal Society and Material Metaphors

However, I do not believe that this interest in a time lag is a Eurocentric concern of only peripheral interest. Instead it goes to the crux of the issue of the investigation of society among hominins and why this topic has received scant attention from Paleolithic archaeologists.

Brains, anatomy, genes and culture all produced hominins who marked time within their regions of origin rather than show a propensity for global travel. They may have had language, although we do not know what they were talking about or even if they had syntax. However, leaving such speculation to one side, we can say they most definitely had solid, material metaphors with which they constructed relationships based on the bodily experiences that any hominin has of the world and of others (Gamble and Porr 2005a).

Bodily metaphors involve not just our experiences, physical states and emotions but also the materials with which we engage in social life. I see a simple distinction in material culture between *instruments* and *containers*. The former are analogies of the limbs while the latter of the trunk and head. Container metaphors are particularly common. Linguistically we speak of living *in* fear or feeling that the past is all *around* us. These expressions verbalize the dominant material metaphors of our social worlds. We live *inside* houses, we put *on* clothes and *festoon* ourselves with ornaments, many of which encircle and so contain the body. We travel *in* cars and *aboard* planes, and we examine our inner selves by all sorts of means; psychological, philosophical and medical. Our understanding of the world and its social relationships is charged with metaphors that depend on our experience of containment. For example, a network is a container of relations. Kinship, that most difficult of concepts for archaeologists pursuing a rational approach, is best defined as a container since for anthropologists it is the setting-up of categories of relatedness (Gamble 2008). These categories contain not flesh and blood individuals, but rather the relationships that make them social rather than biological creatures (James 2003). Certainly we are familiar with instruments such as pens, ploughs and swords, but today our material worlds are dominated by solid metaphors of containment and this structures our social experience. Archaeologists take those commonplace experiences to the study of the Paleolithic and look for embracing social concepts such as Band Society and ranked hierarchies: pigeon-holes to put Paleolithic people *in*.

However, this dominance of containers has not always been the case. They have always been part of the history of human technology since the first tools 2.5 million years ago. But instruments once dominated the cultural arrays, as indeed they still do among chimpanzees (McGrew 1992). During the long introduction to human technology hand-held stone tools, digging sticks, probes and spears dominated the record. On this time-scale containers in the form of huts, houses and graves are all recent by comparison to what went before. However, there was no sudden shift, no "container revolution", but instead a gradient between the two (Gamble 2007: Table 7.4 for details). The emerging identity of *Homo sapiens* has always been bound up with this shift from a record dominated by material metaphors of instruments to one resplendent with containers. The identity of Neanderthals was no less distinctive, but based on material metaphors of the world that referred to instruments, rather than containers, as the dominant form.

The important thing to note about this gradient of change is that social life, those experiences of the world and others, was based on metaphorical understandings from 2.5 million years ago. This was long before language or the community sizes of 150 predicted by the large, social brains of Neanderthals and *H. sapiens*.

Now, there is nothing in the brain that determines why this substitution of instruments by containers should have taken place and why containers came to dominate the material record. The changes arose because of the material worlds within which hominins now lived and grew. At these timescales any changes to the material arrays they would have experienced from childhood were small and incremental, akin to microevolution based on Darwinian selection. But the cumulative effect was to expand the hominin understanding of the unlimited potential of relationships through the material metaphor of the container. According to this conceptual framework we should not be surprised by the time-lag between the anatomical and genetic appearance of Modern Humans, 200 ka, or between the increase in encephalisation 500 ka and the burst of geographical dispersals after 60 ka.

Conclusion: Neanderthals Come to the Party

I have argued here for two novel perspectives for the Paleolithic in general, and the Neanderthals in particular. The first concerns the characterization of social life and the second a metaphorical basis for the interpretation of material culture. The former overcomes the problem that the Paleolithic is regarded as poor in social data (Gamble 1999). The latter directs us away from looking for revolutions and origins in the fossil and cultural records (Gamble 2007) and towards appreciating the material basis of all hominin and human identity.

As Donald (1998) has discussed, we are dependent on the brain as an imaginative device, supported by what Fodor (1985: 4) has called the mind's passion for analogy. Such imagination does not exist without the metaphors that make associations between unrelated categories through both material and linguistic means. Rather than language, Donald identifies mimesis: "the ability to model the whole body, including all its voluntary action systems, in three dimensional space" (1998: 49), as our key skill. It arose because of the need for social actors to communicate information to others and was achieved through an "implementable action metaphor" (Donald 1998: 61) that is familiar to us from the techniques of the body and the rhythms and gestures that structure everyday life. Material culture as an aspect of hybrid culture has been integral to such action metaphors throughout human evolution, and containers and instruments provide categories for archaeologists to understand the importance of artifacts in the construction of social life among all hominins, Neanderthals included.

Metaphor did not appear with language, but rather with the earliest artifacts. Metaphor and material culture evolved together to enact those claims based on imaginative geographies and societies as Wolf (1988) proposed. Metaphors were extended when containers assumed greater significance. For example, two containers, boats and kinship, were needed to overcome the constraints of distance. The former was a necessary but not sufficient requirement to reach Australia and people the Pacific. The latter was a sufficient but not necessary condition to achieve extension and enable social life to be enacted in the face of prolonged absence. As a result society did indeed become a "claim", an imaginary geography where actors met and performed without ever coming together.

This was not the Neanderthal way. These large brained hominins dealt with the cognitive load of larger communities most probably through mechanisms such as language and by accepting constraints on the extent of their fission-fusion. Their restricted geographical distribution and lower ecological tolerances to environmental change (Davies and Gollop 2003) provide the archaeological evidence. But they were not alone. Other large brained hominins starting with *H. heidelbergensis* and including early *H. sapiens* had found similar social solutions to accommodate the selection pressure for larger community sizes without adopting the full release from proximity. The issue of complexity predicted by the social brain model as the integration of more, smaller units into these larger communities had been solved after the increase in brain size some 500 ka. What followed among some African *H. sapiens* was the further co-evolution of materials and emotions, the core of any hominin's social life, which changed the parameters for social cognition and its institutional outcomes. This co-evolution is recorded archaeologically as the trend in the last 100 kyr to a material world based on containers and their varied metaphorical content. Therefore, on the 150 year birthday of the first named Neanderthal we begin to see exactly how similar they were to Modern Humans and how different to Global Humans. The cognitive development of a distributed mind owes more to the material world than it does to neurons and neocortex. Now let us light the candles on that Neanderthal cake.

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Chapter 16
Stability in the Intermittence

A Spatio-Temporal Approach to Mousterian Behavior in the Near East Based on the Technological Analysis of Lithic Industries of Complex VI3 at Umm el Tlel (Central Syria)

Antoine Lourdeau

Abstract The site of Umm el Tlel (El Kowm Basin, Syria) has revealed an extremely rich stratigraphic sequence, in particular for the Middle Paleolithic, which allows synchronic and diachronic approaches to the analysis of occupation dynamics. Complex VI3 corresponds to a lacustrine phase during which the site was regularly covered by water and sedimentary deposits. Nine archeological layers are present, dating to around 70 ka. The assemblage from layer VI3a has revealed the co-existence of at least two *chaînes opératoires* of reduction: (a) recurrent Levallois focused on the production of points associated with quadrangular and overshot flakes; (b) recurrent Levallois focused on the production of points, laminar and quadrangular flakes. Other data, such as that related to the remains of hunted fauna recovered in this layer, complement these results and also contribute to a better understanding of the status of the site of Umm el Tlel and, more generally, its role within a broader territory that we can now better define. In a diachronic perspective, occupation dynamics can also be addressed by the study of all of the archeological layers in complex VI3. Based on results of analyses completed, these layers are remarkably uniform throughout this specific geological context, from all perspectives (reduction techniques, hunting strategies and faunal treatment, sites functions, etc.). Thus, the human behaviors revealed by the material recovered from complex VI3, although relatively complex, seem to have been quite stable. This stability, at present difficult to quantify in terms of duration, suggests a degree of rigidity in Mousterian territories where, despite intermittent occupations, human groups regularly returned to the same places to carry out the same range of activities.

Keywords Paleolithic settlements • Middle Paleolithic • Levantine Mousterian • Lithic technology • Levallois • Lacus-trine context • Site function • Neanderthal behavior

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Introduction

Modes of occupation and territories during the Middle Paleolithic have been the subject of much research. Approaches vary, each with a particular interest. They are characterized by different scales and temporalities. The regional or extra-regional dimension is often taken into account as unit. The geographic distribution of sites discovered in the area of interest is thus considered, sometimes associated with the distribution of lithic raw material sources utilized (e.g., Féblot-Augustins 1993; Le Tensorer et al. 2001; Zilhão 2001; Bernard-Guelle 2005; van Andel and Runnels 2005). This method makes it possible to identify broad patterns, but is limited by being based only on a synchronic view of the occupations, which in reality may have extended over a relatively significant time frame (from several hundred to several thousand years). The strict contemporaneity of the sites is effectively impossible to demonstrate for such early periods. A general view of spatial organization in a given region, deduced on the basis of known sites attributed to the Middle Paleolithic could be the result of several successive occupation phases corresponding to quite differentiated modes of occupation. On a larger scale, certain studies focused on a single occupation which also make it possible to attempt to reconstruct the settlement dynamics (e.g., Conard and Adler 1997; Costamagno et al. 2006). Based on analysis of a single archeological level, several elements can be deduced with respect to spatial organization. The technological study of the lithic industry, among others, constitutes a precious data source in this respect. Using the *chaîne opératoire* concept, lithic reduction activity can be described in time and space (Geneste 1991). Given the presence or absence of different phases of production in an excavated area, the transport of material to and from the site can be identified. Such circulation necessarily implies the existence of contemporaneous virtual complementary sites characterized by specific functions and uses (Soriano 2000). Mobility patterns and a reconstructed territory can thus be deduced from the networks of trajectories defined. Such an approach, more effective than the former, is also limited: its range is shorter. When one passes to a more general view, in order to compare modes of occupation in a given region

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diachronically as well as synchronically, such studies encounter the same problem as those based on simple site distribution: the absence of proof of contemporaneity *sensu stricto* or a clearly defined succession between the sites of interest. It is, however, possible to go beyond a short-term study, and thus avoiding these difficulties, thanks to certain sites with particularly rich stratigraphies. This is interesting from diachronic perspective since it gives an overview of the succession of events in the same place. Then, evolutions, shifts or, on the contrary, stabilities of the modes of occupation are perceptible by means of the comparison of the results obtained from analysis of each archeological level discovered (e.g., Meignen and Brugal 2001; Richter 2001; Vaquero 2003). Data becomes even more useful when the sedimentary sequence is fine-grained. The site of Umm el Tlel (Central Syria) is particularly amenable to such an approach, both by its stratigraphic richness, composed of many Mousterian levels, and by the richness of the levels, which makes a detailed analysis of the remains possible (Boëda and Muhesen 1993; Boëda et al. 1998a, 2001). It thus permits a clear reconstruction of these occupations and their succession.

It is within this perspective of reconstruction of the modes of occupation that we present here part of the stratigraphic sequence of this open-air site – geological complex VI3 – which contains around ten archeological strata. To do so, we take the technological study of stratum VI3a′ as a point of departure. A comparison with the other strata of this complex and a discussion of non-lithic data from these strata will then be presented to reach an understanding of the spatial organization of the site occupants and its evolution.

Geological and Archeological Context

The Site

The site of Umm el Tlel is situated in the vast El Kowm comb, in the centre of the Syrian Desert (Fig. 16.1). It is one of numerous open-air Paleolithic sites in the region. Studied for the first time in 1978 by Cauvin et al. (1979), it

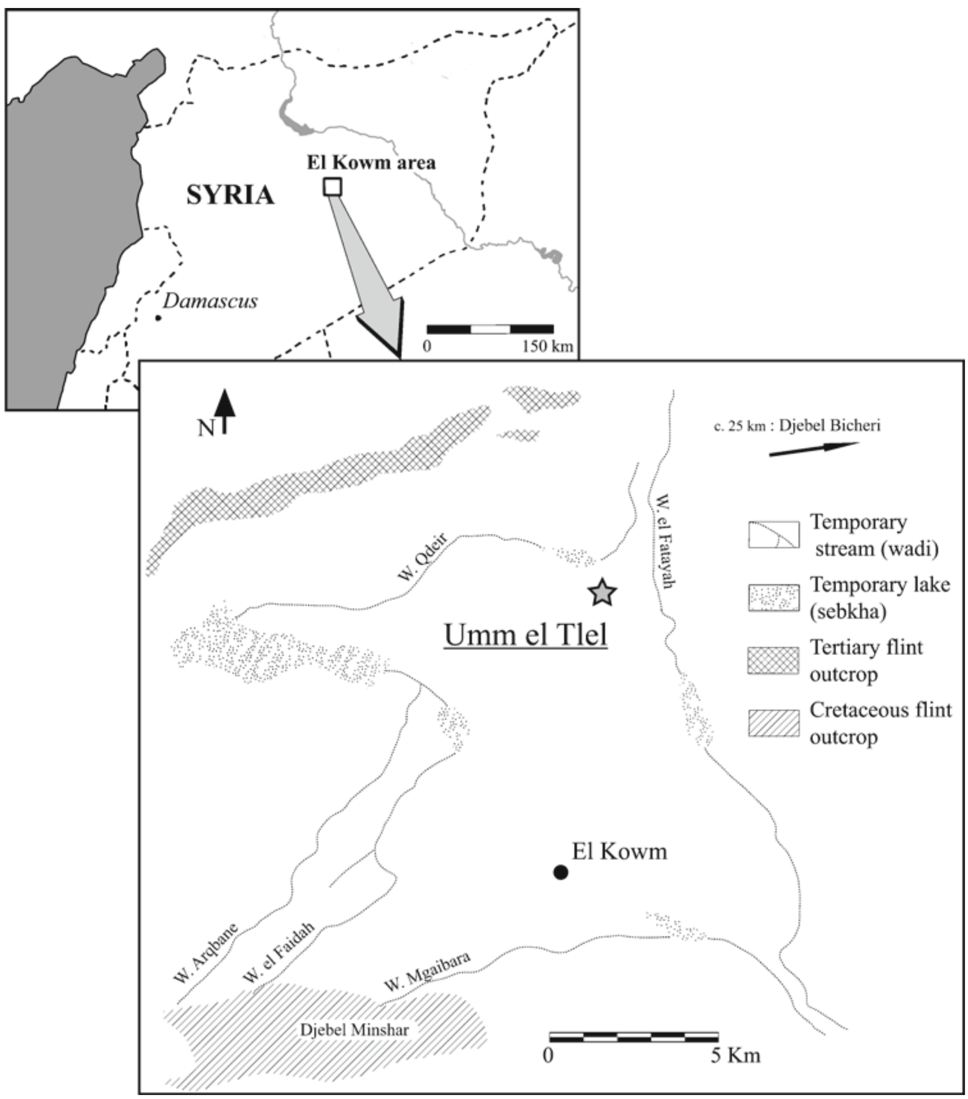


Fig. 16.1 Geographic position of the El Kowm depression and the site of Umm el Tlel, Syria. Main wadis and flint outcrops of the area are localized (After Boëda and Muhesen 1993)

has been excavated since 1991 by a Franco-Syrian team directed by E. Boëda, S. Muhesen and H. Al Sakhel.

Its stratigraphy is more than 30 m in depth and ranges from the Lower Paleolithic to historical periods. Recent and Final Mousterian occupations, the earliest levels reached,[1] are particularly numerous. Excavation extends over an area of 150 m², with a stratigraphic depth of more than 4 m, in which more than 50 archeological strata can be identified (Fig. 16.2) (Boëda et al. 2006: 33).

The site is actually formed by two hillocks, one to the north with a maximal height of 10 m, another to the south, less high but wider. These two formations are linked to the west by a dune range delimiting a depression at the centre of the site, open to the east, in which an artesian source occurred (today dry). These two hills, composed on the accumulation of archeological strata and aeolian sediment of gypsum nature, were formed over the last 40 kyr years (Boëda and Muhesen 1993). During the Middle Paleolithic, this was a human occupation on the edges of a lake during temperate periods, or a backwater during drier periods, in the heart of an arid shrubby steppe (Emery-Barbier 1998; Courty et al. 2006). Sedimentation of these alternating lacustrine and paludal environments was calm but fairly rapid. It thus allowed the excellent preservation of faunal and lithic material in the Middle Paleolithic levels by covering them with sandy and/or muddy deposits. Such material is particularly abundant. The very good preservation conditions are also the reason for the discovery of materials very rarely, if ever, mentioned for such ancient periods. This is the case for bitumen, found on certain lithic artifacts and used to attach handles to aid in grasping tools (Boëda et al. 1996, 1998b).

Sedimentary Complex VI3

Sedimentary complex VI3 was excavated over an area of 70 m². It is formed of fine grayish silts with a small clastic fraction of rounded quartz grains and corresponds to a lacustrine phase during which the site was regularly covered by water and sedimentary deposits. During periods of lake shrinkage, the site was systematically occupied by humans. Nine archeological levels, separated by 3–15 cm of sterile sediment, succeed one another in this complex dating to around 70 ka BP (in chronological order: VI3e′, VI3d′1, VI3d′, VI3c′, VI3b′1, VI3b′, VI3a′1, VI3a′ and VI3a′0) (Boëda et al. 2008). Of the entire site, this geological complex has yielded the highest number of archeological levels (Boëda et al. 2001) (Fig. 16.2). The study of pollen collected

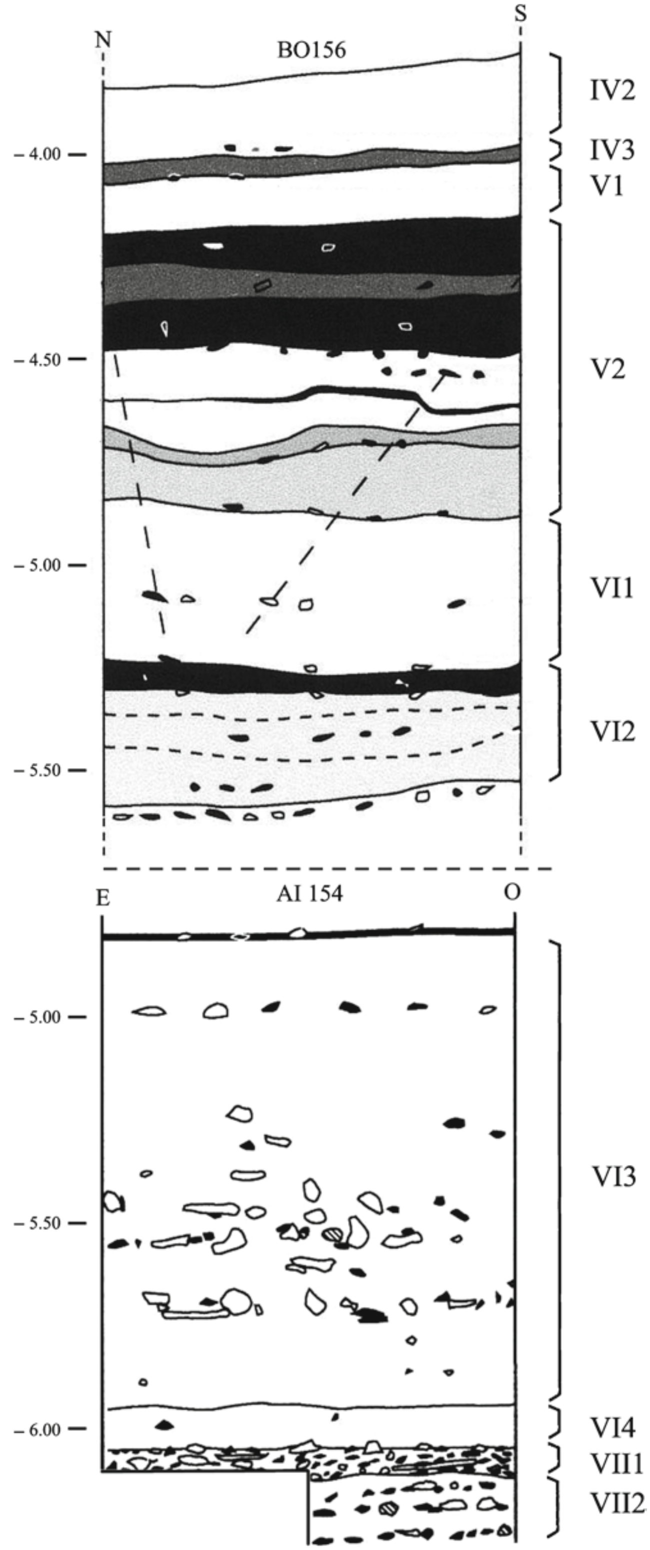


Fig. 16.2 Synthetic stratigraphy of the Mousterian sequence of Umm el Tlel, Syria. The sedimentary complex VI3, dating to around 70 ka BP, has yielded the highest number of archaeological levels (After Boëda et al. 2001, 2008)

[1] Earlier phases are known only from a pit dug by the local population.

from these levels indicates an arid steppe vegetation characteristic of a hot and dry climate, probably fairly close to that which currently exists in the region (Emery-Barbier 1998).

Spatial Approach to Behavior Based on Technological Analysis of the Lithic Industries from Stratum VI3a´

The Chaînes Opératoires

The results presented below come from analyses carried out in the framework of two university research projects (Bourg 2000; Lourdeau 2004) on an assemblage of 1,878 knapped artifacts, which is the number of artifacts discovered to date. The operational sequences that have been defined are presented here with the aim of a spatial characterization of the technological activities of the site occupants.

Raw Materials: Nature and Origin[2]

Since no lithic raw materials suitable for knapping exist at the site itself, all of the stone recovered to date was transported to the site. The VI3a′ assemblage was primarily made on very fine Tertiary flint. Its texture is smooth and color varies from dark grey to black (with some brown to olive green varieties). Outcrops of this raw material are present in hills north of the El Kowm comb in the form of blocks of varying morphology and size which are of excellent quality for knapping. These sources are located around 2 km to the north (Fig. 16.1). This flint variety can also be found in secondary position north and east, in particular on the Qdeir Plateau and in the el Fatayah Wadi deposits, here present in the form of small plaquettes a few cm thick or as small nodules (Boëda and Muhesen 1993). These raw materials have been collected in both primary (thick chalky cortex) and secondary (thin cortex, or even neo-cortex) (Table 16.1) context. The context has been deduced from the state of erosion of cortex visible on partially or entirely cortical flakes.

A second category of flint was also knapped and is an Upper Cretaceous variety with a much grainier texture and a color generally lighter than the Tertiary flint. Its presence indicates that the site occupants had direct or indirect contact with the sources of this raw material, but its use was only occasional, since there are only 10 flakes out of more than

Table 16.1 Umm el Tlel, stratum VI3a′ – Predetermining cortical and partially cortical flakes from primary and secondary position Tertiary flint

	Cortical flakes	Partially cortical flakes	Total
Primary position	45	217	262
Secondary position	40	227	267

2,000 artifacts. The provenience of this material has not yet been clearly identified. It has been found in primary position in the southern part of the basin, 25 km from the site (Fig. 16.1), and in secondary position in the form of small pebbles along the Arqbane and el Faidah wadis east of the basin (about 10 km from Umm el Tlel) (Boëda and Muhesen 1993). However, at these sources, the forms are too fragmented to have permitted knapping of the artifacts recovered from Umm el Tlel. This material could have been procured from further away.[3] The small number of artifacts and the lack of cortical flakes prevent determination of procurement context for this flint. This leads one to assume that these artifacts, particularly large predetermined flakes, were transported to the site and not produced there.

Technology: An Industry Almost Exclusively Structured According to a Levallois Concept of Reduction

Lithic production at the site is part of the complex currently identified as the Levantine Mousterian, more precisely in its later phase. This complex encompasses the material cultures discovered in the Near East attributed to the Middle Paleolithic, dated between around 250 and 45 ka (Meignen 1998; Bar-Yosef 1998; Bar Yosef and Meignen 2001; de la Torre Sáinz and Domínguez-Rodrigo 2000; Shea 2003). Far from being a uniform entity, the Levantine Mousterian has been divided, on the basis of the stratigraphic reference sequence at Tabun, Israel, into three sub-groups (Garrod and Bate 1937). The question of the validity of this tripartite division, still debated (chronological, geographical, functional, etc.), is not directly relevant here. We note simply that the industry of stratum VI3a′ is comparable, both by its recent date and typo-technological characteristics (described below), to what has been termed “Tabun B”. Tabun B is particularly well-represented between 80 and 45 ka BP and is characterized by an essentially Levallois concept of reduction, often using a unidirectional convergent method aimed at producing Levallois points.

In stratum VI3a′, only debitage products were recovered, the Levallois concept being very clearly dominant. No tool was

[2] Only flint has been taken into account here. It is important to emphasize, however, that limestone (equally allochtonous as flint) was also used as a raw material in lesser proportions and for unretouched tools or tools not used for cutting (Torchio 2006).

[3] The largest nodules of this raw material were observed around Palmyra, 40 km southwest, and in the Euphrates Valley, 80 km north (Al Sakhel 2004: 151, after Boëda, pers. comm.).

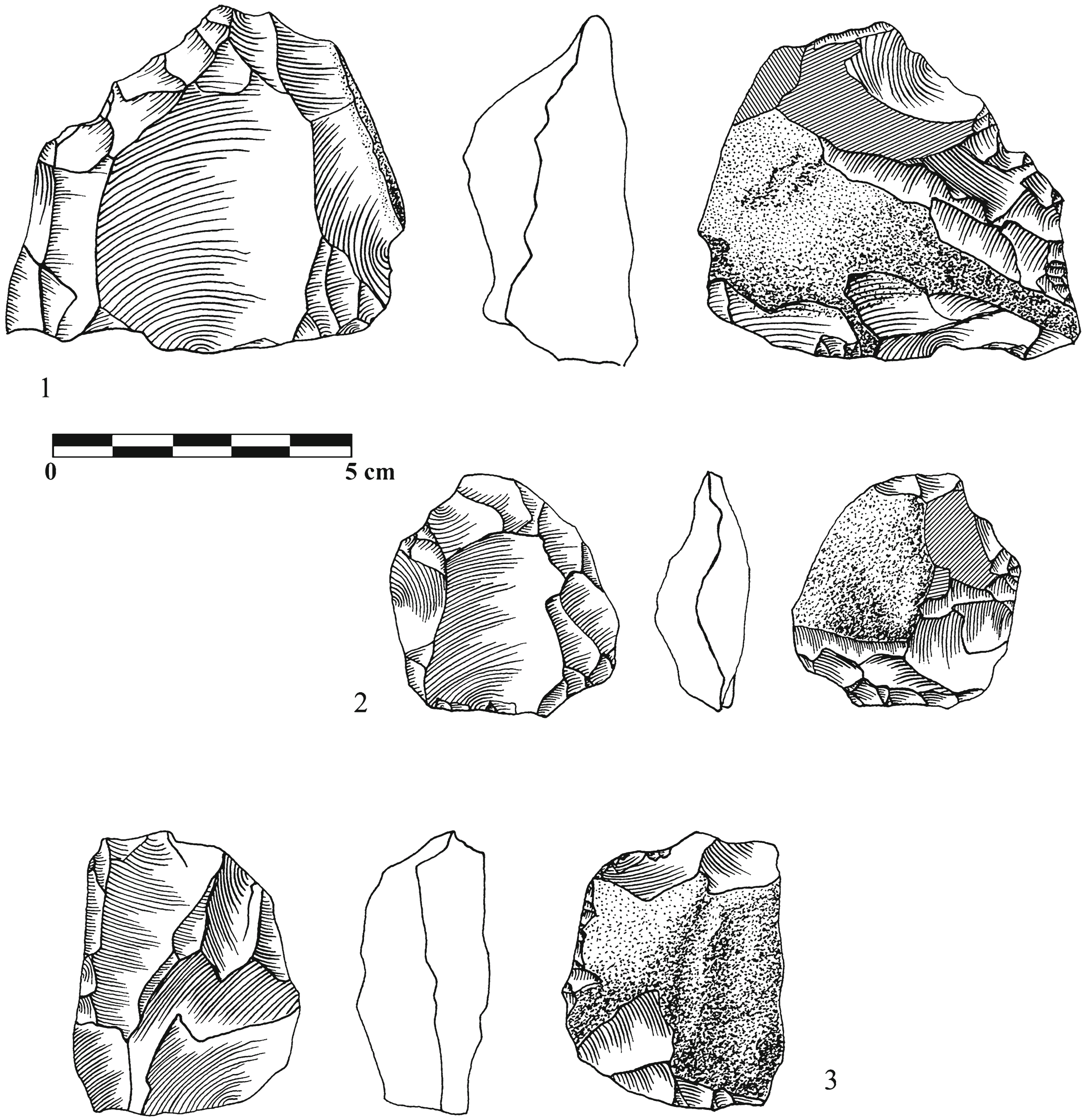


Fig. 16.3 Umm el Tlel, stratum VI3a′ – Levallois cores. *1* and *2*: lineal method; *3*: recurrent method (Drawings by M. Pagli)

produced. Out of a total of 89 cores, 76 have characteristics defined by this method of reduction[4] (Boëda 1994) (Figs. 16.3 and 16.4). The others belong to reduction systems that can be qualified as "poorly developed". For these, in contrast to Levallois, where we can clearly distinguish between predetermining and predetermined flakes, it is not possible to establish a hierarchy of products obtained. However, these cores correspond to a poorly developed production characterized by two surfaces with clearly differentiated functions: one being the flaking surface, the other serving only as a striking platform. This strict relationship between the two surfaces on the cores is also one of the main characteristics of the Levallois method.

[4]The definition of Levallois reduction and the terminology employed to characterize it are relatively variable from one publication to the next. The concepts used here are those developed by Boëda (1994, 1995) and the terminology as determined at the round table meeting held in 1990 at Champlitte, Haute-Saône (Collective, unpublished).

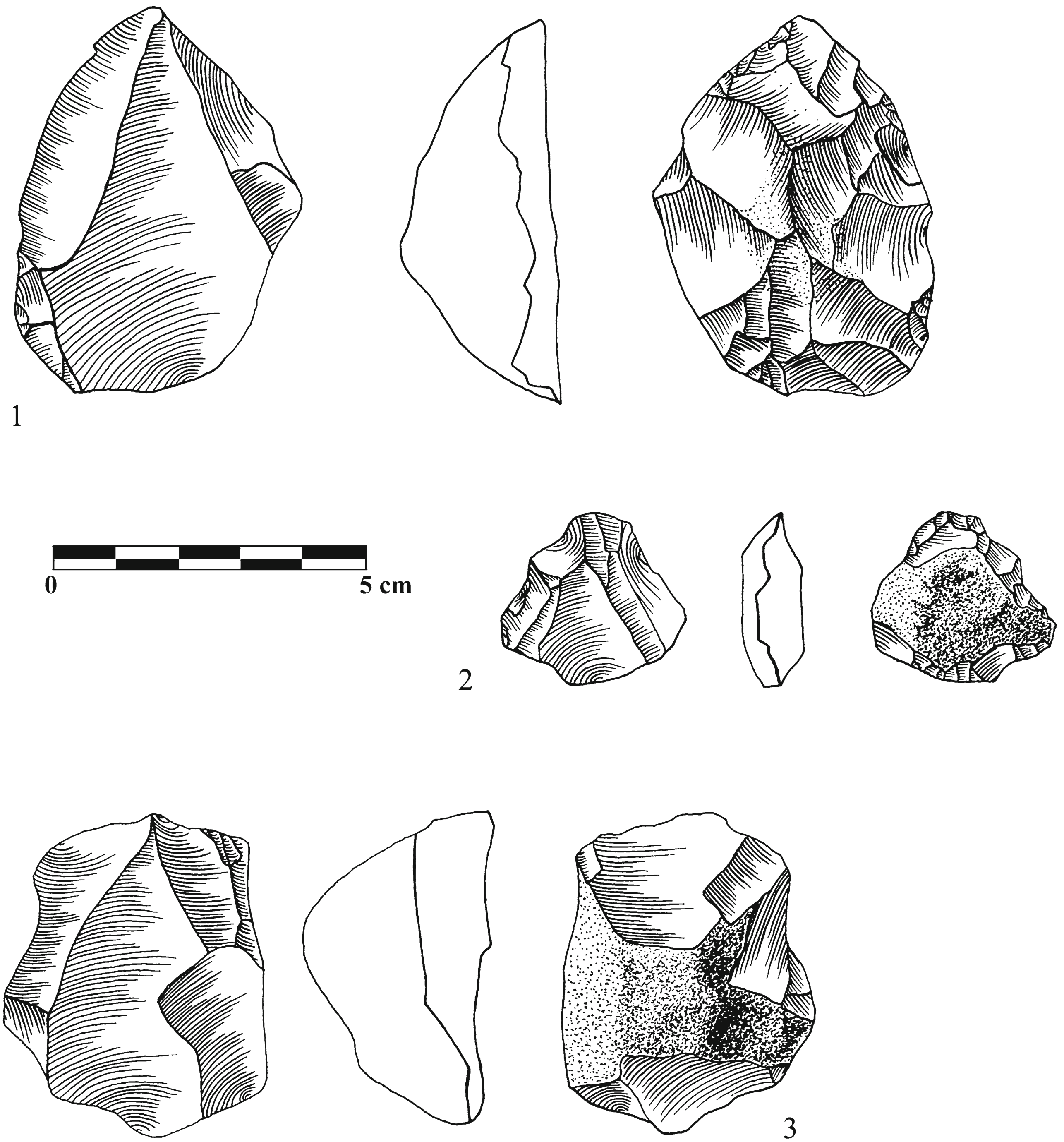


Fig. 16.4 Umm el Tlel, stratum VI3a′ – Levallois cores. Recurrent bidirectional and centripetal methods (Drawings by M. Pagli)

Despite observed differences, there thus exists a relationship between these two conceptions of reduction.

Moreover, all of the flakes analyzed can be attributed to one or several Levallois *chaînes opératoires* (Table 16.2). Within this assemblage, we can distinguish:

- Predetermined Levallois flakes (points, quadrangular flakes, laminar flakes). The platform for about 75% of these artifacts is facetted. Scar patterns on the upper face

Table 16.2 Umm el Tlel, stratum VI3a′ – Morpho-technical categories of flakes

Predetermined flakes: 457 (294)	"3-blow" points: 67 (47) "Constructed" points: 109 (63) Quadrangular flakes: 155 (109) Laminar flakes: 101 (75) *Débordants* flakes: 25
Predetermining flakes: 929 (780)	
Underdetermined broken flakes: 293	

In parentheses: Entire flakes, taken into account in the graphics.

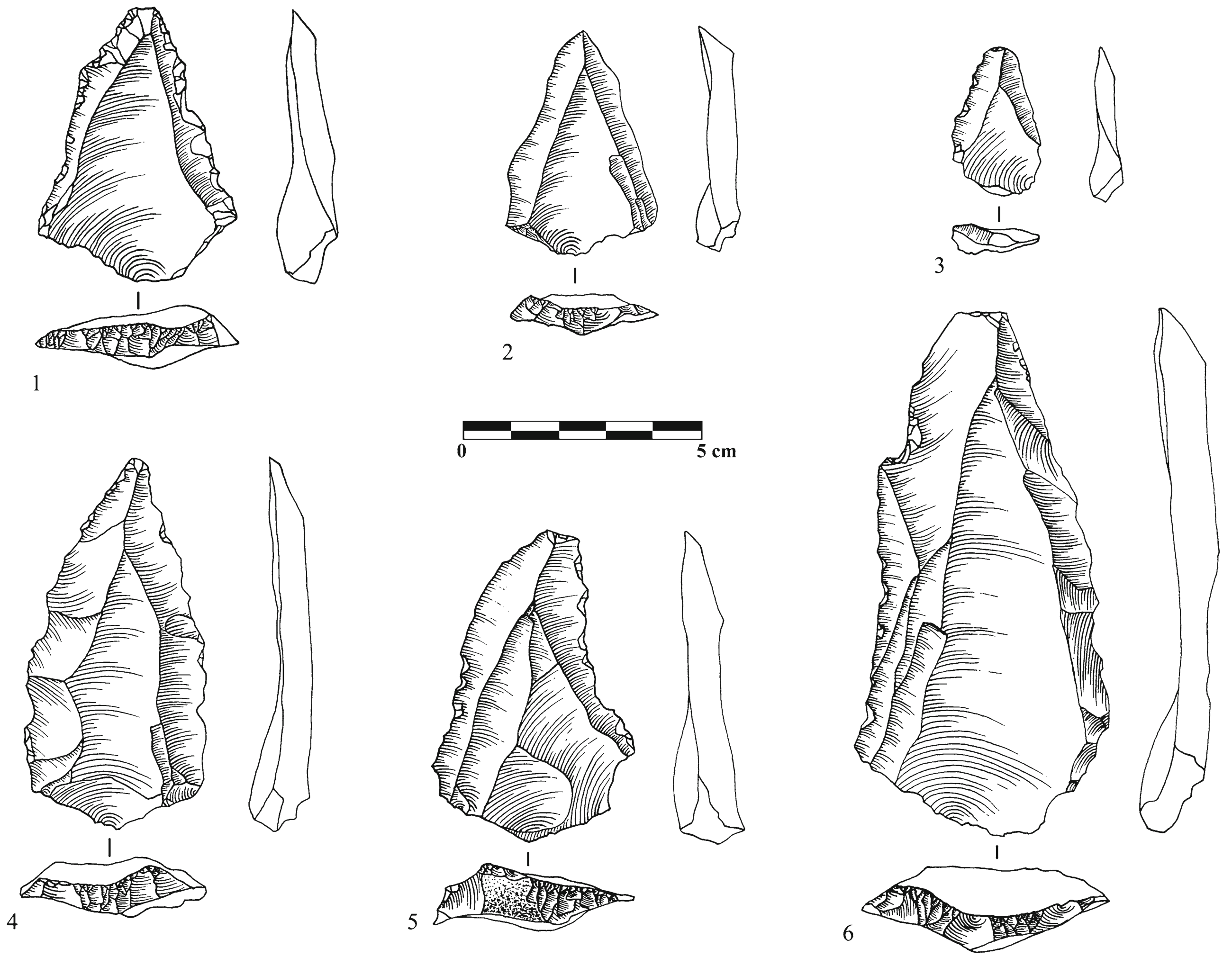


Fig. 16.5 Umm el Tlel, stratum VI3a′ – Predetermined products. Levallois points. *1–3*: "*3*-blow" points; *4–6*: "constructed" points (Drawings by M. Pagli)

indicate complete control of flake characteristics even before its production (Figs. 16.5 and 16.6).

- Predetermining flakes (cortical, partially cortical or non-cortical) that prepared the flaking surface and the striking platform.
- Some *débordants* flakes, quite often obtained during Levallois reduction. Sometimes simply predetermining, sometimes both predetermining and predetermined, they are significant for control over the lateral convexities of the flaking surface (Beyries and Boëda 1993) (Fig. 16.6).

In accordance with one of the defining criteria for Levallois reduction, all of these flakes were obtained by direct percussion with a stone percussor. One of the distinctive features of Levallois production for all of the strata of complex VI3 is the very low number of retouched tools. Barely 10% of predetermined flakes show evidence of preparation of the cutting edge, and always retouched from the ventral face (inverse retouch). It is thus highly probable that most of these blanks were used with unretouched cutting edges. Knapped production in stratum VI3a′ is almost exclusively governed by the Levallois concept, aimed at obtaining predetermined flakes that were in the main used without subsequent retouch.

Modules of Raw Material Used: Identification of Two Distinct *Chaînes Opératoires*

The recognition of a Levallois structure of reduction is not sufficient to precisely characterize one or more *chaînes opératoires* carried out by the knappers who created this assemblage. It has, in fact, been demonstrated that significant variability in methods could also be applied within the framework of this concept of reduction (Boëda 1994). We focus first on the acquisition phase of the *chaînes opératoire(s)*. It was mentioned above that 99.5% of the raw material used was Tertiary flint, collected both in primary and secondary contexts. Since raw blocks were not recovered at the site,

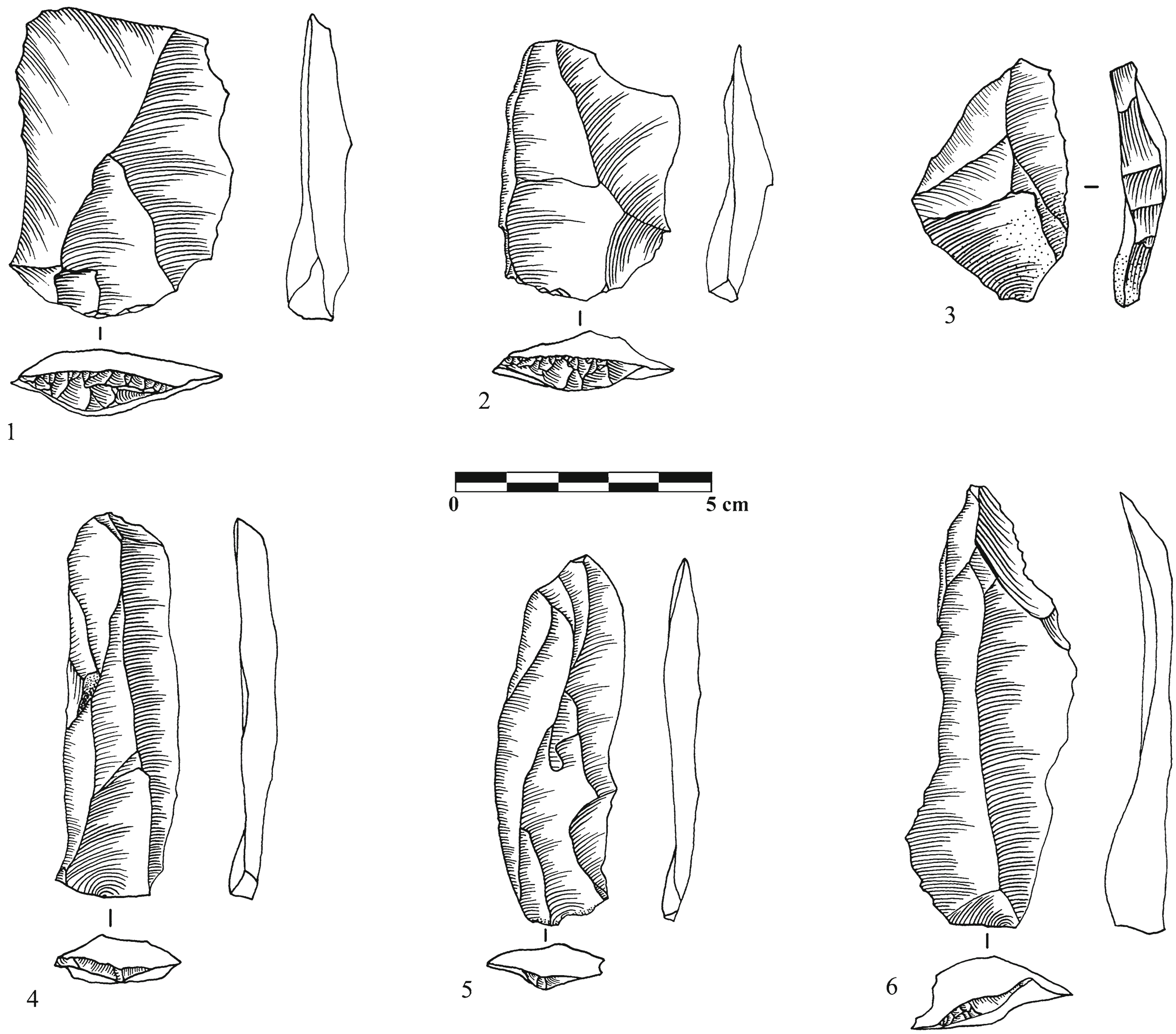


Fig. 16.6 Umm el Tlel, stratum VI3a′ – Predetermined products. *1–2*: quadrangular flakes; *3*: *débordants* flakes; *4–6*: laminar flakes (Drawings by M. Pagli)

the volumetric modules used can only be estimated by observation of the lithic assemblage. The distribution of length for the different technical classes of artifacts shows a clear differential distribution (Fig. 16.7). Most predetermining flakes and cores have a length between 2 and 5 cm. Artifacts longer than 7 cm are quite rare. By contrast, predetermined flakes are all longer, with a range between 3 and 8 cm, and sometimes reaching 10 cm.

A metric difference between predetermined artifacts and reduction debris (predetermining flakes and cores) can thus be observed. How can this be interpreted?

Two hypotheses have been formulated:

- The largest predetermined flakes were obtained at the beginning of the *chaîne opératoire* since subsequent smaller predetermining flakes were obtained. Their reduction in size is directly associated with the progressive decrease in core size during exploitation. The original blocks would have thus been greater than or equal to 11–12 cm in length.
- Lithic production resulted from two distinct *chaînes opératoires*, one from large blocks (≥11–12 cm), and the other from smaller blocks (around 7–8 cm maximum). From the first *chaîne opératoire*, we recover only predetermined flakes; from the second, all technical categories were found at the site.

Is it possible to eliminate one or the other of these possibilities? Several indices complement this first view. Metric observation of 529 predetermining cortical and partially cortical flakes found at the site, indicators of the initial phase of the *chaîne opératoire*, provide key data with respect to the modules of raw material used (Fig. 16.8).

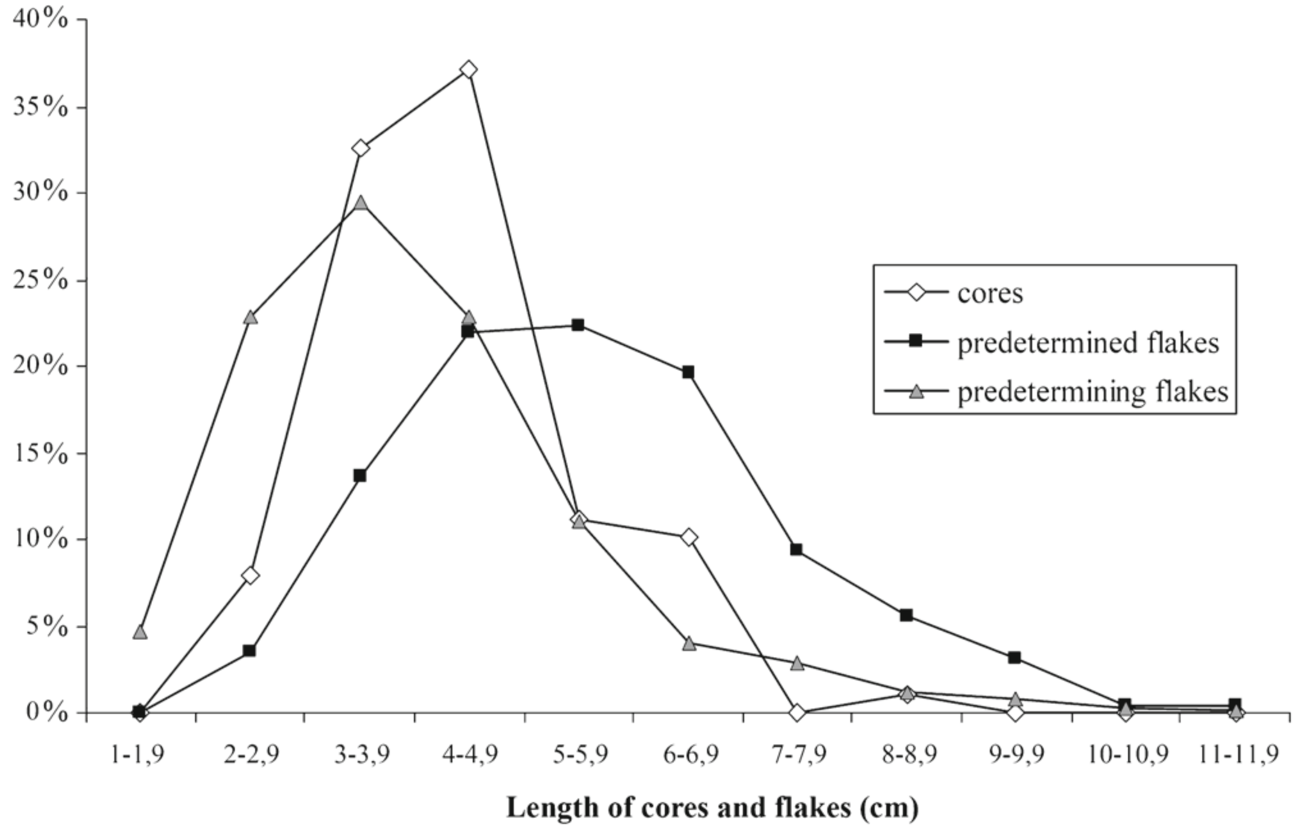


Fig. 16.7 Umm el Tlel, stratum VI3a′ – Frequency distribution of length of cores (N=89), predetermining flakes (N=780) and predetermined flakes (N=294)

It should be noted that graphs of length for these flakes demonstrates nearly identical employment for blocks acquired in primary and secondary contexts.[5] A quasi-identical distribution can be observed. All of these flakes have a length between 2 and 12 cm, but more than 87% are less than 6 cm long, and only 3% are longer than 8 cm. These results seem to support the second hypothesis, cortical and partially cortical flakes appearing to come mainly from smaller raw blocks (7–8 maximum, for the most part). Rare flakes longer than 8 cm could have been introduced as such onto the site. It would be possible to argue against this observation concerning cortical flakes that the production of large predetermining blanks does not necessarily imply the preparation of cores by large predetermining flakes. This could have been done by the removal of medium-sized flakes along the entire perimeter of the core, using the centripetal method. In this case, such preparation flakes would not be longer than half the length of the core. However, other than the fact that, even in a situation such as this, the absence of large initial flakes would be relatively difficult to explain, other arguments reinforce the hypothesis of two independent *chaînes opératoires*:

- First, the size of preparation scars visible on large predetermined flakes (i.e., greater than 6 cm). The dorsal faces of these artifacts present at least one scar longer than 5 cm (up to 10 cm) 95% of the time. Moreover, the pattern of these scars corresponds only to a very minor degree to centripetal initialization. Such data are thus incompatible with a preparation that would have been made by small centripetal removals.
- Second, the fact that recovered cores quite often have large cortical patches on the striking platforms. In effect, some cortex can be observed on more than 90% of these platforms. For more than half of the cores, cortex covers more than two thirds of the platform surface. These characteristics correspond to slightly reduced cores rather than to cores abandoned after several successive series of exploitation.

Such observations thus lead us to conclude that the lithic assemblage from stratum VI3a′ is the result of at least two Levallois *chaînes opératoires*, which are differentiated both by the dimensions of the raw blocks exploited and by the spatial organization of their employment.

[5]Flakes produced from the first are always slightly smaller than those from the second.

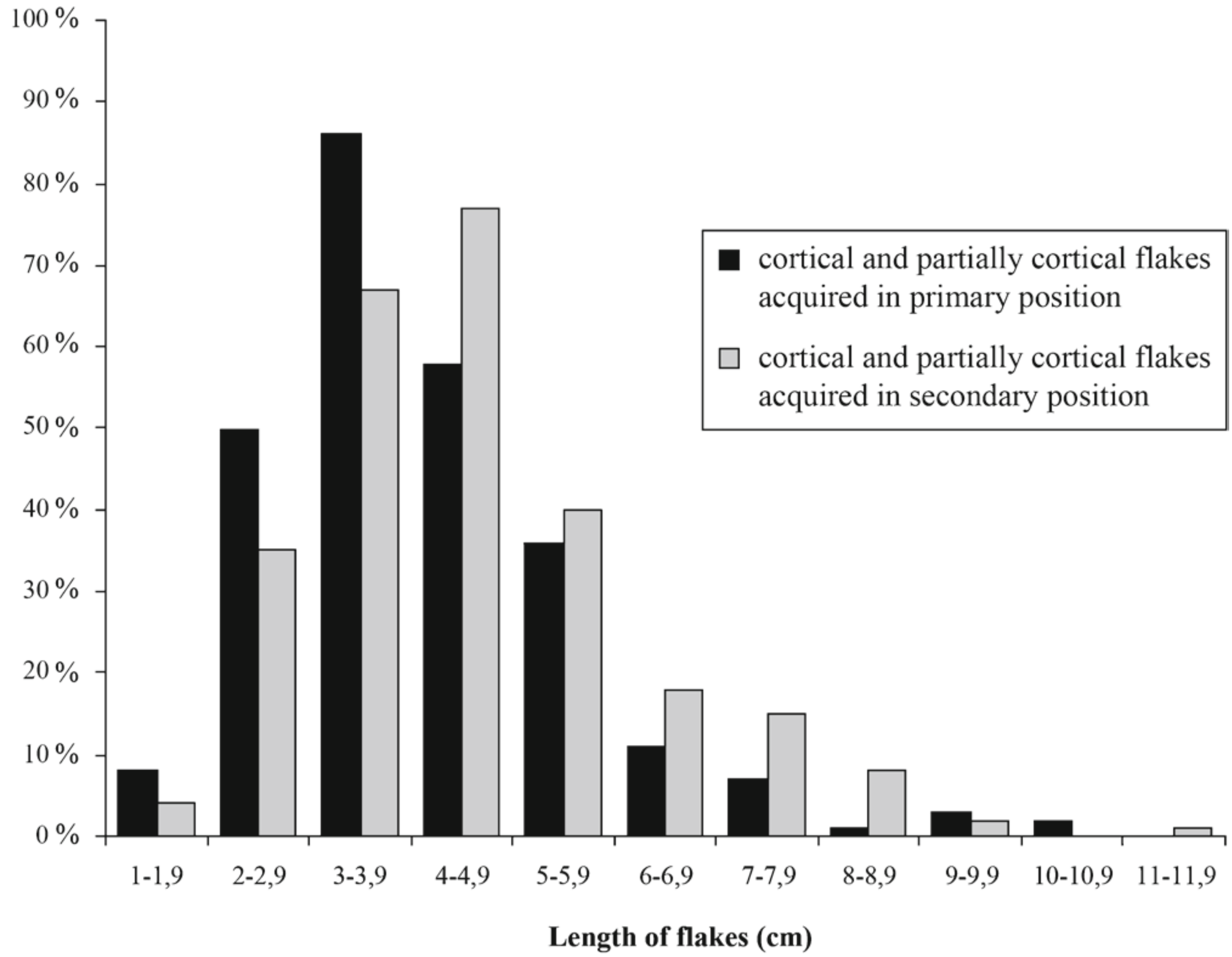


Fig. 16.8 Umm el Tlel, stratum VI3a′ – Frequency distribution of length of predetermining cortical and partially cortical flakes ($N=529$)

Operational Sequence 1: In Situ Production from Small Raw Blocks (≤7–8 cm)

Initialization methods Preparation of the flaking surface on cores before obtaining a flake or series of predetermined flakes was done by large removals detached on a plane secant to the intersection plane of the two surfaces forming the core or by small removals, secant or not. There does not seem to have been a significant rigidity with respect to the patterning of these removals, in other words, to the initialization methods. These could be unidirectional, bidirectional or centripetal. Some patterning does, however, appear clearly as a function of the categories of artifacts recovered. Predetermining flakes, like predetermined flakes less than 6 cm long (with scars from the initialization phase still visible on the dorsal face), result most often from a unidirectional method. In general, the relationships between the three possible methods are as follows:

– Unidirectional: 60%; bidirectional: 25%; centripetal: 15%.

On cores, in contrast, when evidence for this phase is still visible, initialization is most often bidirectional, and the relationships are almost reversed:

– Bidirectional: 50%; unidirectional: 30%; centripetal: 20%.

To explain such divergence, one could consider the possibility of modification of the method between the beginning and end of exploitation of the core (first unidirectional, then bidirectional), but small predetermined and predetermining flakes seem to have been produced in majority from unidirectional initialization methods.

What to conclude? Is this the result of the circulation (import and/or export) of prepared cores and cores still in active use? Were blanks exported? Regardless, this difference suggests the existence of constant movement of objects (finished or not) and thus humans.

Reduction methods and intended blanks The two families of reduction methods defined for Levallois reduction

(Boëda 1994) are represented among the cores of stratum VI3a′:

- Production termed lineal (a single predetermined flake per series of removals) is evidenced by the presence of around ten preferential flake cores (Fig. 16.3). The blank thus produced is either a "3-blow" or a constructed Levallois point,[6] or a quadrangular flake measuring 3–6 cm.
- Recurrent production (several flakes per series of removals) is better represented, by 38 cores[7] (Fig. 16.4). The succession of removals was made primarily by unidirectional method, often convergent. Bidirectional and centripetal methods respectively represent only 20% and 10% of these pieces. Reading of the final removal scars on the flaking surface of the cores shows that each production series allowed the removal of a Levallois point (by three or more removals), two *débordants* or quadrangular flakes and, possibly, a laminar flake. The blanks obtained, when the length of the scars is measurable, have a maximum length of around 6 cm, nearly half less than 3 cm. The proportions of the reduction methods observed on the cores corresponds to that for small and medium-sized predetermined flakes (less than 6 cm), when these have one or more scars of previous predetermined flakes on the dorsal surface (Figs. 16.5 and 16.6).

In brief, the production that we group here under the terms "operational sequence 1" seems to correspond in fact to several "overlapping" *chaînes opératoires* for which the variability lies in initialization methods and production, as well as the spatial division of activities. These Levallois *chaînes opératoires*, principally recurrent, were applied to raw blocks maximally 7–8 cm in length. They were focused on the production of points (by three or more removals), associated with the production of quadrangular and *débordants* flakes. The assemblage of technical categories is present at the site, but a difference between initialization methods observed on cores and blanks obtained suggests the possibility of a permanent circulation of artifacts between several sites occupied by the human group. In addition, another *chaîne opératoire* exists in the stratum VI3a′: the reduction of flakes produced by that operational sequence 1. Around 100 artifacts interpreted as cores-on-flakes have been recovered from stratum VI3a′. The size of removals produced in this way is quite small (often <2 cm). With respect to such flakes that have removal scars after production which cannot be considered to be retouch, the question has often been asked whether they represent the production of small flakes or the shaping of a flake blank into a tool (e.g., Solecki and Solecki 1970; Delagnes 1992). We will not linger here on the question, but retain simply the existence of this supplementary operational sequence, which includes artifacts that can assuredly be considered as retouched flakes, others as cores on flakes, and a third category of more ambiguous pieces which are more difficult to define.

Operational Sequence 2: Non-local Production of Large Predetermined Blanks

For this *chaîne opératoire*, only predetermined blanks have been recovered and were thus probably introduced into the site after they were produced. These are essentially large constructed Levallois points and laminar flakes (Fig. 16.9). They show that initialization methods were principally bidirectional, although the unidirectional method is also well-represented. The significant number of flakes with large dorsal scars suggests use of a recurrent method of production. The production of these blanks seems to have been mainly unidirectional and, less often, bidirectional (Figs. 16.5 and 16.6).

The technological analysis of the acquisition and production phases of the lithic *chaînes opératoires* confirms the existence of two main sequences principally, initially distinguished by morphometric criteria. These distinguish the modules of raw material exploited, the production methods employed, the morphotechnical characteristics of the intended blanks, and the spatial organization of activities.

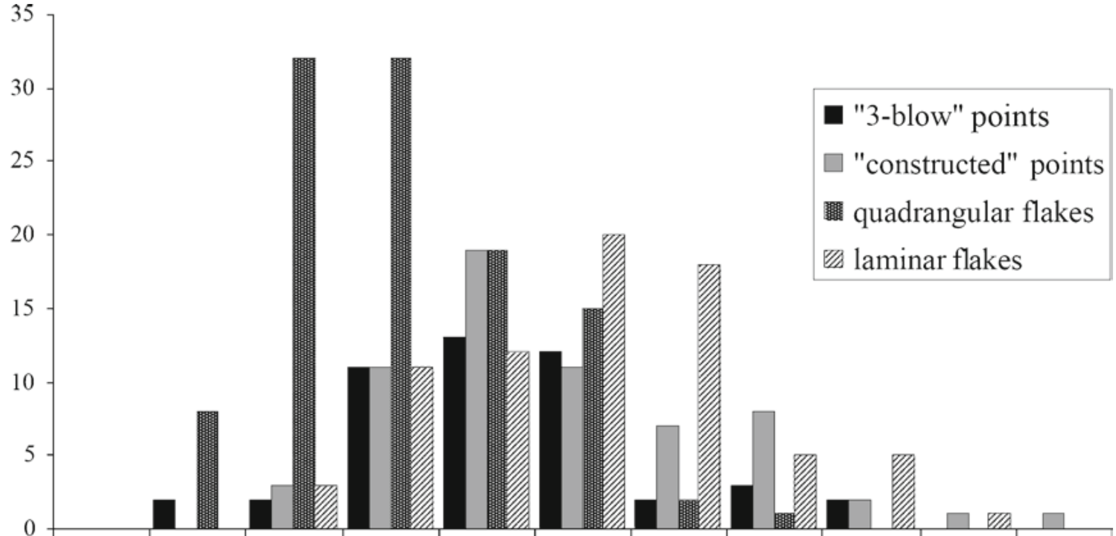
The Chaînes Opératoires *from a Spatial Point of View*

If we try to synthesize the data discussed above in spatial terms, we can construct the following representation (Fig. 16.10). The two sequences defined are organized in space according to two entirely different approaches:

- For sequence 1, production appears to have taken place at the site, following the transport of the raw material blocks necessary. Variations observed in initialization methods permit hypotheses of circulation of blanks or prepared cores to be formulated (*cf.* notably sequence 1′ in Fig. 16.10).
- For sequence 2, production did not take place at Umm el Tlel, but in one or more sites elsewhere. The fact that the modules used were clearly larger than those reduced on site suggests the exploitation of different lithic sources than those

[6] A "3-blow" point has only three dorsal scars: one forming the "basal triangle" typical of all Levallois points and the two others from the lateral edges. For the "constructed" point, one or more of the three elements of a Levallois point (basal triangle and two edges) were made by several removals (Boëda et al. 1998a).

[7] For 26 cores, the state of the flaking surface did not permit identification of the method employed.



	1-1,9	2-2,9	3-3,9	4-4,9	5-5,9	6-6,9	7-7,9	8-8,9	9-9,9	10-10,9	11-11,9
"3-blow" points	0	2	2	11	13	12	2	3	2	0	0
"constructed" points	0	0	3	11	19	11	7	8	2	1	1
quadrangular flakes	0	8	32	32	19	15	2	1	0	0	0
laminar flakes	0	0	3	11	12	20	18	5	5	1	0

Length of flakes (cm)

Fig. 16.9 Umm el Tlel, stratum VI3a′ – Distribution of length of predetermined products: “3-blow” points, “constructed” points, quadrangular flakes, laminar flakes

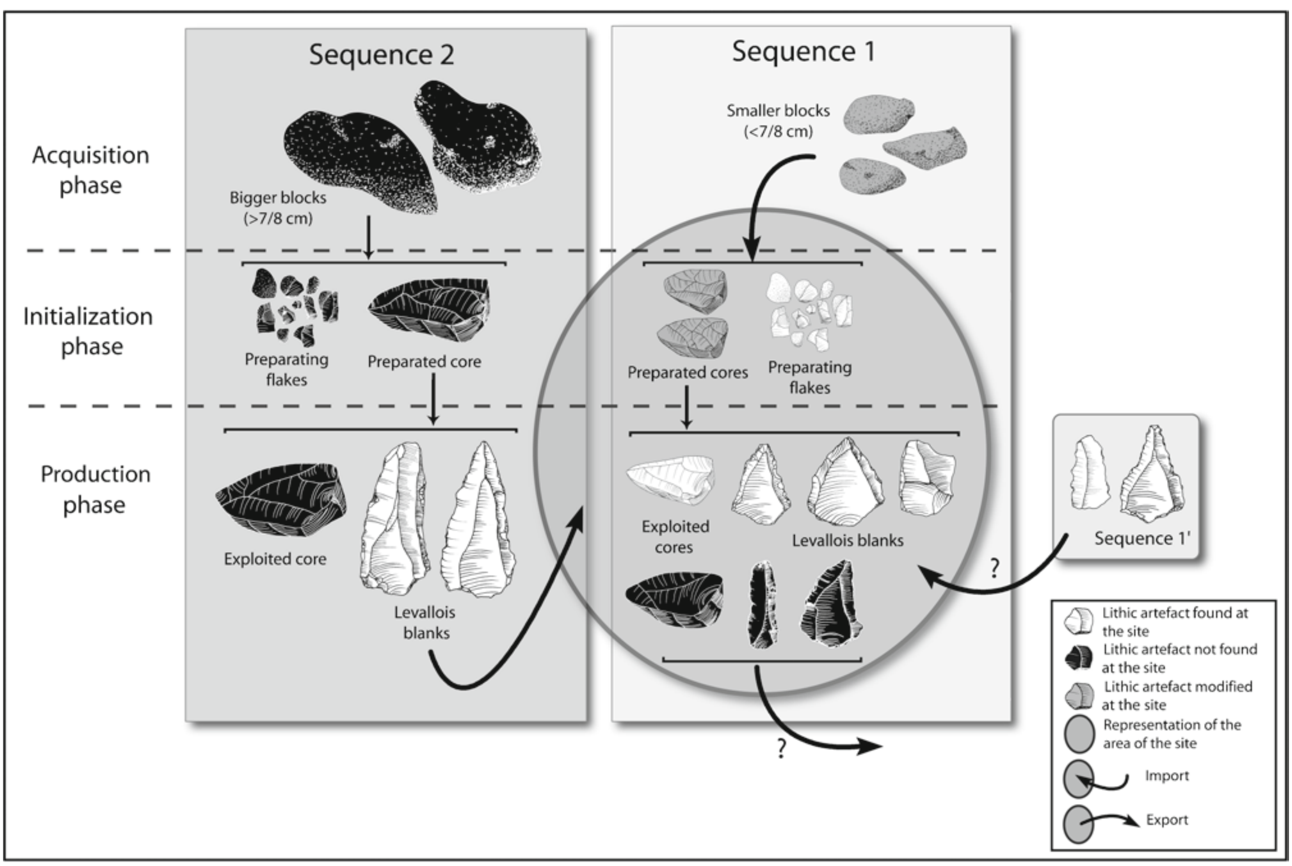


Fig. 16.10 Umm el Tlel, stratum VI3a′ – Synthetic representation of spatio-temporal organization of lithic technical activity inside and outside the site. Two sequences can be distinguished: one for which all products of the *chaîne opératoire* are present at the site and aimed at the production of small blanks (less than 8 cm): “3-blow” or constructed points, quadrangular and laminar flakes; and a second for the production of larger predetermined flakes, especially constructed points and laminar flakes, evidenced at the site only by these blanks which were quite probably produced elsewhere and then introduced onto the site

identified for sequence 1. Once produced, some or all of the blanks were transported to Umm el Tlel (for which the schematic limit is represented by the circle in Fig. 16.10).

To complete this discussion, the operational sequence for Cretaceous flint must be added. Among the ten artifacts from this raw material, there is neither cortical flake nor core. Only predetermined flakes and quite large predetermining flakes were discovered. At a spatial level, the acquisition phase excluded, this flint was exploited in the same manner as sequence 2 above. Based on the analysis of the lithic data recovered from stratum VI3a′, the site of Umm el Tlel appears to us to be both a centre of production and a point of circulation of these industries. In other words, Umm el Tlel is not uniquely a place of production or uniquely a place of consumption of knapped material.

Comparison of Results with Those Obtained from Analysis of Lithic Industries in the Other Archeological Levels of Complex VI3

The knapped material from three other strata within complex VI3 has already been subject to analysis, some of which has been published (Boëda et al. 1998a, 2001; Al Sakhel 2004). The main results obtained are presented in Table 16.3, compared with those from the analysis of the stratum VI3a′ assemblage.

The comparison, while it highlights some differences between one stratum and another, also demonstrates the high degree of uniformity of these assemblages: From a sample of comparable quantitative importance (from 1,724 to 2,500 artifacts), we have shown the utilization of the same raw materials (essentially Tertiary flint) and thus a probable unity in procurement strategies. Reduction methods and techniques are also quite similar from one stratum to another, always structured by a Levallois concept, mainly recurrent and often unidirectional convergent. The respective proportions of products and by-products, when mentioned, are relatively similar, even for the proportions of predetermined products: Levallois points, with three removals or constructed, seem to have been the most commonly sought product (between 40% and 60%), and production accompanied by the removal of laminar and quadrangular flakes in non-negligible proportions (20–35% for each). In all strata, these blanks were relatively unretouched (2.5–9.6% of each sample) and when they were retouched, inverse retouch is common. With respect to the spatial and temporal organization of the technical activities creating these assemblages, a strict similarity must again be highlighted between the archeological levels. The two sequences described above for stratum VI3a′ were clearly distinguished in each sample: one for which all products of the *chaîne opératoire* are present at the site and aimed at the production of small blanks (less than 8 cm): “3-blow” or constructed points, quadrangular and laminar flakes; and a second for the production of larger predetermined flakes, especially constructed points and laminar flakes, evidenced at the site only by these blanks which were quite probably produced elsewhere and then introduced onto the site. The few differences that were observed concern only the quantitative aspect of the broad lines we have just summarized. Certain numerical data differs from one stratum to another, but these variable values remain quite often in the same degrees of magnitude. If we consider that most small variations could have resulted from slight individual differences in analytical methods and data recording by different people carrying out the analysis of each stratum, we can estimate that we are faced with four identical levels of occupation from any point of view, at least with respect to the lithic industries, and more particularly their phase of production.[8] Moreover, the analysis in progress for stratum VI3d′ (S. Bonilauri, pers. comm.) and preliminary analyses of the four other strata of complex VI3 (E. Boëda, pers. comm.) seem to show, in general, characteristics entirely compatible with the levels already published. Sedimentary complex VI3 at Umm el Tlel contains more than ten archeological levels yielding lithic material that evidences nearly identical forms of behavior. This similarity informs as much on technical knowledge employed as on site function and the organization of space invested by its occupants. Figure 16.10, constructed on the basis of stratum VI3a′, could thus be applicable on a general level to complex VI3 as a whole.

Contribution of Other Data Recovered from These Strata

Some of the data recovered from the strata of complex VI3 complement the reconstruction obtained from analysis of the lithic assemblages with respect to the territory covered by the Umm el Tlel groups during this period and the organization of this space. These indices are of mineral origin and organic.

Other Mineral Raw Materials

A lithic raw material other than flint was also worked and/or used by the site occupants: limestone. Represented only by a few dozen pieces per stratum, this material was used in the

[8]It is important to note that the functional aspect of these assemblages is not addressed in this article. Variation in function and use of the blanks from one stratum to another is entirely possible, but the type of analysis carried out here, focusing uniquely on the production phase of these blanks, does not permit formulation of hypotheses on this subject.

Table 16.3 Umm el Tlel – Main features of the lithic production of the strata VI3a′, VI3b′, VI3b′1 and VI3c′

Stratum	VI3a′	VI3b′	VI3b′1	VI3c′
Reference	–	Boëda et al. (1998a)	Boëda et al. (2001)	Al Sakhel (2004)
Assemblage	1,878 artifacts	2,500 artifacts	1,724 artifacts	2,173 artifacts
Raw material	Mainly tertiary flint (primary and secondary position)	Tertiary flint	Mainly tertiary flint (primary and secondary position)	Tertiary flint: 94% (mainly primary position)/ Cretaceous flint: 6%
Flaking methods	Levallois structure: recurrent method, uni or bidirectional initialization, mainly unidirectional convergent production (and lineal method)	Levallois structure: recurrent unidirectional convergent method	Levallois structure: recurrent method, mainly unidirectional convergent production (and lineal method)	Levallois structure: recurrent method, mainly uni- and bidirectional initialization and production (and lineal method)
Technical categories				
Cores	89	170	124	74
Predetermining flakes	929 (67% of the flakes)	?	c. 931 (54% of the assemblage)	c. 1,343 (64% of the flakes)
Predetermined flakes	457 (33% of the flakes)	?	?	c. 756 (36% of the flakes)
Predetermined flakes				
Points (“3-blow”/ constructed)	41% (38%/62%)	61% (41.5%/58.5%)	43% (?/?)	43% (26%/74%)
Laminar flakes	23%	22%	32%	22%
Quadrangular flakes	36%	17%	21%	35%
Retouched flakes	2.5% of the assemblage	7.7% of the assemblage	9.6% of the assemblage	7.6% of the assemblage
	Inverse retouch	Mainly inverse retouch (sidescrapers or marginal retouches)	Mainly inverse retouch (simple and convergent sidescrapers)	Mainly inverse retouch (sidescrapers) (+ denticulates)
Number of sequences defined	2	2	2	2
Sequence 1				
Spatial organization	Entirely carried out at the site	Entirely carried out at the site	Entirely carried out at the site	Entirely carried out at the site
Metric feature	Reduced blocks ≤ 7/8 cm	Points < 6.5 cm	Predetermined flakes < 8.5 cm	Predetermined flakes < 7 cm
Main methods	Mainly uni- and bidirectional initialization; unidirectional convergent production	Unidirectional convergent or orthogonal	Unidirectional convergent (and bidirectional)	Mainly uni- and bidirectional initialization; unidirectional production
Intended products	“3-blow” and constructed points, quadrangular and laminar flakes	“3-blow” points	Points, quadrangular and laminar flakes	“3-blow” and constructed points, quadrangular and laminar flakes
Sequence 2				
Spatial organization	Import of the predetermined flakes	Import of the predetermined flakes	Import of the predetermined flakes	Import of the predetermined flakes
Metric feature	Reduced blocks > 7/8 cm	“big points”	Predetermined flakes > 8.5 cm	Predetermined flakes > 9 cm
Main methods	Mainly bidirectional initialization and unidirectional production	Mainly bidirectional initialization	?	Mainly bidirectional
Intended products	Constructed points and laminar flakes	Constructed points	Points and laminar flakes	Constructed points and laminar flakes

? = No information

form of raw or shaped blocks and cobbles (more rarely knapped). These artifacts rarely have sharp edges capable of cutting. They are most often interpreted as hammerstones (Torchio 2006). Limestone raw materials are varied and for the most part come from sources not yet identified. Only a single limestone, Maastrichtian, composing the substrate of the El Kowm combe, was located in its natural source around the site (Torchio 2006, after pers. comm. from M. Rasse). The current lack of source data prevents reconstruction of the trajectories of these raw materials, but their presence at the site nevertheless highlights the complexity of acquisition networks of human groups responsible for the assemblages found within these strata. At Umm el Tlel, bitumen use as an element aiding in grasping tools is also clearly evidenced in some strata more recent than complex VI3 (c. 45 ka BP) (Boëda et al. 1996, 1998b). Analyses have established that it comes from the Djebel Bicheri; a mountainous massif located more than 20 km from the site. After the last discoveries, it seems that this raw material has been used since 75 ka BP (Boëda 2005). The source of that ancient bitumen has not been identified yet.

Fauna

Abundant faunal remains associated with these minerals, essentially herbivores, were also found in the strata of complex VI3. The human origin for this accumulation is certain (Boëda et al. 1998a; Griggo 1998, 1999, 2000, 2004) for the following reasons:

- Carnivore remains are rare, including gnaw marks on the bones;
- Human traces are, in contrast, quite numerous;
- A flint artifact embedded in an ass vertebra during hunting and butchery activity was discovered in strata VI3b′1 (Boëda et al. 1999);
- Certain anatomical elements are sometimes absent, suggesting the possibility of carcass transport.

As observed for the lithic assemblages, the faunal assemblages are also quite similar from one stratum to another. The faunal composition is constant: more than 80% are dromedary (*Camelus dromedarius*), around 15% are Equids (*Equus africanus* and particularly *Equus hemionus syriacus*) and rare evidence of other species (oryx, gazelle, etc.). In each stratum, several hundred bones were found, corresponding to a minimum number of a few dozen dromedaries and several horses. Data from the level richest in fauna are presented in Table 16.4.

Table 16.4 Umm el Tlel, stratum VI3a′1 – NISP and MNI counts for dromedary and equids (after Griggo 2004)

	NISP	MNI
Dromedary	2,321	46
Equids	421	7

If we consider the meat weight implied by this quantity, the numbers are relatively large, keeping in mind that these data come from a 40 m² excavated zone and not the entire surface of the occupation levels. This pattern observed from one stratum to another cannot be explained only by purely environmental factors. If we take into account the proportions of the different skeletal elements for each species, a pattern of a different order appears: dromedaries are particularly represented by the upper bones of limbs while all elements are present for equids. It seems that there was a differential treatment of carcasses in relation to animal size. Dromedaries would have been dismembered at the kill site and only the parts rich in meat would have been transported to Umm el Tlel. By contrast, the smaller equid carcasses were entirely transported (whole or quartered) (Griggo 1999, 2000, 2004). Such differential distribution thus reveals continuity in behavior for the acquisition and transformation of prey, not determined by environmental factors but resulting from specific choices. So, like the lithic data, the faunal data highlight the cultural unity of the different strata of complex VI3, which is demonstrated by specific behavior patterns such as the management of a highly stable environment.

Synthesis: The Same Space over the Long-Term

Based on the data presented here, the archeological levels of complex VI3 reflect an astonishing uniformity throughout this specific geological context. This fact underlines the existence of a succession of occupations similar in several aspects (reduction concepts, acquisition and treatment of fauna, spatial organization of activities, etc.).

Site Function and Operation

The pooling of such data makes it possible to construct a precise idea of the function and operation of the site during this period. We develop these notions using a systemic approach (Boëda et al. 2000): the site is considered as a system structured by different elements (materials, energy and data) and open to the exterior by incoming and outgoing flow. The application of this system to material data (the only ones available) of the complex VI3 strata can be formulated as follows:

– Entering the site:
  - Lithic elements: raw material blocks (Tertiary flint, limestone), blanks or retouched artifacts (Cretaceous and Tertiary flint);
  - Bitumen;
  - Faunal elements: as whole or partial carcasses.
– On site:
  - Lithic production;
  - Butchery activities (disarticulation, defleshing, bone breakage, etc.) using lithic tools;
  - Probable practice of other activities such as water consumption for different uses, suggested by the privileged selection of site location for this occupation. Working of non-ligneous materials, certainly common at this time around the water source, by some lithic tools is also likely, given the results from use-wear analysis (H. Plisson, cited in Boëda et al. 1998a).
– Elements leaving the site are not as easy to determine because they would be identified by their absence. We discussed earlier the possibility of export of some of the lithic artifacts produced on site. If exportation took place, the quantity was probably small and would not have had a significant effect on the proportions of artifacts in the assemblages. By contrast, the abundant faunal data recovered from the site could indicate butchery activity destined for one or more other sites (Boëda et al. 1998a, 2001; Griggo 2000). If we consider only the zone currently excavated, suspected to be only a very small part of the total extent of each occupation, the quantity of meat prepared can be estimated on the order of several tons! Yet observations based on experimental data have demonstrated that the excellent state of freshness of the bones is compatible only with rapid covering by sediment, from one to several years (Griggo 1999). For such a short interval, it is difficult to imagine the consumption of such a large quantity of meat uniquely? at this site.

These observations have led us to consider the main function of Umm el Tlel to be butchery, or more precisely to consider it as a site with activities specialized in the treatment of meat. The site would have constituted a "stage between the animal kill site and another site to which the meat prepared at Umm el Tlel would have been exported" (Boëda et al. 2001).

Space, Territory

In addition to the definition of the status of Umm el Tlel during this period, the richness of the material recovered also makes it possible to define more generally its role within the territory, which can now be broadly outlined. Data obtained from the excavated zone have led to the reconstruction of virtual sites complementary to Umm el Tlel and the mutual relationships that they maintained. Such sites, while virtual, can often be placed in more or less precise manner in geographic space, notably by identification of the origin of certain raw materials. It is thus possible to free oneself from a traditional "site-based" view in which the excavated site is the centre of a territory exploited by its inhabitants, a "node" by which all paths would pass. The bias resulting from the fact that our study is based on the study of a single site can thus be sidestepped. These complementary sites, points of passages necessary for the Umm el Tlel occupants are of several types:

– Procurement sites:
  - For mineral raw materials: Tertiary flint in the hills and wadis of the El Kowm Basin, Cretaceous flint probably from further away, limestone near the site and perhaps further, bitumen.
  - For prey (kill sites): these sites are impossible to localize precisely, but we can estimate that they were probably situated around the site. The distribution of watering-places could have influenced hunting strategies as well as site selection for occupation. Moreover, it is certain that the hunters did not go to these sites empty-handed. We must thus consider their existence "upstream" from sites in which their weapons and cutting tools were made.
– Sites for transformation of material: These notably concern the *chaînes opératoires* aimed at producing large blanks in Tertiary flint (sequence 2) since these were introduced in such form onto the site of Umm el Tlel.[9] The same is true for lithic production on Cretaceous flint. These activities could have taken place either at the procurement site or other specialized (workshop) sites.
– Place(s) of consumption of meat prepared at Umm el Tlel that can be considered "habitation" site(s) (Boëda et al. 1998a, 2001).

The relationships between each of these points in space and the hypothetical sites around them or those of other regions are discernable by the reconstruction of material flow. A relatively complex dynamic web is thus revealed, far from being a linear model (Fig. 16.11).

It is, however, important to emphasize that the example of the occupations of complex VI3 at Umm el Tlel does not correspond strictly to the logistic system model described in the 1970s by Binford (1978, 1980, 1982). While the term "butchery site" has been used, this still does not imply a specialized place, in the sense that a single activity took place. We have

[9] Perhaps after having been used to butcher carcasses at the kill site (Boëda et al. 1998a).

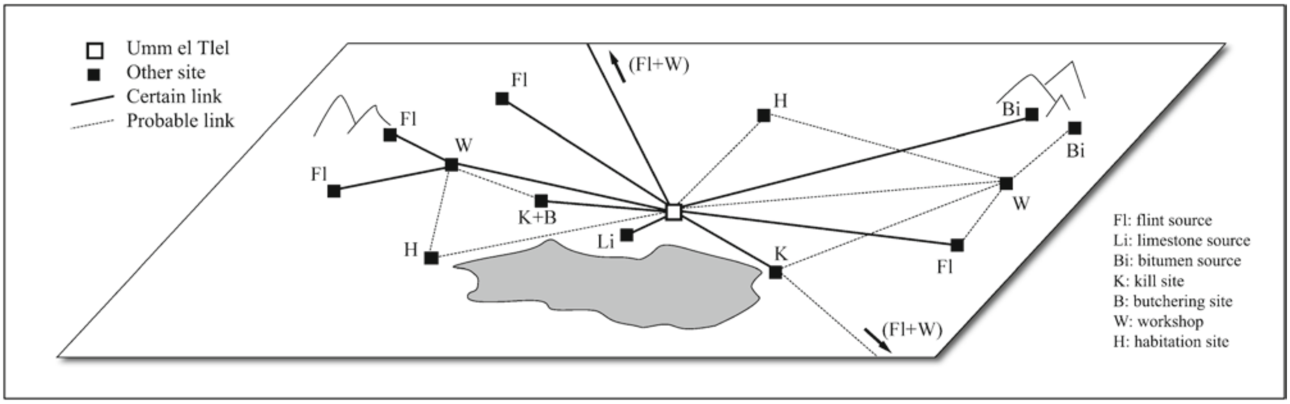


Fig. 16.11 Spatial representation of the reconstructed network of circulation of Umm el Tlel – Complex VI3 inhabitants

seen that lithic production is also a significant activity at the site, perhaps for needs going beyond those required at this site alone. The term "specialized site", and by this the notion of logistical organization of space and activities, thus does not appear applicable to the situation described here. It is more appropriate to refer to sites with multiple functions, possibly characterized by one or two dominant activities (Boëda et al. 2001).

Diachronic Considerations

If we integrate temporal depth with this partial spatial reconstruction, we are led to questions of the astonishing stability through time. In effect, as complex as this web of sites and the relationships maintained appears, the organization that we have just described is not less perennial, since nine occupations succeed one another, repeating exactly the same pattern. This situation is even more interesting since it is unique in the stratigraphy currently known at Umm el Tlel for the Middle Paleolithic. First, complex VI3 is the only geological unit that includes so many archeological levels. Otherwise, the sedimentary context varies from one occupation to another in the rest of the sequence. Second, this case excluded, the other Mousterian levels at Umm el Tlel (more than 50) are all clearly different from one another. In short, the occupations that succeed one another do not resemble each other. These variations concern both the cultural attribution of the group present and the functional aspects of the site and territorial organization. For example, levels V2βa and VI1a0 correspond respectively to a site of diversified activities, interpreted as a habitation, and a hunting site (Boëda et al. 2001). Clear difference in reduction methods demonstrate in addition that these are not two different occupations of the same group or groups sharing the same knowledge, but truly two cultural differentiated groups. Such heterogeneity of occupations, implying an incessant movement of groups that never returned to the site, has been interpreted in spatial terms as resulting from a high degree of mobility, the exploitation of vast territories by the displacement from oasis to oasis on the Syrian steppe, each point being associated with a network of complementary sites (Rasse and Boëda 2006). Thus, while different groups came to Umm el Tlel throughout the Middle Paleolithic for different activities, moved? by a very broad view of their territory, we note in contrast during the period corresponding to complex VI3 a permanence in technical traditions of the group or groups coming to the site and in the reasons that brought them there, which is namely an apparently relatively stable environment. How can such exceptional duration be explained?

To try to respond to such a question, we must above all understand the validity of the intermittence of the occupations of complex VI3, and identify the *tempo* (Boëda et al. 1998a) that regulates the phases of presence and absence of humans.

Occupation Tempo *of Complex VI3*

Detailed examination of the faunal material, coupled with experimental observation (Griggo 1999), suggests relative rapidity for sediment cover of the archeological material. The very good preservation of bone and the absence of disturbance by carnivores are also incompatible with a long duration of exposure of the archeological levels. However, the interval of time separating each occupation is difficult to estimate. Interruption in the human presence itself is not recognized *a priori* in such a context. In cave contexts, for example, the site area (and its excavation) is limited by the walls; in an open-air site, identification of the total surface area of an occupation is much more subtle. This is even truer in a site on the edge of a lake, for which the natural limit is highly fluctuating depending on climatic variation and the amount of water. So, in the present case, we can consider that the human presence was unceasing during the period represented by the stratigraphy of complex VI3. The occupation loci could simply have been changed based on variation in lake level, away from the lake when the level was high, towards the lake when it was low. In this case, the interruptions observed stratigraphically would be an artificial result due to the limited area excavated.

Taking into account this specific reality, we can propose schematically three broad hypotheses regarding the occupation tempo for complex VI3:

– *Hypothesis 1*: An uninterrupted presence. This would quite simply explain the homogeneity of the archeological levels; they would in reality be one and the same occupation, corresponding to the presence of one group whose technical traditions and territory, if relatively limited, were constant. Humans would have come and gone frequently at the site, without ever abandoning it for a long period.
– *Hypothesis 2*: Site abandonment for fairly short periods (on the order of a few years or a few decades). The site would have been regularly deserted by its occupants, who would, however, have returned to carry out the same activities and would have exploited the same territory. The interval between each occupation, longer than a seasonal abandonment, would have nevertheless been less than the length of a generation. The observed stability could thus be explained by preservation in memory of the location and its organization.
– *Hypothesis 3*: Abandonment phases for longer periods (several hundred or thousand years). This possibility is the most difficult to accept when we consider the archeological data. We have seen that a cultural explanation for much of the determined behavior is the most probable. How then, can such stability, such memory, notably a memory of places and spaces, despite absences corresponding to several generations, and thus a total renewal of the population of the group or groups who were established at Umm el Tlel during the preceding occupation, be explained? This hypothesis seems, however, the most probable on the basis of microstratigraphic analysis in progress (Courty et al. 2006).

With the current data, it is thus difficult to determine the occupation tempo of complex VI3. Awareness of the extreme stability observed on the basis of archeological data can only be reached by the determination of the rhythm according to which the intermittence of these occupations occurred. For this, we must await definitive results from analyses in progress in several areas.

Conclusion

Umm el Tlel, in the sedimentary complex VI3, appears to have been a lakeside site in a relatively arid environment, where butchery activities had an important role. Judging by the quantity of meat prepared, it was intensively occupied during this period. It was a key point in a more or less extended territory, characterized by a relatively complex network of trajectories. Such a network reflects both a high degree of anticipation of activities and a very good knowledge on the part of the Mousterian groups of the space occupied, in particular with respect to sources of raw material.

The second particularity of complex VI3 is the strict similarity between the archeological levels preserved. Such similarity demonstrates that the organization of occupation such as have been described here persisted during a relatively long period and this probably by episodic visits. This persistence, for which the duration is still difficult to estimate, cannot be explained by some form of environmental determinism. By contrast, it suggests a high level of standardization in technical traditions and territorial memory. Complex VI3 is exceptional in the Umm el Tlel stratigraphy, in which the strata are generally all different. The regularity of the VI3 occupations could be interpreted as a reduction in the territory traversed, possibly in relation to a relative abundance of prey in this zone (Rasse and Boëda 2006). It has thus been possible to comprehend, due to a favorable sedimentary context that recorded short-term archeological events, both the complexity and stability with which these Middle Paleolithic humans perceived the space that they occupied. Moreover, from a methodological point of view, analysis of complex VI3 emphasizes that the dichotomy of the two classical models (logistical mobility vs. residential mobility) does not always work. It would appear that this is an "intermediary" case, Umm el Tlel being considered as neither a specialized site, since a certain range of activities were carried out (notably meat preparation and lithic production) nor as a residential site, since certain of these activities (butchery) clearly dominate. Finally, this paper demonstrates the great value of a precise analysis of lithic production sequences using a technological approach to questions related to Paleolithic modes of occupation. The reconstruction of the existing *chaînes opératoires* and their organization in space offers the possibility to refine the reconstruction of exploited territories and to clarify, in the event, their complexity. While we could have limited ourselves to simply noting the local use of an essentially unidirectional convergent Levallois operational sequence aimed at producing points, the deeper analysis demonstrates in contrast the technical reality in its entire spatial dynamic: import of large prepared blanks, local production of smaller blanks according to other methods, certain blanks used on site and other probably exported, etc. As certain analyses have already demonstrated (Soriano 2000; Boëda et al. 2000), this type of study would in addition, benefit by a complementary approach of the functional sphere of these industries, not addressed here.

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Chapter 17
Territorial Mobility of Neanderthal Groups: A Case Study from Level M of Abric Romaní (Capellades, Barcelona, Spain)

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Abstract The Abric Romaní site is located in the northeast Iberian Peninsula, 50 km from Barcelona 317 m above sea level, in a travertine cliff on the right bank of the Anoia river, which is a tributary of the Llobregat river. This river passes by the Capellades locality, forming a narrow gorge known as “Cinglera del Capelló”. This corridor crosses the mountain range “Cordillera Prelitoral”, and is considered as a natural passage between the inland and coastal Catalonia regions. This situation provides the possibility to exploit a great variety of biotopes. The site yielded an important and complete stratigraphic sequence of European Middle Paleolithic. Fifteen archeological levels have been excavated until today, which appear as thin layers between sterile travertine platforms. This sequence has been dated by U-series between 70 and 40 ka BP, except for the uppermost level, which is attributed to the Early Upper Paleolithic. Pollen analyses have revealed five climatic phases, ranging from the milder conditions at the bottom to an interstadial climate at the top, correlated with the Hengelo interstadial. It is, consequently, a key site for human behavioral studies among Neanderthal groups. This paper presents the results of studies on resource procurements, lithics and animals and on the territory used by Neanderthal groups, through the example of level M dated around 55 ka BP. The results of the lithic analysis and faunal assemblages suggest that the resource procurement and management is focused on a local and semi-local exploitation in a geographic area of about 20 km around the rock-shelter.

Keywords Middle Paleolithic • Resource management • Faunal assemblages • Lithic technology

Introduction

At present some studies about Middle Paleolithic are focused on the identification of settlement patterns and mobility strategies. The latter are related and give information about modalities of territorial occupation, variability of archeological assemblages, and cognitive capacities of Neanderthal groups. The attempt to find the explication about this variability and the reasons that produced it has been developed in various ethnoarcheological studies (e.g., Yellen 1977; Binford 1978, 1980, 1981; Bunn et al. 1988; O’Connell et al. 1988; Bartram et al. 1991) and constitute a reference frame for many archeological works (e.g., Lieberman 1993; Kuhn 1995). They have demonstrated that the settlement and mobility pattern are the consequence of complex decisions associated to social and environmental factors (Kelly 1992, 1995). The correlation of these factors can be explained from a dynamical perspective, but not directly transferred to the archeological record (Kroll and Price 1991; Kent 1992). However, some researchers (Shott 1992; Conard 2001a) proposed that the ethnographic models could be transferred to the past and give a better understanding of the interaction between individual and environment, its relationship with technology, the biotic resources and their use. However, those models cannot be mechanically transferred to the static archeological record (Kroll and Price 1991). Since late 1980s the development of zooarcheological studies (e.g., Farizy et al. 1994; Stiner 1994; Gaudzinski 1995, 1996; Auguste et al. 1998;

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Böeda et al. 1998; Cáceres et al. 1998; Meignen et al. 1998; Patou-Mathis 1996; Stiner 2005; Faith and Gordon 2007) has demonstrated that Neanderthals have different hunting strategies and various transport and treatment modalities of animal biomass. These strategies not only require a collaboration and cooperation between human groups, but also a development of anticipation and planning strategies in their territorial mobility. At the same time, the studies of lithic remains are focused on the procurement and management of raw materials developing different concepts like "embedded procurement" (Binford 1982a), "*approche techno-économique*" (Geneste 1985, 1990), "technological provisioning" (Kuhn 1995), "technological organization" (Shott 1986). All of them consider a more direct relationship between the settlement patterns and the organization of the lithic *chaîne opératoire* which provide different ways of technical activities transport and organization and also help us to interpret the functional variability observed in sites (Geneste 1985; Meignen 1988; Otte 1990; Turq 1992). Nevertheless, some researchers still question this behavior of anticipation of activity and planning realized by the Neanderthals (e.g., Binford 1982b; Mellars 1996; Trinkaus 1986, 1989; Straus 1996). For them, they are behaviorally attributed to anatomical modern humans. Ingold (2000) defined mobility as the strategic displacement of the residential settlement from one location to another in order to obtain vital subsistence resources such as fuel, raw material, water and food. These strategies are designed to reduce risks derived from the discontinuous character of biological resources, such as animals and plants in the landscape. Following this definition, each site represents one stop in a determinate place and during a period of time before to continue the movement across the territory. These displacements can be characterized spatially and temporally, according to the time and the distance covered and whereas the group composition (displacement of a part or the totality), purpose, activities realized during the movements, etc. Some researches focus their study of archeological sites through two different scales of resolution (Burke 2006a). The first analyzes the function of the site as an individual entity, and the second places the site in a regional scale to establish relationships between other sites of the same geographic area and the land use patterns (e.g., Conard 2001b, 2004; Burke 2006b; Costamagno et al. 2006).

Abric Romaní is an archeological site with a well documented sedimentary context (growth of travertine layers which embed the archeological deposits). Moreover its methodology of excavation (whole surface of the shelter) allows us to realize this kind of analysis. In the first resolution scale, we observe at the spatial level the existence of patterns in the structure, composition and distribution of the archeological record. The hearths play a central role in the space organization. They focused the subsistence activities realized and they are mainly located in the internal zones of the site. Our basic elements of study are the discrete archeological material accumulations, the relationship between them, and their function (Vaquero and Pastó 2001). These studies allow to identify different kinds of settlement patterns (short and long term occupation) (Martínez and Rando 2001; Vaquero et al. 2001, 2004; Chacón et al. 2001, 2005, 2007; Chacón and Fernández-Laso 2005a, b; Vallverdu et al. 2005; Vaquero 2005). The obtained data leads in a regional scale to reconstructions of lithic and faunal *chaînes opératoires* and provides information about the territory occupation pattern and in the consequence hints about Neanderthals cognitive complexity. Abric Romaní, located at the junction of three ecosystems, provided a wide variety of resources for Neanderthal groups. This paper presents the results of the multidisciplinary study (lithics, bones, and vegetal remains), carried out for the archeological record from level M. The aim of this work is to realize the first study of this archeological record at two scales of resolution as described by Burke (2006a) to identify subsistence strategies and landscape management developed by Neanderthals. However, within the second scale, we are not able to compare our results with other sites, due to the lack of this kind of work on sites from the same geographical area.

Abric Romaní: Landscape and Availability of Resources

The Abric Romaní site is located in the town of Capellades (north-eastern Spain), 50 km from Barcelona in the Catalonian Prelittoral Chain. It belongs to the Quaternary travertine formations located on the right bank of the Anoia River. The shelter is oriented towards northeast and located 317 m above the sea level. Situated in a strategic position between the mountainous inland and the coastal plain Abric Romaní offers a good opportunity for developing an integrated approach. This rock-shelter is one of the many cavities found in the travertine complex known as "Cinglera del Capelló" (Capelló cliff) and represents a strategic passage way. Three main ecosystems occupy the area around the shelter: riverside, mountain uphill, and plain beyond the gorge. This territory provides a great variety and quantity of vegetation, faunal and lithic resources to hominids that occupied the site. The stratigraphic sequence is about 20 m thick; the sedimentary activity is mainly related to the growth of travertine layers, which embed the archeological deposits. Twenty-seven archeological levels have been documented. This sequence has been dated by U-Series to 40–70 ka (Bischoff et al. 1988, 1994) (Fig. 17.1).

Biotic Resources: Plants and Animals

The pollen sequence shows a large variety of woody taxa that grew in different environments from the region (Burjachs and Julià 1994). Herbaceous plants and pines are the most

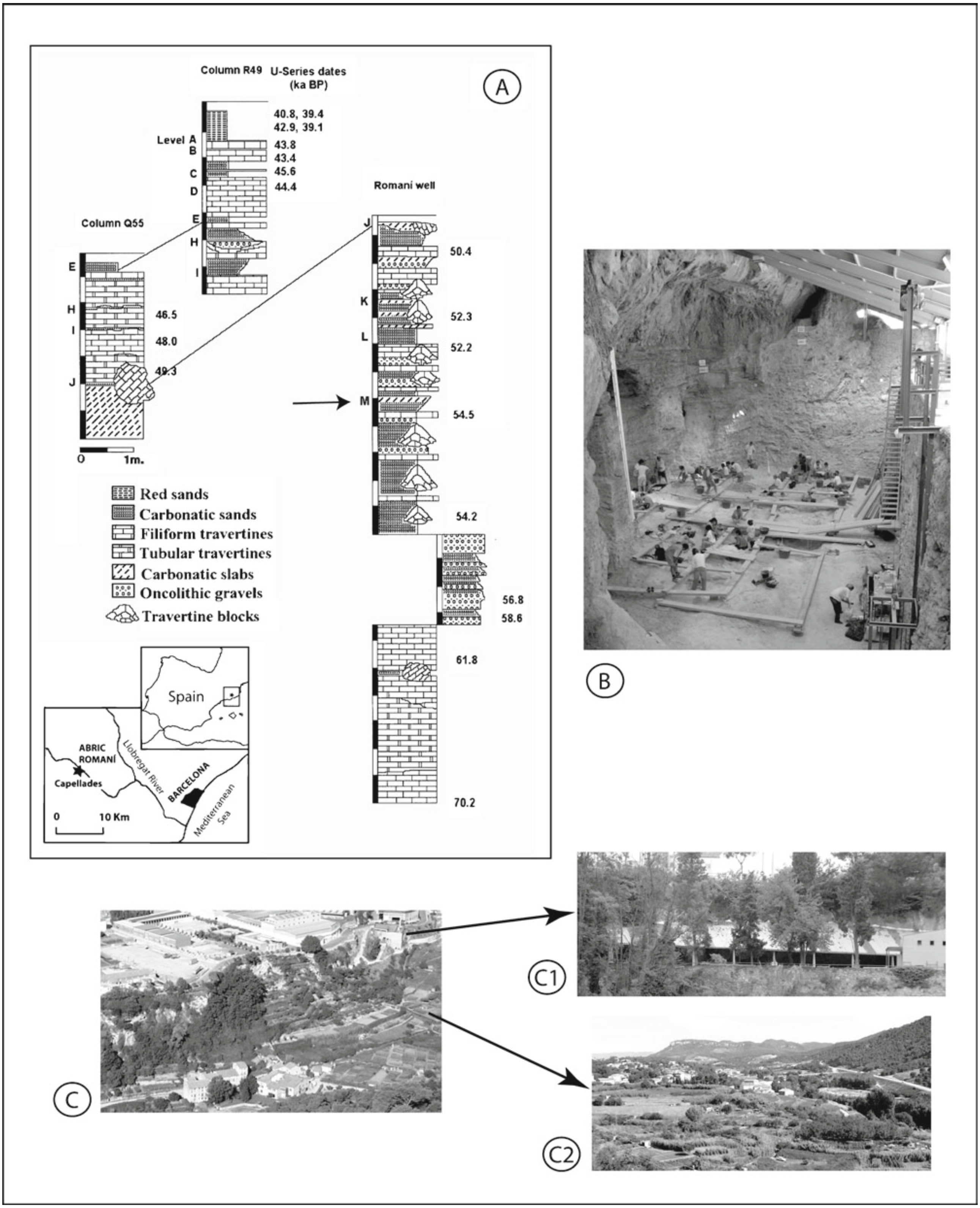

Fig. 17.1 (**a**) Abric Romaní geographic location and schematic lithostratigraphy of the sequence with the U-Series dates. (**b**) General view of the excavation in the level M. (**c**) General view of a part of the “Cinglera del Capelló”. (**c1**) Front of the site; (**c2**) General view of the Anoia Valley

important taxa in the pollen assemblage. Trees, shrubs, pines, and junipers were the main species of the arboreal cover. Other taxa such as *Quercus*, *Rhamnus*, *Olea-Phillyrea* and *Syringa* were also present. There were also riverside taxa, including *Populus*, *Alnus*, *Salix* and *Ulmus*. The palynological analysis shows a dominance of arboreal pollen, suggesting a mild cold climate (pine forest). Thermophylous taxa were constrained to places where extreme conditions were ameliorated by the Mediterranean influence, as well as by the proximity of water sources in the Capellades Strait area. The rest of the surrounding landscape was steppe-like, occupied by plains of *Poaceae*, *Asteraceae* and *Artemisia*. Finally, the climatic evolution of this part of the archeological sequence shows an environmental context which progressively worsens in level M to L (mild cold conditions) and reaches the least favourable climatic conditions in levels I and H (Burjachs and Julià 1994). We can assume that the surroundings of the site were a pine forest, which does not exclude other biotopes, such as the river side formations in distant areas. During the Paleolithic, the forest resource exploitation depended basically on the environmental constraints. They were important and diverse, in areas with favorable climatic conditions especially. Immediate needs had to be fulfilled during short occupations and consequently the most abundant and nearest wood resource available were exploited for fuel. Moreover the species that produce more dead wood are more likely to have been chosen as fuel. It is the case for pine tree. This species produces more deadwood than others such as junipers. The perishable character of fuelwood and its immediate use do not require a selection process. This raw material is not dependent on quality as it could be for wood manufacturing (Allué and García-Antón 2006).

The ecological conditions of the surrounding landscape of Abric Romaní offer a wide variety of habitats with high diversity of large mammals. The remains of carnivores are scarce and evidences of their activities were identified with the presence of coprolites and tooth marks on bones. In normal conditions the Abric Romaní is not an ideal habitat for this kind of animal because the formation of travertine involves high humidity levels. Nevertheless, as the ground of the site approaches the roof, there is a greater cave-like environment and the presence of carnivores is more frequent. Consequently, most of them are concentrated in the upper levels (Cáceres et al. 1993; Carbonell et al. 1996). It was documented the presence of ursids, canids, felids and hyenas that show an abundance and variety of herbivores in the environment as potential preys. So, we would find equines and rhinoceros in the open plain situated in the two side of Capellades Strait, and cross it the Anoia river. In the same way the cervids has a similar emplacement although more integrated in the open forest of conifers. The bovids are situated closer of the river beds. In the top of the mountain we find the caprins. All this herbivores have been identified in the different levels of the Abric Romaní site into the anthropogenic contexts. The species of ungulates identified in the level M (Table 17.4) were analyzed to provide information about their habitats and the Neanderthal behavior. For this purpose we selected dental microwear analysis to provide a better reconstruction of paleodiets and paleoenvironments. The microwear analysis was performed following methods described by Solounias and Semprebon (2002) and Semprebon et al. (2004). We made high-resolution epoxy casts for 37 molar teeth. Casts were screened using a stereomicroscope and any specimens exhibiting signs of weathering were excluded (only two specimens). Our sample is made of 35 teeth which were suitable for microwear analysis: 13 for *Equus*, 19 for *Cervus*, and only three for *Bos*. The latter is a too small sample to get definite results. However because we have a few number of species, we decided to keep the sample. Microwear features were identified and quantified using a stereomicroscope under a 35× magnification. Those features were categorized as pits and scratches of various sizes and textures (Fig. 17.2). To approximate their frequency, they are counted in a standard $0.4 \times 0.4\ mm^2$ area on the lingual (inner) band of enamel on the paracone of the upper second molar and on the protoconid of the lower second molar.

Summary statistics of microwear features for the three species are given in Table 17.1. The three species plot either in the grazing morphospace, or in the grazing-dominated mixed feeding morphospace (Fig. 17.3). Both *Cervus elaphus* and *Bos primigenius* (even if the latter is a very small sample) plot close to each other and they fall in or near the grazing morphospace. *Equus ferus*, with high number of scratches, is located in the high abrasion end of the spectrum. Its diet was certainly more abrasive than the diet of *C. elaphus* or *B. primigenius*. Our findings suggest that the ungulates hunted in the level M enjoyed large amounts of high abrasive plants, such as grasses. This is especially true for *Equus* who has here a diet with higher abrasive level than any other modern ungulates. Because grasses are incorporated more in the diet of the fossil when they are abundant in the environment, we propose that they were selectively feeding on grasses. All three species selected open habitats probably because forest habitats were probably not very abundant at this time around the rock shelter. Their diet reveals here a rather cold climate as suggested by the faunal association this study) and by the pollen analysis (Burjachs and Julià 1994). We can suggest that *E. ferus* was living in open grasslands, whereas *C. elaphus* and *B. primigenius* were probably in areas where ligneous plants (trees or shrubs) were more abundant.

Abiotic Resources: Raw Materials

The studies realized until now about the origin of lithic resources at Abric Romaní have been focused on levels I, E

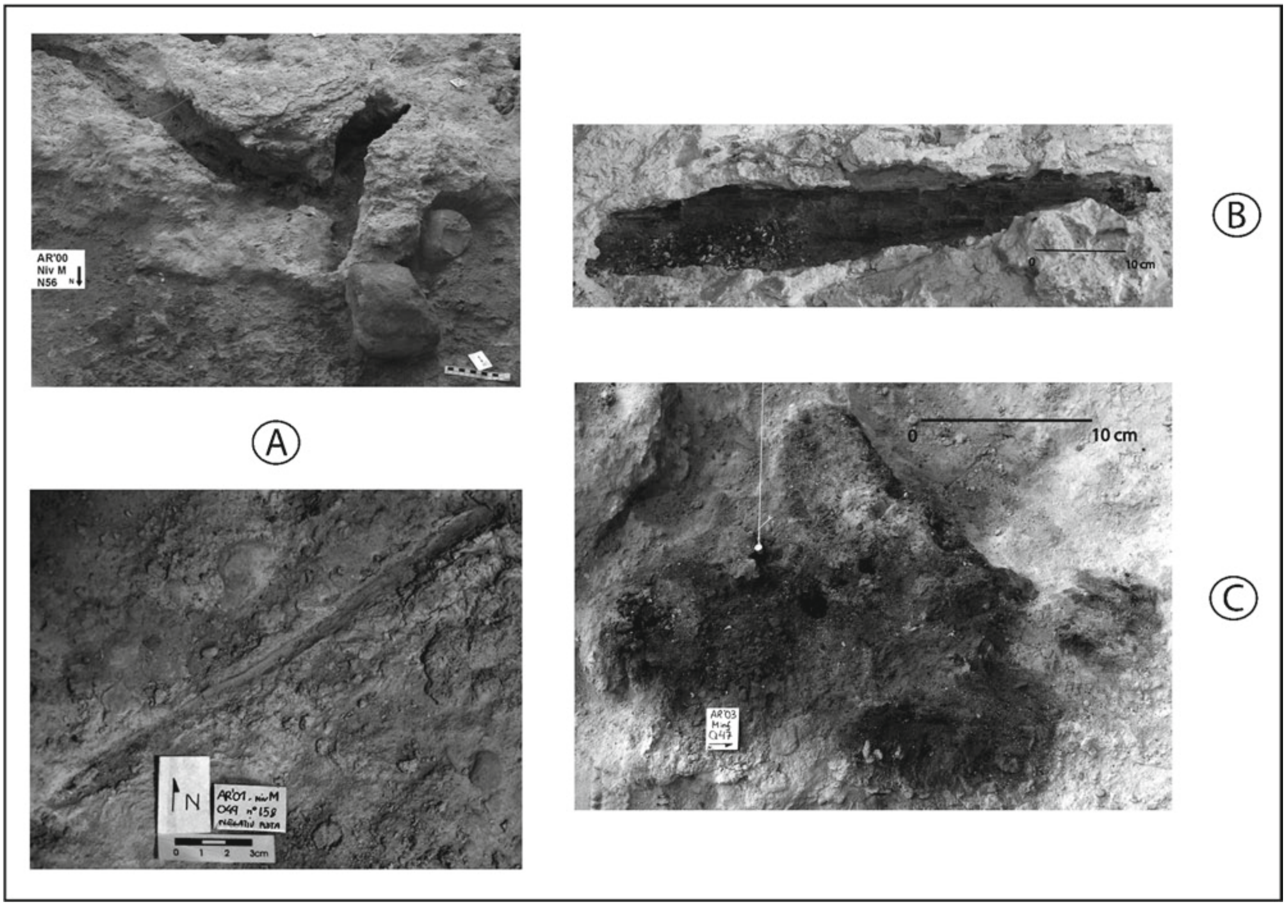

Fig. 17.2 (**a**) Wooden implements in negative; (**b**) Negative in carbonized wood; (**c**) Hearth

Table 17.1 Summary statistics for the microwear features in the level M

	Number of specimens	Statistics	Number of pits	Number of scratches
Equus ferus	**13**	**Mean**	**11.8**	**34.3**
		Standard deviation	3.0	4.5
		Coefficient of variation	25.5	13.0
Cervus elaphus	**19**	**Mean**	**9.8**	**28.2**
		Standard deviation	1.9	4.2
		Coefficient of variation	19.8	14.9
Bos primigineus	**3**	**Mean**	**9.7**	**25.9**
		Standard deviation	2.7	9.7
		Coefficient of variation	27.6	37.6

(Morant 1998; Bofarull 1997; Morant and García-Antón 2000) and L (currently under study). This works have based their methodology on a wide geological prospecting and rocks sampling (mainly flint). Subsequently the samples were analyzed using crystallographic rayon X diffraction and two kinds of microscopes: petrographic (Olympus BH2) and SEM (Scanning Electronic Microscope Jeol JSM-6400). In relation to these studies different supply raw materials areas have been identified. These include flint and Paleozoic stones in primary position and other in secondary position that provide the same kind of rock that in the primary positions and also limestones and sandstones suitable for knapping (Table 17.2, Fig. 17.6). The raw materials closer to the site are located in the secondary outcrops on the fluvial terraces of Anoia River and the Carme (CME) and Sant Quintí de Mediona (SQM). Those conglomerates areas contain clasts and their dismantling would have allowed getting raw materials. The stones of Paleozoic origin (PZC) are situated in primary position, although their materials come from quaternary dismantling of the terraces and the colluviums near the site. The predominant raw materials are quartz, slate, porphyry and quartzite. All the siliceous outcrops identified are semi local and their

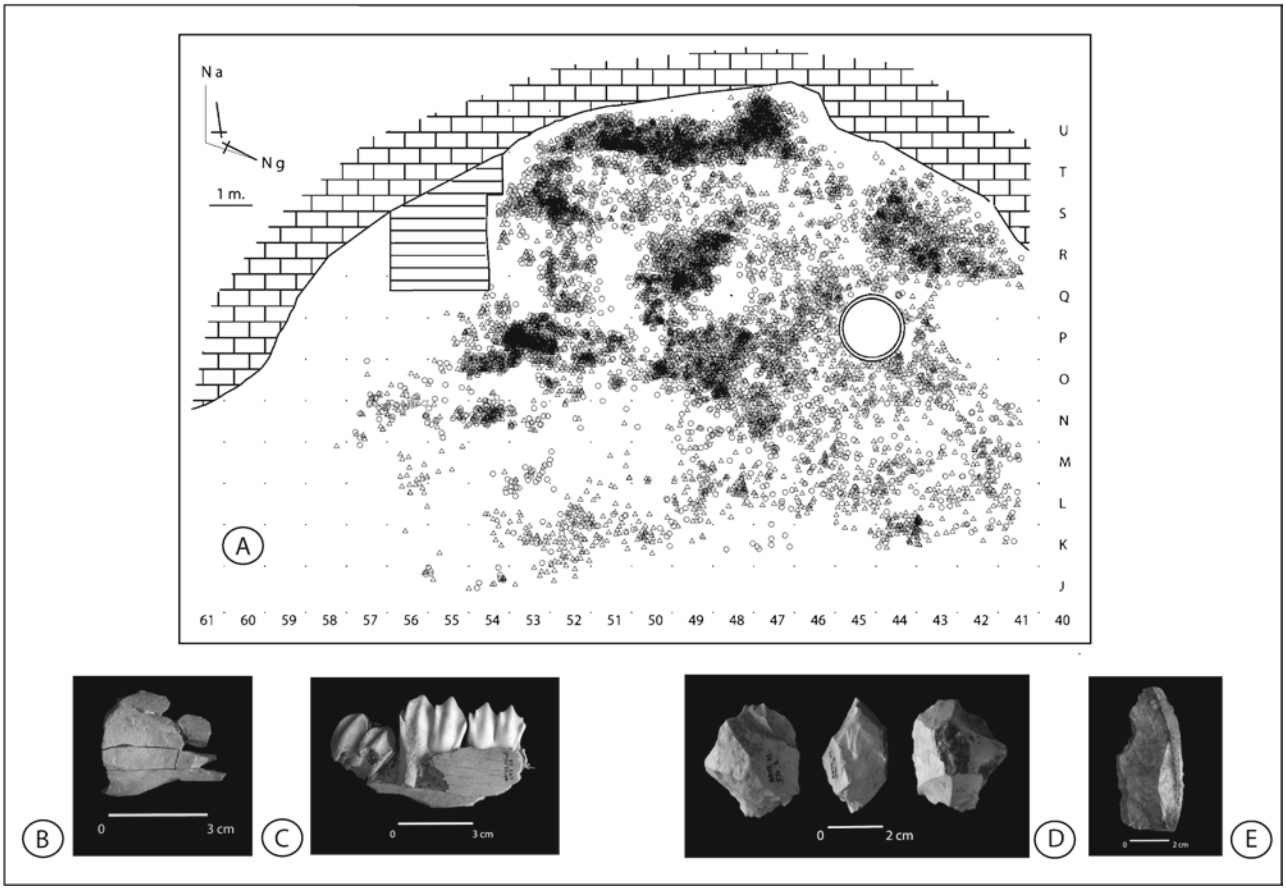

Fig. 17.3 (**a**) General distribution of the level M archaeological remains; (**b**) Bone refit; (**c**) Mandible of red deer (*C. elaphus*) with M3 in eruption; (**d**) Discoidal core in flint; (**e**) Denticulate in flint

distance is about 20 km from the site. Flint angular clasts also appeared in the Anoia River terrace. The closest outcrop from the site (≥8–10 km) belongs to the Trias (Lower *Muschelkalk*) and is situated towards the west in the dolomitic limestones mountains near Sant Quintí de Mediona (MED). It contains flint lens nodules of 20 cm, with a grey bluish coloration. The flint of Valldeperes (VLD) formation appears in different positions in the same formation. In this work the rocks from Vallespinosa and Llacuna have been analyzed. They are located about ≥18–20 km towards the west-northwest from the archeological site. This outcrops origin is the Paleogene (Cuisiensian-Lutetian) evaporitic formation with bluish brown flint blocs fits in marls and lacustrine clays. Near the Sant Martí de Tous (SMT) appears a Lagoonal area which belongs to the Paleogene (Sanonian) gypsum bearing (evaporitic) formation. It contains flint translucent nodules (black, bluish and reddish) and blocks measuring up to 1 m. In relation to the limestone we identified a primary position outcrop near the site from ≥4 to 10 km toward the west. This is the Orpí formation belonging to the Eocene (Ilerdian) and formed by biomicritic marine limestone. They are brown light yellowish with *Nummulites perforatis* fossils and various alveolines. The raw materials more used (Table 17.5) are flint from Vallespinosa (VLD) y Sant Martí de Tous (SMT) and limestone from the Anoia River and Orpí formation, probably because of their suitability for knapping.

Concerning the introduction of raw materials used, several modalities have been documented: whole blocs or pebbles, cores tested, cores in the first moments of the reduction sequence, middle or large tool blanks and retouched tools. The closest raw materials are generally introduced without modifications. It is the case for limestone, sandstone, and slate. Although the quartz has the same supply areas, in this level it shows a similar introduction pattern than agate, quartzite, porphyry, and granite that were brought to the site as final knapping products. The flint, raw material which procurement requires the longest displacement in the territory shows all kinds of introduction cited above (Table 17.2). These ways of introducing lithic resources into the site reflects the spatial and temporal breakage of the *chaînes opératoires*. A part of flint, limestone, sandstone and slate show reduction sequences realized in the site. The others are only represented by finished products (flakes and retouched tools) (Table 17.5). Likewise the core transport shows the

Table 17.2 Localisation and description of the raw lithic materials formation

Geological formation age	Geological formation description	Outcrop location ([a])	Raw material	Microscopic texture	DRX	Size	Suitability for knapping	Distance
Eocene (Cuisiensian-Lutetian)	Valldeperes formation, Palaeogene evaporitic formation with flint blocs (whit metric dimensions) fits in marls and lacustrine clays	Vallespinosa (VLD)	Flint in primary position	Crypto to microquartz and fibrous LFC	Quartz and moganite	≤1 m	Good for knapping	≥15–20 km
Triassic (Lower Muschelkalk)	Dolomitic limestone formation that contains flint lens nodules	St. Quíntí de Mediona (MED)	Flint in primary position	Cryptoquartz small mosaic quartz and calcite	Quartz, calcite and dolomite	20 cm	Knapping difficult (by the internal fractures)	≥8–10 km
Oligocene (Sannonian)	Lagoonal area which belongs to gypsum bearing (evaporitic) formation that contains flint translucent nodules and blocks	St. Martí de Tous (SMT)	Flint in primary position	([d])	([d])	≤1 m	Good for knapping	≥18–20 km
Eocene (Ilerdian)	Marine limestone Orpí formation that contains fossils (*Nummulites perforatis*) and micro-fossils (severals types of alveolines)	Orpí	Limestone in primary position	Biomicrite	Calcite	≤50 cm	Good for knapping	≥4–10 km
Eocene (Cuisiensian-Lutetian)	Conglomerate coarse detritic facies with rounded flint nodules	Carme (CME)	Flint in secondary position	Cryptoquartz small mosaic quartz and larger crystal calcite	Quartz, calcite and moganite	≤5 cm	Good for knapping	≥3 km
Late Upper Miocene (Turolian)	Stratified conglomerates formation that contains calcareous and siliceous rounded clasts whose	St. Quínti de Mediona (SQM)	Flint in secondary position	Crypto to microquartz and fibrous LFC mosaic quartz and euhedral quartz	Quartz	6–18 cm	Variable knapping suitability	≥5–10 km
Paleozoic (Ordovícian)	Materials come from quaternary dismantling of the terraces and the colluviums	Capellades Strait (PZC)	Slate, quartz, porphyry and quartzite in primary position	–	–	5–40 cm	Variable knapping suitability	In front of the site ≥300 m
Quaternary	Fluvial stepped terrace deposits that contains in sandy matrix, pebbles ([b]) and cobbles ([c])	Anoia River	Limestone, flint and quartz in secondary position	–	–	≤6 cm ([b]) ≥25 cm ([c])	Variable knapping suitability	≥150 m

[a]Origin place of the samples
[b]Pebbles size
[c]Cobbles size
[d]In process of study. LFC = Length-Fast Chalcedony

discontinuous character of the lithic resource management, not only at the intersite level, but also at the intrasite one. Lithic artifacts and raw materials were also transported for reserves (tool kit), in order to maintain a minimum resource availability to face unexpected problems. These patterns of raw materials introduction and representation in the assemblage indicate some capacities of anticipation and prevision. This technological behavior can be integrated in the provisioning individual model proposed by Kuhn (1992, 1995).

Activities Carried Out on the Site: Level M

The level M is dated between 52.2 ± 1.6 ka (USGS no. 53) and 54.9 ± 1.7 ka (USGS no. 54) (Bischoff et al. 1988). Over 247 m^2 were excavated and cover the entire surface of the rock-shelter. The archeological record yielded 13,993 remains (7,906 bones and 6,087 lithics). This implies an average density of 56.6 remains by square meter. The characteristic of the travertine surfaces favor the conservation of archeological evidences, such as hearths and wooden implements in negative, pseudomorphs or burnt forms (Carbonell and Castro-Curel 1992). The calorific impact of hearths is recorded perfectly on these surfaces and the location and size of these structures can be documented even when their sedimentary matrices have been substantially affected by post-depositional processes. Thirty-seven hearths were identified in the level M (Fig. 17.4).

The archeological record is distributed on the whole surface although we observed areas with high densities of remains (Fig. 17.5). In this paper we assume that the formation of this level could be contemporaneous or perhaps the consequence of one or several occupational events. The spatial and archeostratigraphic analysis currently under way will allow to characterize vertically and horizontally this level, and to define the settlement pattern. However those data were not available for this paper.

Vegetal Resources

The vegetal resources recorded in level M are known from pollen and charcoal analyses. The range of dates of level M is within the OIS 3 (Bischoff et al. 1988). The palynological analysis show that this level is inserted in a cold phase among warm and humid episodes, in which open space taxa develop (mesothermophilic such as *Quercus* and thermophic as *Pistacia*) (Burjachs and Julià 1994).

All the charcoal remains correspond to residues coming from the use of wood as a combustible. In this level we can identify a total of ten negatives in carbonized wood (NFC) along with 30 wooden negatives (NF) (Fig. 17.4). The paleoenvironmental reconstruction according to the results of charcoal analysis shows a dominance of *Pinus type sylvestris/nigra* and unknown pines (Table 17.3). These data show a prevalence of cold and dry conditions in open pine areas. The varieties of species of *Pinus* show a change in altitude of the levels of vegetation. We observed two kind of wood exploitation, as firewood (primary access) and raw material to

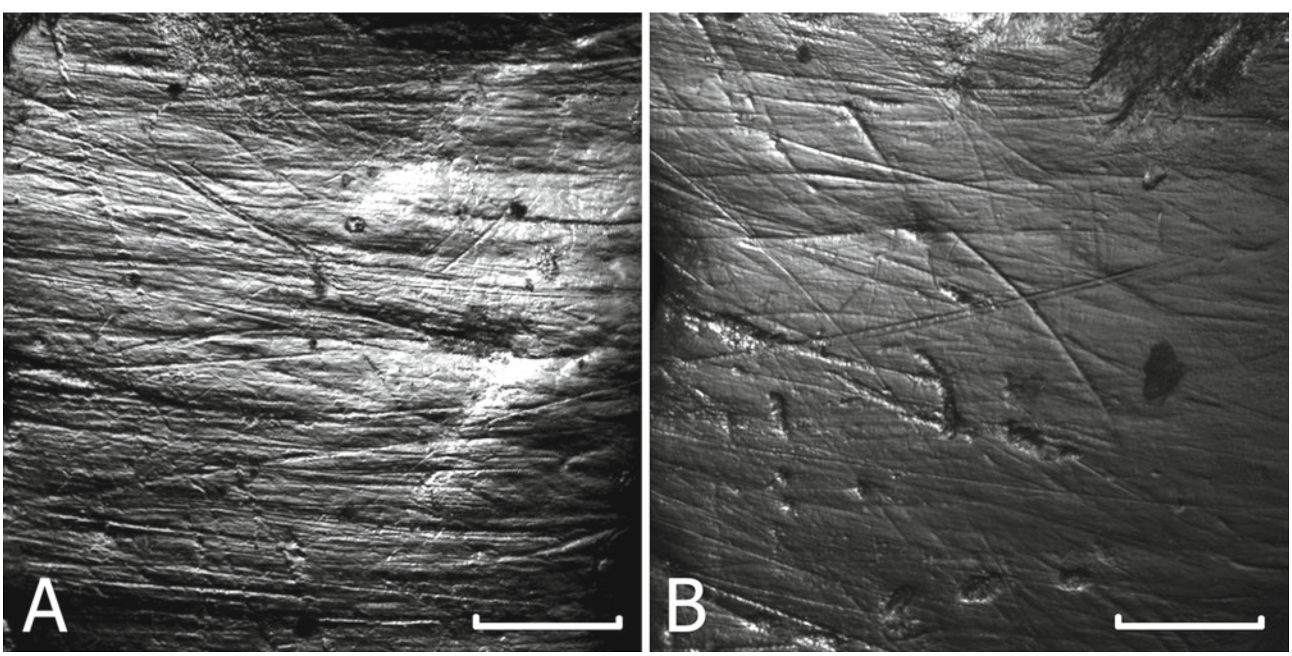

Fig. 17.4 Photomicrographs of *Equus ferus* (**a**) and *Cervus elaphus* (**b**) tooth surfaces at 35× magnification under a stereomicroscope. Scale bar equals 0.2 mm. Specimens numbers: AR'02-M-S50/55 (**a**) and AR'00-M-N47/41 (**b**)

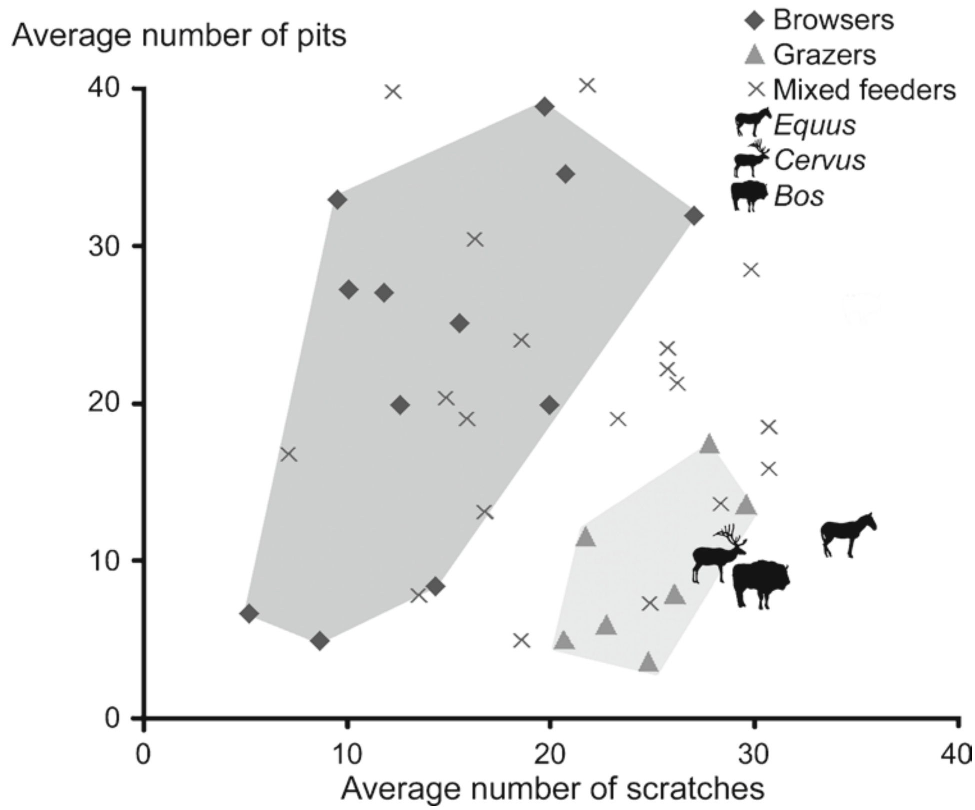

Fig. 17.5 Bivariate plot of the average number of pits versus average number of scratches in extant ungulates and fossils from the level M at 35× magnification (Extant data from Solounias and Semprebon 2002). Convex hulls are drawn around extant leaf browsing taxa and extant grazing taxa for ease of comparison

Table 17.3 Results of charcoal analysis in the level M (Allué 2002b)

Taxa	Nº fragments	%
Pinus type sylvestris/nigra	155	59.2
Pinus type sylvestris/uncinata	7	1.5
Pinus sp.	17	6.6
Undetermined conifer	59	26.2
Undeterminable	16	6.5
Total	254	100.0

produce wooden tools. In the two cases the use was immediate (Allué 2002a).

Faunal Assemblages

The minimum number of individuals (MNI) was calculated from dental remains (Table 17.4). Non identified bones have been grouped into categories following anatomical and taxonomical criteria. On one hand, we use the categories of long, flat and short bones. Long bones are represented by limbs; flat bones by cranial and axial skeleton; and most of short bones are located at the end of the limbs. On the other hand, bones have been grouped by animal weight, taking into account the taxon and the age of animals. The following categories have been selected: large-sized (>300 kg), medium-sized (between 150 and 300 kg) and small-sized animals (<150 kg). The faunal assemblage from the level M is characterized by (1) a high number of remains (NR = 7,906) in comparison to the other upper levels, (2) a high degree of bone breakage (54.52% of total are ≤2 cm long), and (3) a high percentage of bones with signs of cremation (12.7% on maximum degrees). The intense bone breakage produced by human activities (6.9% of the NR) has made difficult anatomical and taxonomical identification.

The main species identified are *Cervus elaphus* and *Equus ferus*, specifically combined with *Bos primigenius*. The mortality profile shows that all age categories are represented, although prime adults are dominant, immature and old adults are also present (Table 17.4). The season of settlement was estimated by studying teeth with reduced use-wear (wear stage corresponding to the eruption of the tooth out of the gum). This criterion was used for detecting seasonality on isolated teeth, mandibles and maxillae using data from modern red deer (*Cervus elaphus*). Stages of tooth development were identified and assigned a score according to a scheme developed for modern red deer (Mariezkurrena 1983; Carter 1998). The molar dentition of two individuals (over a MNI of 9) compare favorably with animals which died between 17 and 18 months (Fig. 17.5c). Taking into account that for modern red deer birth occurs in June (Nowak 1999), we can propose

Table 17.4 Number of identified specimens (NISP) and percentage (%NISP) and Minimum Number of Individuals by tooth (MNI) recovered at level M

			NMI				
	NISP	%NISP	Juvenile	Immature	Subadult	Prime	Old
Equus ferus	58	11.39		2		4	
Cervus elaphus	435	85.46	1		1	5	2
Bos primigenius	16	3.14		1		2	
Total	509	100.0	1	3	1	11	2

that red deer were hunted from October to December. However, because the archeostratigraphy is currently under study, we cannot generalize this result to all hunting activities from the level M. The skeletal part profiles shows differences between large-sized animals and medium and small sized animals. Large-sized animals are only represented by heads and forequarter and hindquarter (scapulae, humerus, radio-ulna, femur and tibia), axial skeleton, forefoot and hindfoot (metacarpal, metatarsal) and compact foot bones (carpal, tarsal and phalanges) are not represented. Sometimes axial skeletons of medium and small-sized animals were introduced to the site, where they were processed and consumed. These differences result of a differential transport realized by hominids. This strategy varies depending on the type of processing (Perkins and Daly 1968; Binford 1978, 1981; Brain 1981; Bunn 1986; Klein 1989; Gifford-González 1991; Faith and Gordon 2007). Large-sized were transported selectively. The location where the animals were obtained took place preparation and dismembering at, being consumed and/or leaving those anatomic parts with the lowest meat content.

The results of the zooarcheological and taphonomical analysis indicate that they developed systematic and repetitive behavior patterns to obtain and consume animals. This pattern is repeated in the upper levels, highlighting an early and persistent reliance on herbivores. Everything suggests systematic activity related to the size of the animals, likely reflecting hunting strategies (Carbonell and Castro-Curel 1992; Carbonell et al. 1996; Aïmene et al. 1996; Cáceres 1998; Cáceres et al. 1998; Rosell 2001; Vaquero et al. 2001; Cáceres 2002; Carbonell 2002; Chacón and Fernández-Laso 2005a, b). The hominids carried out their activities around the hearths. Some bones present signs of heating by fire. They are usually small fragments located in/or close to the combustion areas. We identified cutmarks (3% of the NR) and bone scraping (2% of the NR) on burned bones (58.8% of the NR), so after preparing and consuming the animals, hominids threw the bones to the hearths (Fig. 17.5b and c). Cut marks were identified on large-sized animals. They are located on forequarters, hindquarters and mandibles and are associated with the defleshing, skinning and long bone scraping. In medium and small-sized animals, cut marks related to evisceration were also identified. There are a large number of percussion cones and marks. The bone fracture technique applied to obtain marrow implies separating the two epiphyses from the shafts longitudinally. We observe a systematic fracturing of epiphyses, which is not well represented in this level.

Lithic Technology

The number of lithic remains recovered in level M is high (Table 17.5) in comparison to the others levels of the stratigraphic sequence (Vaquero 1999; Vallverdu et al. 2005; Martínez et al. 2005). Only level J has a similar total lithic assemblage (Martínez and Rando 2001; Vaquero 1999).

Flint is the dominant raw material (81%) but a great variety of other rocks ($n=10$) have been identified in this level. The aims of *chaînes opératoires* are the knapping products for all the raw materials used. Cores and retouched tools are very scarce (Table 17.5). This pattern is the general rule in the lithic assemblages of Abric Romaní sequence, but in level M it is even lower. We do not observe different knapping methods on raw materials. The strategies applied can be seen as belonging to the discoid technology. The core reduction was organized by dividing it in two opposed secant surfaces, separated by an intersection plane (normally the horizontal) in order to obtain various numbers of flakes by centripetal and generally bifacial organization of removals. This reduction strategy offers a wide variability which depends on the relationship between the two flaking surfaces. This level is mainly characterized by non-hierarchical strategies (Fig. 17.5d). We have to point out the presence of some cores whose attribution to the discoid method has raised doubts because their morpho-technical characteristics are close to the Levallois method (Boëda 1993, 1994). The refitting analysis currently under study may help us to ascribe them to one or another knapping method. Cores tend to be exhausted, flint ones especially. The big sized cores recovered were not totally exploited due to the bad quality of raw material, independently of the rock used. The final stages of reduction are characterized by a systematic production of small flakes (≤2 cm) and by a change in the striking surface from horizontal to transversal. This change allows for optimal exploitation of small cores, thus producing small flakes from the last series of detachments. These patterns reflect an economic behavior, characteristic of the whole

Table 17.5 Lithic assemblage from level M. Values in parentheses are percentages

	Flint	Limestone	Quartz	Slate	Sandstone	Granite	Quartzite	Agate	Porphyry	Stalagmite	Jasper	Total
Unworked nodules		5 (62.5)			3 (37.5)							8 (0.13)
Hammerstones		17 (89.47)		1 (5.26)	1 (5.26)							19 (0.31)
Hammerstones fragments		7 (100)										7 (0.11)
Cores	32 (78.05)	8 (19.51)			1 (2.44)							41 (0.67)
Cores fragments	14 (87.5)	2 (12.5)										16 (0.26)
Retouched tools	33 (82.5)	2 (5)	1 (2.5)	3 (7.5)						1 (2.5)		40 (0.66)
Flakes	2,666 (92.67)	149 (5.18)	27 (0.94)	15 (0.52)	2 (0.07)	6 (0.21)	5 (0.17)	3 (0.1)	3 (0.1)		1 (0.03)	2,877 (47.26)
Flakes fragments	2,152 (80.66)	293 (10.98)	115 (4.31)	101 (3.79)	2 (0.07)	2 (0.07)	2 (0.07)	1 (0.04)				2,668 (43.83)
Fragments	18 (4.38)	94 (22.87)	180 (43.8)	115 (27.98)	3 (0.73)	1 (0.24)						411 (6.75)
Total	4,915 (80.75)	577 (9.48)	323 (5.31)	235 (3.86)	12 (0.2)	9 (0.15)	7 (0.11)	4 (0.07)	3 (0.05)	1 (0.02)	1 (0.02)	6,087

technical system. The knapping products are mainly small and medium-sized (90% ≤ 40 mm). The retouched tools are found principally on the biggest and thickest flakes, and are essentially denticulates (57.2%) with sidescrapers (28.5%) and some notches (14.3%). Retouch is usually lateral, unifacial, direct, and it does not affect more than 25% of the edge and does not modify the general morphology of the tool (Fig. 17.5e). There is no laminar tendency but we have to point out that in level M the percentage is higher (1.2%) than in other levels of the sequence.

Discussion and Conclusions

Multidisciplinary studies of levels M have shown that Neanderthals intensively exploited their environment and their subsistence strategies are based on wide range mobility on the territory (Fig. 17.6). The Abric Romaní rock-shelter, due to its natural strategic situation and the higher resources availability, was a passing site inside the territory exploited by prehistoric settlers during more than 30,000 years.

Biotic resources, both fauna and vegetation, show a local exploitation. First of all, considering the faunal resources they have developed strategies mainly focused to obtain two species: red deer and horses punctually associated with bovids. These species related to ecosystems of plains indicate a mobility axe oriented towards the open areas in the Anoia Valley. Hunting, at least for red deer, occurred during the transition from the warm to the cold season autumn. Assessing the season of kill using mandibular tooth development and wear in red deer has made a significant contribution to solving the problem of when the level M at Abric Romaní was occupied. Identifying at what time of the year humans were present at the site means that wider issues such as social and economic structure may be better addressed. The MNI suggests a high degree of animal exploitation (food) indicating a high availability of animal resources in the surrounding. Animal processing varies in relation to their weight. Horses and bovids were exploited in the killing site to make their transport to the shelter easier and also to reduce the energetic spending. Red deer were transported entirely to the site and their exploitation is totally realized in the site. The principal activities developed are the meat filleting and the bones breakage to obtain the bone marrow. These strategies of animal transport and exploitation show that hunting requires the cooperation and planning of the hominid groups.

On the other hand Neanderthals exploited different vegetal resources for fuelwood or to make wood artifacts. The most used species is *Pinus nigra*, the most abundant in the surrounding environment. They do not use the species of river plains although they are closer to the site. The need of an immediate resource makes the operative chain of fire production an important activity that was solved at low energy costs (Allué 2002a; Allué and García-Antón 2006). In contrast to the biotic resources the abiotic ones show local and semi-local exploitation but they came principally from longer distance areas (Table 17.2). Flint is the main raw material (Table 17.5) used, and was collected further away from the site, about 5–10 km at least. The local raw material has two different models to introduction. Limestone and sandstone are introduced without modification and the complete reduction sequence was carried out in the site. The other local raw materials (Paleozoic rocks) were introduced as finished knapping products. There are two evident mobility axes. The first one has a northwest-southeast direction following the Anoia River bed towards Prelitoral Depression. In this area they collected the siliceous materials from Sant Martí de Tous (SMT) and Ódena (ODN). The other one have an east–west direction from the terraces in front of the site following by the Carme valley towards Vallespinosa (VLD). In this area they collected the Orpí limestone and the Valldeperes flint. For Orpí, the mobility direction is evident because the raw material appears in the downstream Anoia. The difference between biotic and abiotic resources is usually linked to the easy reuse of the second ones. While biotic resources as wood and meat are perishable and permit one use only, abiotic resources may be recycled by tool resharpening or reuse of broken pieces. Biotic resources show a procurement pattern for immediate use. The abiotic resources do not necessarily follow the same pattern; they could be selected according to other criteria (Allué and García-Antón 2006). Flint was mainly exploited for the reduction and configuration sequences, because it is the best suitable raw material for knapping, although its procurement entails the longest displacement in the territory and requires more time and energy. The results from this first study of level M archeological record allow us to propose that the Neanderthal mobility patterns were based on a deep knowledge of the territory and its resources, as well as a high degree of planning and anticipation. These mobility strategies also indicate the ecosocial complexity and the organization of the subsistence activities. Comparing level M with the other levels of the sequence we observe that mobility pattern and resources procurement are similar but some differences can be recognized. If we consider the animal resources the Neanderthals selected red deer and horse in a systematic and repetitive way in all the levels of the sequence. Sometimes these two species are specially combined to bovids. We observe a higher variety of species in the upper levels and in the level Ja. This high specific diversity could be related to long-term occupations (Carbonell and Castro-Curel 1992; Carbonell et al. 1996; Saladié 1998; Rosell 2001; Vaquero et al. 2001; Cáceres 2002; Carbonell 2002). The patterns of lithic resources procurement show diachronic changes. These variations between different levels depend on the lithological diversity used, but

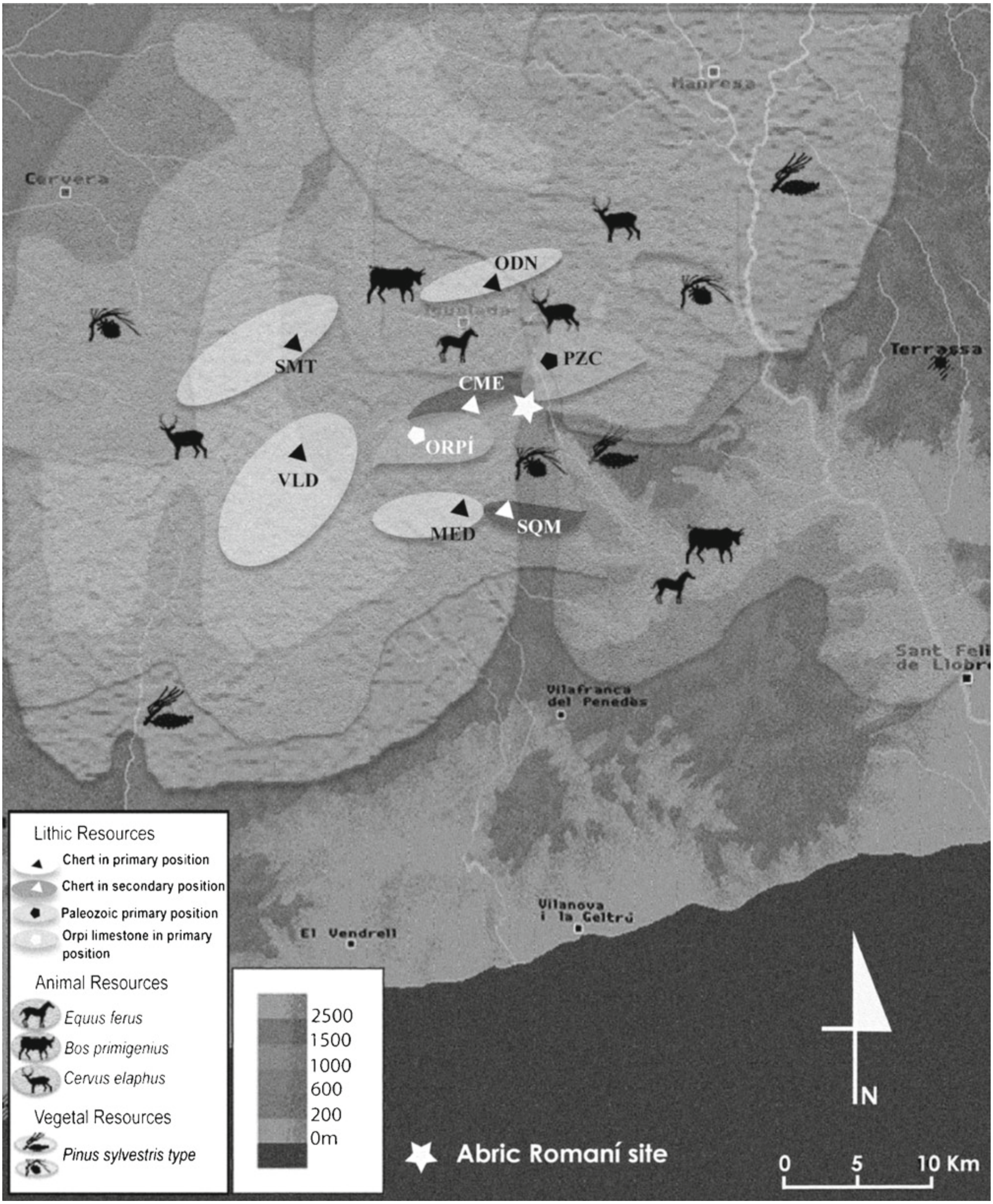

Fig. 17.6 Distribution map of the potential resources collected by Neanderthal groups from Abric Romaní

flint was always preferentially selected. The only rupture identified in this pattern was observed in the intermediate levels (H, I and K), where percentages of flint are similar to local raw materials (limestone and quartz). Level Ja shows the most similar lithic resources procurement and management to level M (Bofarull 1997; Morant 1998; Vaquero 1999;

Morant and García-Antón 2000; Carbonell 2002). The procurement patterns and territorial mobility observed in level M is very similar to those proposed for other archeological sites from the same chronological period such as Roca del Bous, Lleida (Martínez et al. 2004; Mora et al. 2004), Payre, Ardèche (Moncel et al. 2002; Moncel 2003), or La Combette, Vaucluse (Texier et al. 1998).

The archeostratigraphic study currently under way will provide more information about the cognitive and settlement patterns developed in the site to distinguish the kind of occupation patterns in level M. Future studies of this site and other Middle Paleolithic sites documented in the geographical area will enable us to obtain broader knowledge about the mobility of Neanderthals and their patterns of activity in the region. In this way, the realization of the second scale of analysis proposed in this article will be totally possible.

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Chapter 18
Level G of Las Fuentes de San Cristóbal (Southern Pyrenees, Spain)

Availability of Lithic Resources and Territory Management

María D. García-Antón, Leticia Menéndez Granda, and María G. Chacón Navarro

Abstract The archeological site of Las Fuentes de San Cristóbal is located in the Huesca province (north-eastern Spain). It is situated between the mountains of the exterior zone of the central ridge and the central depression of the Pyrenees. This area presents a complex system with wide hydrographic valleys, formed by the Ésera, Isábena and Noguera-Ribagorzana rivers. This system has produced diversified lithological resources exploited by hominids. The level "G" is situated above a basal level with pebbles, dated 55 ka BP, therefore it belongs to MIS 3, but no absolute dates are available at the moment. During this interstadial period the river valleys provided new potential areas for procurement of lithic resources. The lithic assemblage of level G has yielded 4,440 pieces, 2,199 of them analyzed and presented in this study. This assemblage is mainly formed by knapping products, and some cores and retouched tools. The main knapping method is discoidal, and the products are denticulate and side-scrapers. The most employed raw material is flint, in its different varieties and limestone, porphyry, quartzite, sandstone and, in a lower percentage, lydian and quartz were also used. The primary position of all of these lithic materials is located in a "semi-local" area between 9 and 24 km from the archeological site (siliceous formations), and the other raw materials can be found in secondary position in the surroundings of the site (alluvial deposits). The study of the lithic resource availability and territory management brings new insights into the exploitation of high mountain ecosystems in the Pre-Pyrenees.

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Introduction

The petrologic composition of the lithic tools recovered in an archeological site gives an indication of the geographical and geologic origin of rocks that have been used in the knapping sequences. This information can be employed to determine the distances covered by humans to access raw materials. This allows describing the processes of material acquisition, the degree of environmental knowledge and mobility patterns in the territory of hominins. During OIS 3 human groups inhabited the mountain areas called "Axial Pyrenees". Level G of Fuentes de San Cristóbal corresponds to this time period. In spite of various hypotheses on the exact paleoenvironmental conditions of this period, it is commonly accepted that it was a period characterized by great climatic variability, with warm pulses within a general period of climatic harshness. The existence of the so-called "mosaic of ecosystems" in the Iberian Peninsula during this phase, has led to an important discussion in the scientific community about the specific climatic conditions in each geographic region (Carrión et al. 1999; Finlayson and Giles Pacheco 2000; Goñi et al. 2000; Burjachs and Allue 2003; d'Errico 2003; d'Errico & Goñi 2004; Carrión 2004; Finlayson et al. 2004, 2006; Moreno et al. 2005; Goñi and D'Errico 2005). A better understanding of subsistence strategies, mobility and exploitation of the environment by human groups depends on a thorough understanding of the environmental scenario. Access to primary and secondary sources of raw material supplies have certainly been influenced by the environmental conditions, which may have caused temporary difficulties in accessing particular geographical areas. On the other hand, this chronological period is the object of an important discussion on the so-called "crisis at 40 ka BP" (Carbonell and Vaquero 1996) or the Middle to Upper Paleolithic transition, with biological replacement of populations and cultural change. Over recent years the

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"Ebro frontier" hypothesis (d'Errico et al. 1998; Zilhão and d'Errico 1999; Zilhão 2000; Zilhão and Trinkaus 2002), the existence of "transitional lithic assemblages" and the determination of the human species that realized these technological complexes (Karavanic 1995; Maroto et al. 1996; Zilhão and d'Errico 2000; Cabrera et al. 2001, 2006; Slimak 2005; Bar-Yosef 2006, Jankovic et al. 2006; Zilhão 2006; Mellars 2006) became a central issue in scientific archeological publications.

The Fuentes de San Cristóbal archeological site fit within this chronological and cultural frame, with dates that range between 20,220 ± 380 BP for level M (^{14}C AMS, OxA-8591), 27,200 ± 1,000 (^{14}C AMS, OxA-8589) and 36,050 ± 550 (^{14}C AMS, OxA-8524) for level O and 36,000 ± 1.900 BP (^{14}C-AMS, OxA-8590) for level P (Rosell et al. 2000a, b). Although no absolute dates are available now for level G, it is younger than 55 ka since it is situated over a fluvial level of basal pebbles with this age. New dates (40 new samples for the site including level G) are planned for the project "Chronological and cultural context of the final Middle Paleolithic in the Peninsular North" (HUM2004-04679 Spanish Department of Culture and Education). The stratigraphic sequence is composed only of Middle Paleolithic levels that show once again the existence of the so-called "occupational hiatus" indicated by the absence of Aurignacian levels in these zones of high altitude (Maroto et al. 2004; Vaquero et al. 2006). The aim of this paper is to describe and understand strategies of lithic resource procurement of the dwellers of Las Fuentes de San Cristóbal. Lithic material supply areas, its management, technological analysis and mobility of these human groups during OIS 3 in the Huesca Pre-Pyrenees will be studied. Finally, this site is contextualized within the Upper Pleistocene of the northeastern Iberian Peninsula.

Las Fuentes de San Cristóbal Archeological Site

Las Fuentes de San Cristóbal site is located in the Veracruz village, in the oriental area of Huesca province. This area is geologically very complex with a high lithological variety and a particular orography characterized by the presence of wide valleys formed by the Esera, Isábena and Noguera-Ribagorzana Rivers. The site is situated at the entrance of the narrow mountain pass of San Cristóbal, from which it gets its name. It is located at 820 m above sea level and is 20 m from the actual river bed of Isábena River (Rosell et al. 2000a, b) (Fig. 18.1).

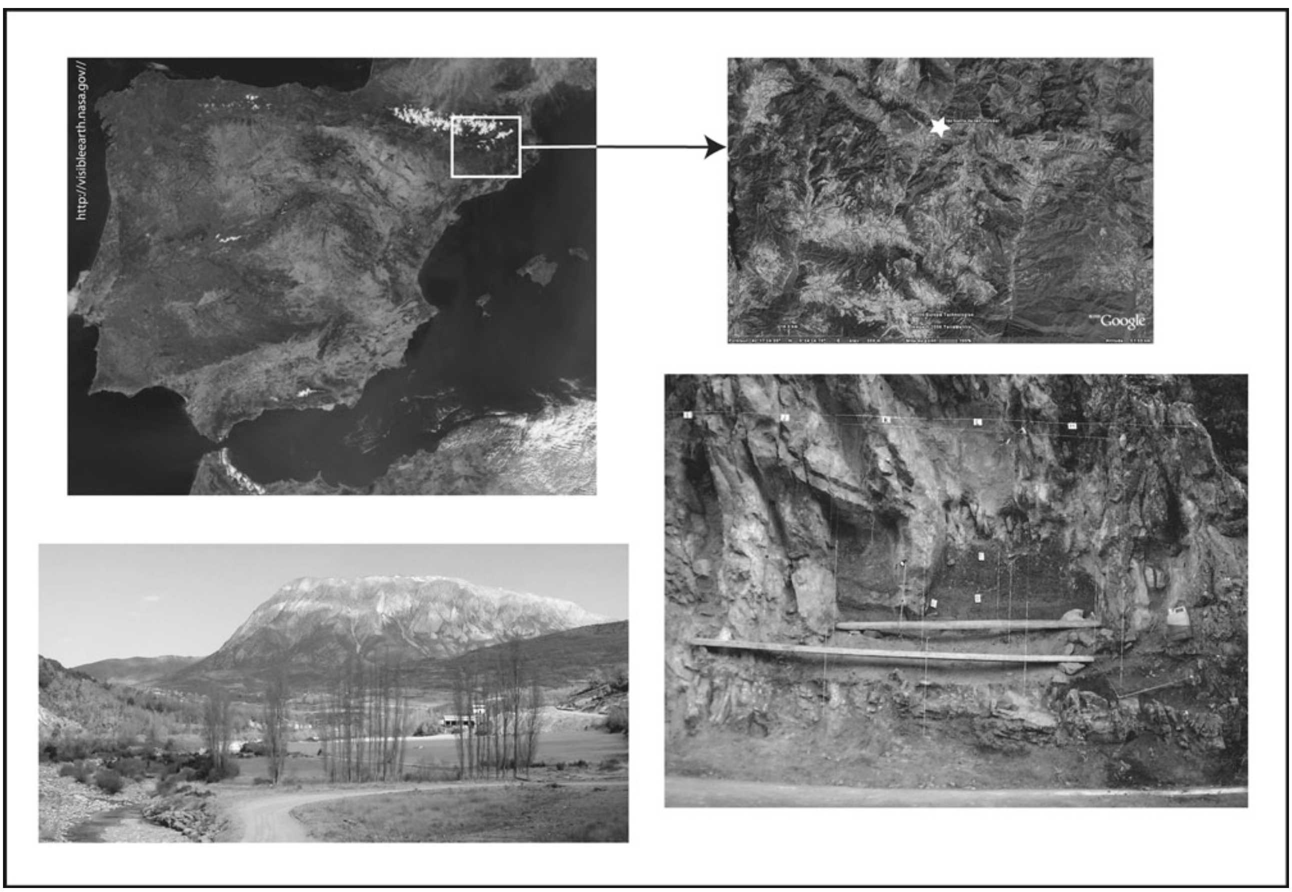

Fig. 18.1 Geographic location and general views of Las Fuentes de San Cristóbal site

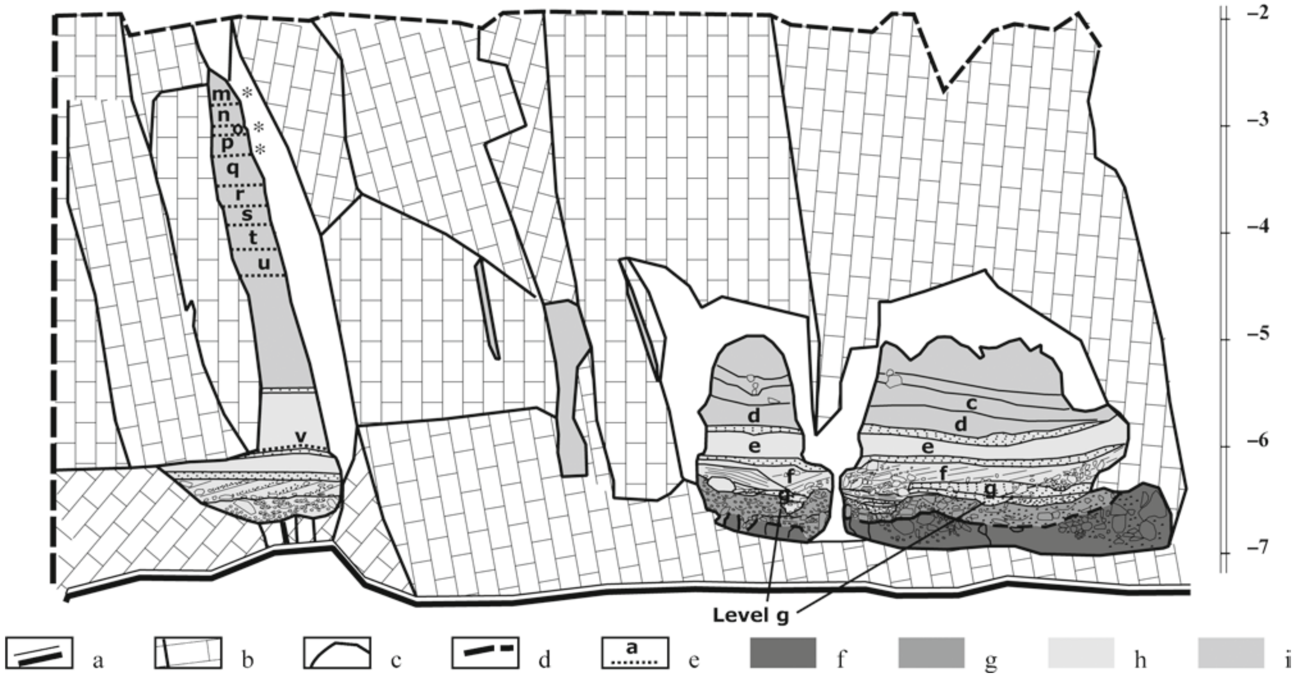

Fig. 18.2 Stratigraphic sequence (made by Josep Vallverdú) of Las Fuentes de San Cristóbal site (*a*: road line; *b*: artificial surfaces and crests produced during the road construction; *c*: artificial crest and surface of natural dissolution by karstification; *d*: artificial limit of this graphic representation; *e*: nomenclature and position of the archeological levels; *f*: stratigraphic sequence formed by allochthonous alterite; *g*: stratigraphic sequence formed by autochthonous alterite; *h*: fluvial stratigraphic sequence; *i*: stratigraphic sequence of slope). *Localization of the ^{14}C AMS datations (Rosell et al. 2000b). Level m: 20,220 ± 380 [OxA-8591]; level o: 27,200 ± 1,000 [OxA-8589] and 36,050 ± 550 [OxA-8524]; level p: 36,000 ± 1,900 [OxA-8590]

The cave has been discovered in 1998 during road extension work. Rescue archeological excavations have been conducted at the site for 5 years (until 2002). In spite of time limits, it was possible to systematically excavate the whole archeological sequence. During the first 4 years the spatial orientation of each archeological object was determined and during the last year the archaeological remains were collected in quadrants of 25 cm due to the limited time available to complete the excavation of the whole stratigraphic succession. The road works damaged the exterior part of the site. In spite of this the complete archeological sequence of the cave could be described. The site comprises of several cavities. In the right lateral cavity a large room occur in the back where two sequences, labeled Profile 1 (P1) and 2 (P2), are described. Profile 3 (P3) is located towards the north (Fig. 18.2).

The stratigraphic reference for the site is Profile 3, correlated with the two other profiles. The sedimentary sequence is 5 m thick and nine archeological levels were identified. The sequence is complex and presents two main sedimentological units: the upper unit formed by contributions from the wall of the cave and the slope and the lower unit with a fluvial origin. They are rich in lithic and faunal remains and hearths. Lithic remains are the most abundant.

The faunal assemblages mainly consist of cervids (*Cervus elaphus*), equids (*Equus ferus*) and rhinoceros, besides some undetermined herbivores. In many cases, the high degree of fracturing and alteration prevented exact taxonomical identification. There is a predominance of long bone fragments of medium-sized animals (150–300 kg) (Rosell et al. 2000a; Menéndez et al. 2008).

Anthracological and palynological studies (Allué 2002; Llácer 2005) indicate the presence of a woodland area as well as a predominance of typical species from warm and humid environments in level P (*Pinus* sp., *Juniperus* sp. and *Ulmus* sp.). Various species of grasses and other taxa indicate the existence of river beds near the site. Towards the top of the sequence taxonomical diversity decreases and species associated with warm conditions appear.

Lithic Raw Materials

Prehistoric hominid groups that inhabited the Fuentes de San Cristóbal site certainly had knowledge about their lithological environment that included not only the rock types suitable for making artifacts, but also those unsuitable for artifact production. In order to assess the lithological diversity of their environment, we surveyed a series of Quaternary deposits, conglomerates and river terraces around the site. In the survey area, there are large conglomerate bodies of Paleogene age that intersect Pyrenean Paleozoic and Mesozoic formations in a north–south direction. These conglomerates are most abundant around the towns of Capella, Laguarres, and Beranúy. In Beranúy, the conglomerates show a yellowish-brown clayey matrix and contain limestone, quartzite, sandstone, lydian stone, and quartz pebbles. In Capella-Laguarres, they belong to the same geological formation and thus exhibit similar characteristics. Their matrix consists of reddish-brown sandy marls. The average size of the pebbles is 10–20 cm, although a few boulders were also documented. The latter belong to a red conglomerate formation of Permo-Trias age. They contain mainly limestone, quartzite, sandstone, lydian stone, and quartz pebbles, as well as occasional flint pebbles of approximately 5–10 cm. The surveyed river terraces belong to the Isábena and Ésera Rivers, and Rialbo stream (Figs. 18.3, 18.4 and 18.8). For sampling of the secondary deposits we counted the gravels present in these river surfaces of about 1 m^2. We collected all the data on pebble size (heterometry) (Krumbein 1941; Sneed and Folk 1958) and their lithology and recorded the qualities of the stone (e.g., toughness, internal fractures). This methodology provides the information on the provisioning possibilities in the secondary deposits.

At present, the Isábena River carries strongly rolled, well rounded pebbles and cobbles. Their sizes are between 430 and

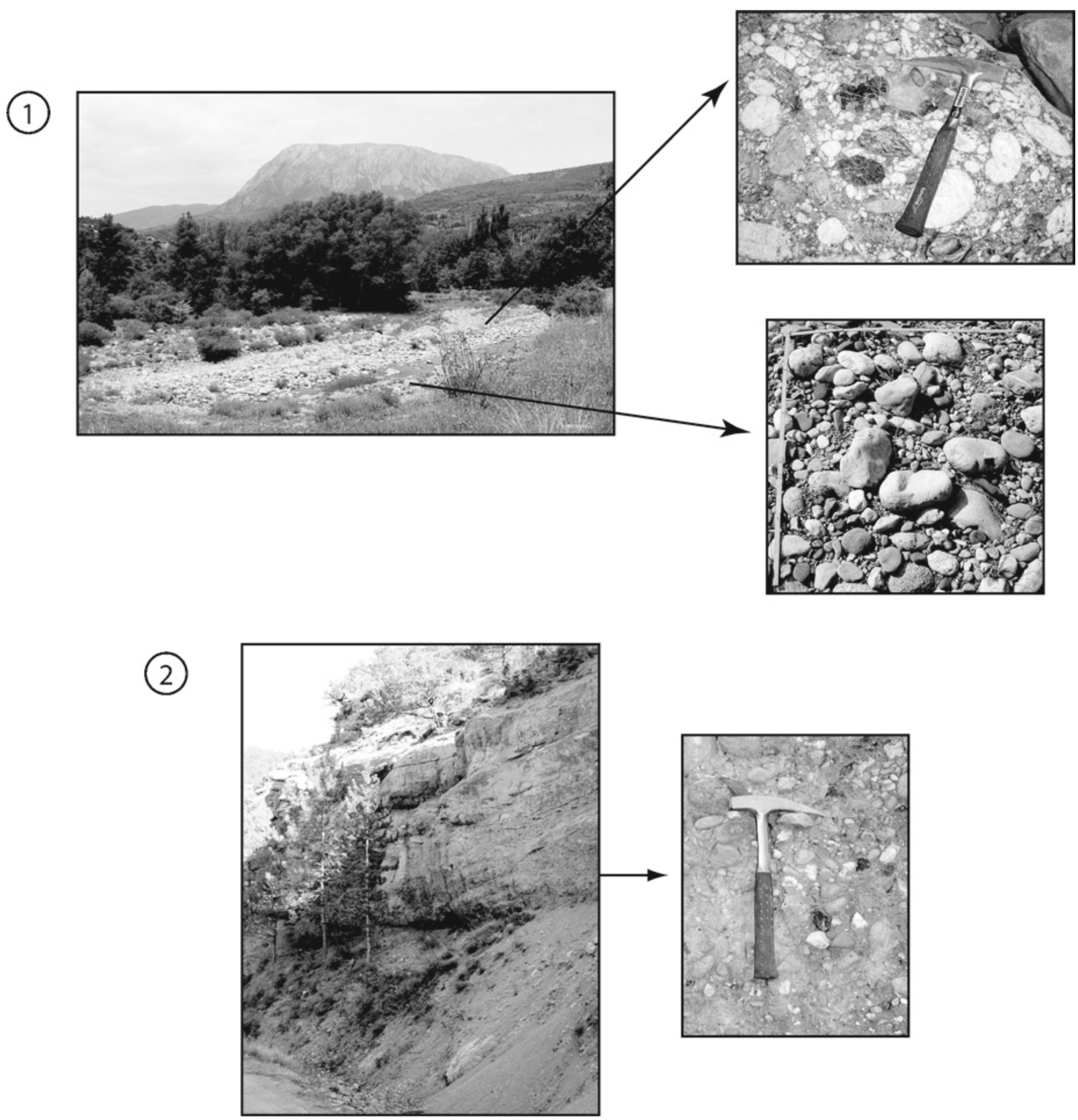

Fig. 18.3 Secondary raw material formations (*1*: Fluvial deposit; *2*: Conglomerate deposit)

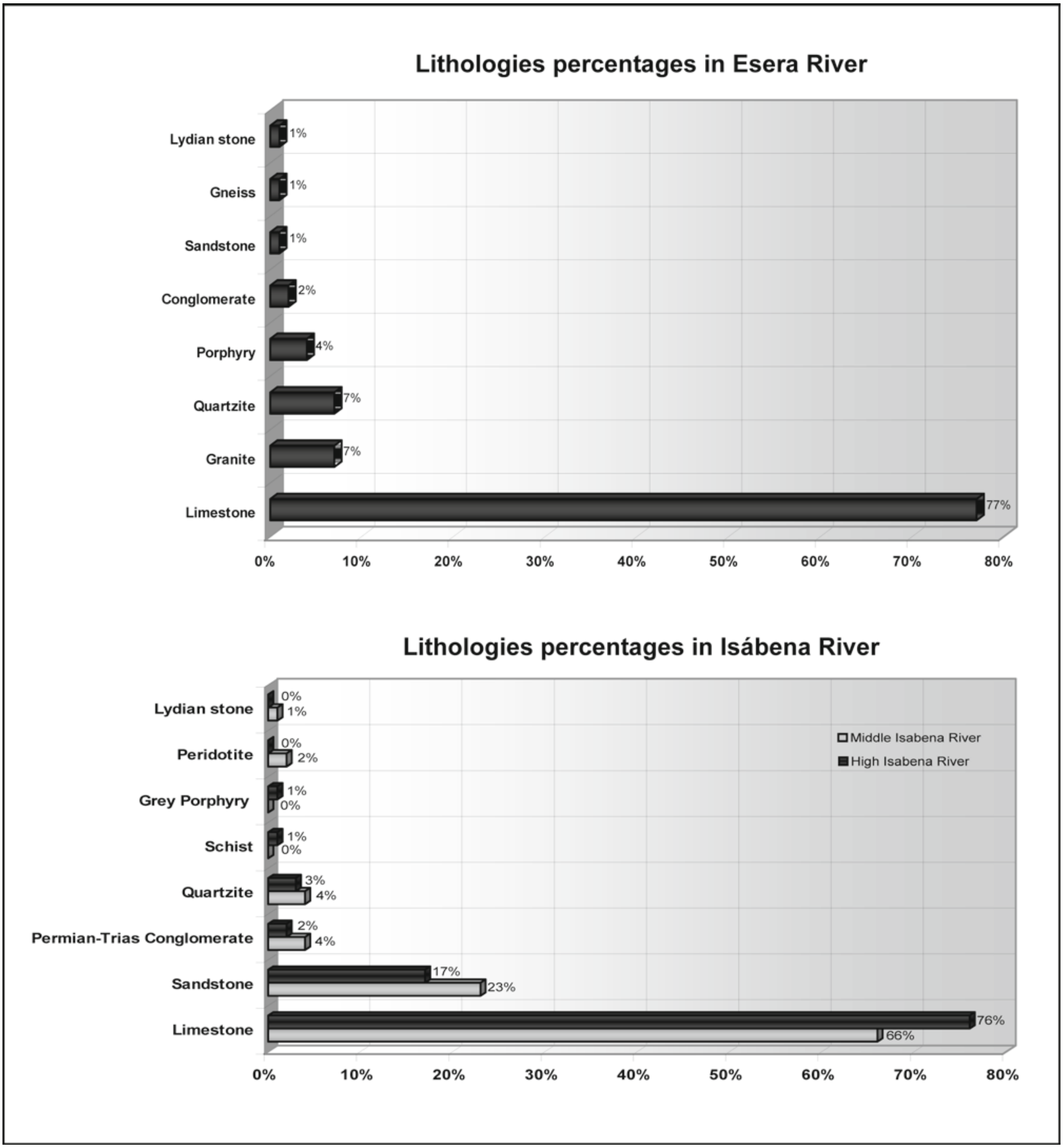

Fig. 18.4 Lithologies percentages in Esera and Isábena River

54 mm in length and 140 and10 mm in width. We analyzed a sample ($n = 100$) in the vicinity of the site. The prevailing lithologies were limestone (76%) and sandstone (17%), with small representation of other materials such as Pyrenean rock types; Permo-Trias conglomerates (2%), schist (1%) and peridotite (1%). A second sample ($n = 100$) was analyzed towards the mid course of the same river, near the town of Roda de Isábena. Here, the prevailing rock type was limestone (66%), and no flint was found. The rest of materials present include sandstone (23%) and Pyrenean rock types; red Permotrias conglomerates (4%), quartzite (4%), porphyry (2%) and lydian stone (1%) (Figs. 18.3 and 18.4).

We sampled the Ésera River terraces upstream, 1 km from its confluence with the Rialbo stream. At this location, the Ésera River deposits its entire load on the left bank. The cobble morphologies are also rounded and heavily rolled, and their sizes range between 370 and 70 mm in length and 150 and 12 mm in width. Similarly to the Isábena River, the prevailing lithology is limestone (77%), although here sandstone is only represented by a mere 1%. Other moderately represented rock types are quartzite (7%) and granite (7%), followed by porphyry (4%), conglomerate (2%), lydian stone (1%) and gneiss (1%). No traces of flint were found. Compared with the previous samples, we observed a decrease in the representation of sandstone and the appearance of materials such as granite and gneiss, which originated in the main batholith of the axial Pyrenees.

The Rialbo stream flows into the Ésera River near the town of Campo. We sampled its headwaters ($n=60$) in the vicinity of the town of St. Meura. We documented sub-rounded to rounded morphologies, with sizes between 260 and 72 mm in length and 120 and 20 mm in width. The load is composed basically of limestone (95%), with 3% quartzite and 2% sandstone. We did not find any flint. Nevertheless, a survey of the surroundings yielded two specimens of sub-angular flint clasts. Each of these represents a different variety of flint. One belongs to the Cretaceous variety of Égea, which will be described below. Its outcrop is located in the headwaters of the stream. We did not determine the origin of the second variety, which comprises an opaque and occasionally translucent, dark grayish blue flint with calcareous cortex and carbonate veins.

We identified two primary flint outcrops (Fig. 18.5); the oldest one belongs to the Mesozoic deposits of the inner

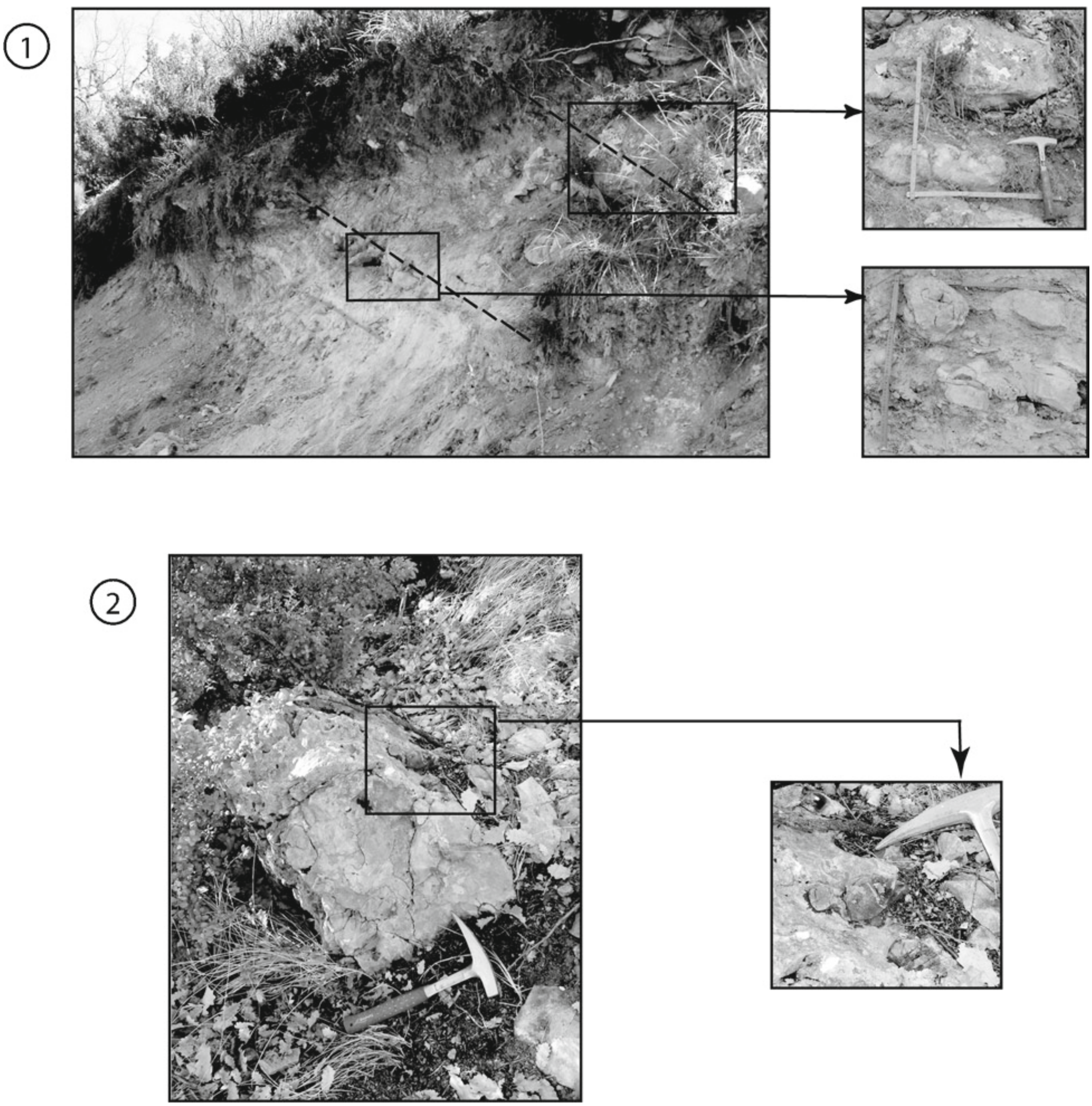

Fig. 18.5 Primary flint formations (*1*: Capella formation; *2*: Égea formation)

mountain ranges. It was detected in the vicinity of Égea, on the southwestern slope of the Turbón Massif, and also north-west of the site. The second outcrop, of Cenozoic age, was identified south of the town of Capella, which is southwest of the site.

Flint Formation of the Égea Cliff

The Égea cliff erodes some of the Cretaceous limestone formations of the Turbón Massif. West of the town of Égea we find a bed of santonien (Upper Cretaceous) marly limestone. These are micaceous, light gray, and contain gastropods (Fig. 18.5(2)) and also *Melobesidaceas*, *Briozoans* and *Lacazines* (Souquet 1967). The Égea flint appears as kidney shaped nodules 10–20 cm in size. They are either encased in the micaceous limestone, or have been eroded and are found lying on the surface. The latter exhibit fractured angular morphologies and maximum lengths of 15 cm. Flint color is 7.5 GY5.1 (greenish gray), homogeneous, fine-grained (microcrystalline) and alternates with bedrock limestone inclusions. The cortex is calcareous. Despite these features, this flint is not suitable for knapping due to an abundance of internal oxidized fracture planes that hamper proper flaking. It does not exhibit any surface chemical alteration. It is well represented among the cliff's colluvium, also appearing in the Rialbo River. It occurs in high numbers in level G of Las Fuentes de San Cristóbal site (Table 18.1).

Flint from Barranco de La Canal (Capella)

This area comprises several formations of Paleogene age, such as the Puy de Cinca formation, which contains siliceous strata. According to Garrido (1968, 1973), the marine-continental transitional formation that prevails in Puy de Cinca was eroded, hence absent, in the Capella area. However, *Nummulite* fossils found in the overlying stratum and in the flint-containing stratum indicate a marine origin. The existence of this formation possibly went undetected

Table 18.1 Level G lithic assemblage

	Structural categories						
Raw materials	Hammer-stones	Retouched artifacts	Cores	Flakes	Fragmented flakes	Fragments[a]	Total
Sandstone				20 (50)	12 (30)	8 (20)	40 (1.3)
Limestone	10 (3.1)	2 (0.6)	5 (1.5)	111 (33.9)	85 (26)	114 (34.9)	327 (10.9)
Quartzite (grey)		1 (0.3)	2 (1.5)	63 (46.7)	36 (26.7)	33 (24.4)	135 (4.5)
Quartzite (red)		1 (2.6)		20 (52.6)	6 (15.8)	11 (28.9)	38 (1.3)
Quartz			1 (20)		1 (20)	3 (60)	5 (0.2)
Lydian stone		1 (20)				4 (80)	5 (0.2)
Porphyry (grey)		3 (4.8)	1 (1.6)	27 (42.9)	16 (25.4)	16 (25.4)	63 (2.1)
Porphyry (green)				18 (60)	4 (13.3)	8 (26.7)	30 (1)
Porphyry (pink)	2 (1.8)		2 (1.8)	40 (36.7)	36 (33)	29 (26.6)	109 (3.6)
Peridotite				1 (100)			1 (0.03)
Flint 1[b]		49 (2.4)	23 (1.1)	776 (38.5)	516 (25.6)	651 (32.3)	2,015 (67.4)
Flint 2[c]		10 (4.5)	1 (0.5)	94 (42.5)	70 (31.7)	46 (20.8)	221 (7.4)
TOTAL	12 (.4)	67 (2.2)	35 (1.2)	1,170 (39.1)	782 (26.2)	923 (30.9)	2,989

Values in parentheses are percentages
[a] Flake fragments, angular fragments and all the fragments that are impossible to introduce in another structural category
[b] Égea and Capella flint: quartz microcrystalline texture
[c] Rialbo flint: quartz microcrystalline texture with black crystal inclusions

due to the fact that the layer is very thin in this area, and is also covered by a well presented conglomerate formation, the Escanilla-Campodarbe formation (Soler-Sampere and Puigdefabregas 1970). The Capella flint was identified on the Cerro de La Canal hill, at 648 m above sea level. It was found in a marly stratum containing *Nummulites* fossils on top of which one finds the siliceous beds. The basal layer contains flint of nodular morphologies and variable sizes between 0 and 10 cm; the second layer is located at roughly 0.5 m over the previous one and contains meter-sized flint blocks (Fig. 18.5(1)). Underneath this stratum we observed the type sequence of the Capella formation, comprising marly clays and bluish marls lacking fossils. In contact with the siliceous layer, we identified the so called Grustau limestones of the Puy de Cinca formation. The presence of Capella formation strata and of Grustau limestones corroborates the stratigraphic position of the flint beds (Soler-Sampere and Puigdefabregas 1970).

The Capella flint is translucent, its color is 5BG 5/1 (bluish gray) with occasional pink shades; 5R 4/1 (dark reddish gray), or light brown hues 5Y 7/6 (yellow). Its cortex is calcareous, not thicker than 1–2 mm. The flint nodules are kidney-shaped and some of them exhibit internal fracture planes, geodes or microfossils. Overall, the suitability for knapping is better than for the Égea flint. Some chemical alterations were identified, including white patina (also documented in archeological specimens). Level G contains only few specimens on this flint variety.

Both, the La Canal and Égea flint types entail some degree of mobility for their procurement. The secondary deposits near the site do not contain flint. The exception is the Rialbo stream, although in this case the nearest primary outcrop is located at 9 km from the site (Fig. 18.3(1)). From the site towards the west, another passage linking the Isábena and Ésera basins possibly represents a corridor crossed by human groups during hunting seasons. It comprises a mid-altitude marly zone with active streams flowing into the Isábena and Ésera Rivers. The water divide is located near the town of Égea (Fig. 18.8). Although few archeological artifacts on La Canal type flint have been recovered, its transport to the Fuentes de San Cristóbal site is evident. The outcrops are located around 24 km from the site, in the lower course of the Isábena River. Its downstream position is an indirect sign of the degree of mobility of the human groups, as is the fact that this variety of flint is not present in any of the secondary deposits near the site. The closest zone to the site in which we can find the Puy de Cinca formation is the Capella area, and therefore this area was possibly frequented by the human groups. If flint was not procured at its original formation, it could have been obtained from the nearby colluvium, which contains angular clasts, or from the Isábena river terrace at a point upstream from its confluence with the Esera River (Fig. 18.8). Perhaps bringing La Canal formation flint blanks into the site was not the choice of the human groups despite of its better quality for knapping when compared with the Égea variety. Regarding the other materials, limestone prevails, probably due to its high representation in the surrounding lithological environment. The close tie between the limestone bedrock and the Égea flint highlights the role of limestone, as it must be removed from the flint blank before it can be exploited. Finally, regarding the hammerstones found at the site, which are made on porphyry, their well rounded morphologies suggest that they were collected at the river terraces. Their matching rock types have been identified in the Isábena and Ésera deposits.

Level G Lithic Industry

Only lithic assemblages from level G have been studied in detail as a part of a Master thesis in Prehistory (DEA) (Menéndez 2005a, b, 2006; Menéndez et al. 2008, 2009). Among the main difficulties arising from this type of rescue excavations was the limited time available before the end of the road work projects in 2002. It was decided to select a representative sample of the pieces found during the last year of excavation. We have to point out that the lithic assemblage selected for this study has been recorded in the entire archeological surface and in association with hearths and faunal remains. For the morphotechnical analysis we selected all pieces with exact 3D positioning and a sample of other lithic material collected by squares of 25 cm. The total of lithics from this level reaches 4,440 pieces, of which 2,986 were sampled. After discarding pieces with a length smaller than 2 cm the sample for the morphotechnical analysis comprised a total of 2,199.

The most well represented raw material in level G (Table 18.1) is flint, followed by limestone, porphyry, quartzite and sandstone, and very few pieces of lydian stone and quartz. Two modalities of introduction of raw materials into the site were identified. The first one concerns limestone, porphyry and quartzite, which were introduced in the form of unmodified pebbles. All of the stages of the reduction sequences on these pebbles took place in the shelter. The second modality concerns flint, which was introduced into the site in the form of flakes to be exploited as cores or in the form of cores in the first stages of the reductions sequence. Therefore the initial stages of cortex removal were carried out before the introduction into the site, in the areas where raw material was collected. The small amount of sandstone, lydian stone and quartz, illustrates the sporadic introduction of preformed objects (flakes or retouched tools) and could indicate intentional avoidance of rocks with bad knapping aptitude. These different modalities of importation identified in level G show the spatial and chronological separation of different parts of the operational chains of lithic production.

To define the quality of raw materials in relation to reduction sequences, four categories of rocks have been distinguished based on knapping suitability (considering physical characteristics of each type): *bad* (not suitable for knapping: presence of microfractures, not very strong and cutting edges, oxidations, impurities, angular fractures, etc.), *acceptable* (microfractures, oxidations, etc., but with a quality that allows to generate relatively sharp and tough edges), *good* (good physical characteristics that allow the generation of sharp and strong edges, conchoidal fracture or a limited presence of fracture planes, impurities, oxidations, etc.), and *very good* (excellent conchoidal fracture).

From the structural categories point of view an absolute predominance of knapping products is observed, with more than 90%. It demonstrates that knapping strategies were essentially oriented to the systematic production of flakes. Cores and retouched tools are rare (Table 18.1). The number of hammers recorded is 12–2 on porphyry and 10 on limestone. The selection of these pieces as hammers is probably directly related to their morphology and hardness, especially the type 3 porphyry hammers (pink porphyry), a rock very resistant to percussion. These two pieces have small dimensions, which could indicate their use to retouch tools (*retouchoir*). However, concretions do not allow us to observe percussion marks and to demonstrate this use. The number of cores is 35, 11 of them were broken and could not be completely analyzed from the morphotechnical point of view. The majority of cores are on flint or sandstone. Lydian stone cores have not been found. A predominance of cores at the final stage of the knapping sequence has been identified. Only in the case of some limestone and porphyry cores the early stages of the reduction sequences and at the exploitation stages have been recognized. We have observed a low degree of cortex, with a predominance of cores without cortex. The low percentage of cortex, the high degree of reduction together with the fact that a high proportion of pieces have flakes as knapping supports (more pebbles and cores) show an intended optimal economy of raw materials (Geneste 1988, 1989, 1991).

Among the identified knapping methods the discoid method dominates, followed by the multifacial multipolar method related to the high degree of reduction mentioned above (Fig. 18.6). It is also important to take into account that maximum exploitation of raw materials would lead to changes in core morphology: certain cores which initially had typical characteristics of the discoid method would finally display varied morphologies due to the intensive use of all potential surfaces to pursue the exploitation. The identification of the discoid method in the lithic set depends on the volumetric conception of the core. Discoid cores present two equivalent, convex surfaces which are separated by one plane of intersection. Both surfaces are used as striking platform as well as exploitation surface. The detachment planes of the knapping products are intersecting. The morphology of the core is usually pyramidal or bipyramidal in relation to the intersection plane of the two surfaces (Boëda 1993). It is also necessary to indicate the presence of two cores whose attribution to the discoid method has raised many doubts because their morphotechnical characteristics are closer to the Levallois method (Boëda 1993, 1994). Differential treatments in the knapping methods depending on the quality of the raw material are also visible. Discoid cores are always made in flint and porphyry, whereas more expeditious schemes like longitudinal ones are only identified on limestone and quartzite. Those raw materials can be found from sources located only few meters in front of the deposit and their aptitudes for knapping are not very good.

Knapping products are the most represented structural categories in the lithic assemblage (Table 18.1; Fig. 18.7b). Among the 1,170 sampled pieces, only those with length higher than 2 cm were analyzed. Backed flakes percentage is high (28.32%). The abundance of this kind of products is usually associated with discoid methods, but even other knapping methods like the Levallois centripetal recurrent method, can also produce a high number of such pieces during the reduction sequence (Terradas 2003). The degree of cortex on knapping products is very low or almost non-existent, mainly in the case of flint. Dimensions show an abundance of medium (800–1600 mm^2) and mainly small sized (<800 mm^2) products. Large sized flakes (>1600 mm^2) were identified only in limestone, porphyry and sandstone. This could be related to the kind of supports used to obtain these products. In the case of flint, most of the supports are small nodules and essentially flakes. On the contrary, for other rocks, supports were mainly pebbles of large dimensions. Finally, the typometric index shows a small proportion of laminar products (6.6%) and a low index of thickness, pointing out that flakes are not very thick.

Retouched tools are very rare in level G (Table 18.1). They have all knapping products as support and are essentially made on flint (Fig. 18.7a and c). Retouch is usually laterally positioned, although retouched transversal edges are also significant. Retouch is mainly unifacial, direct, with semi abrupt angles; it does not affect more than 25% of the edge and does not modify the general morphology of the tool. From the morphotechnical point of view there are no significant differences between unmodified and retouched flakes. The biggest and thickest flakes were selected to be retouched. The indexes for elongation and thickness are higher than in the non retouched knapping products. The denticulate group dominates with 31.34% for denticulated side-scrapers and 25.37% for marginal denticulates. The presence of

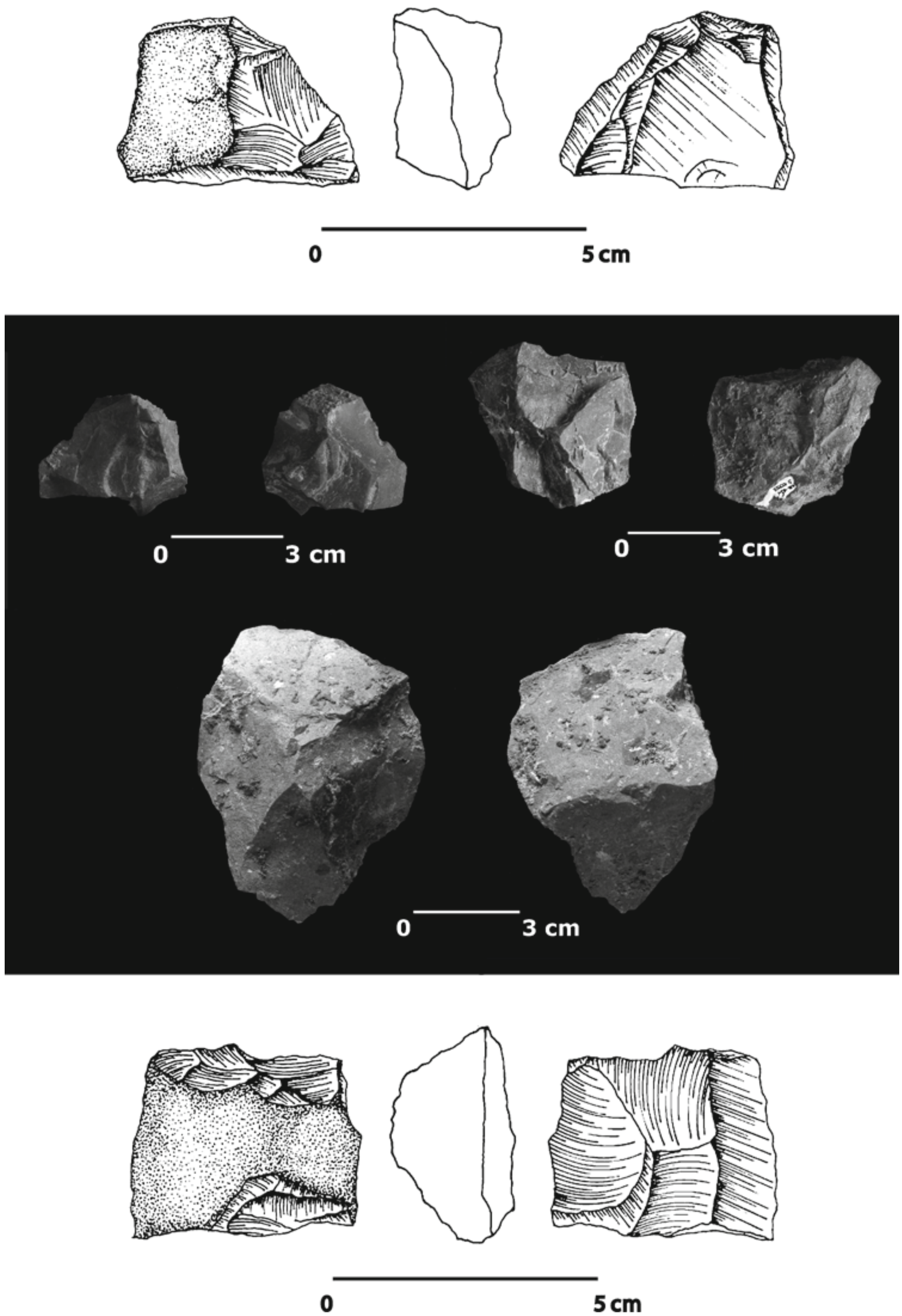

Fig. 18.6 Examples of cores from Level G

some marginal side-scrapers is also observed with 13.34% (Fig. 18.7a). It is necessary to indicate the existence of a nosed end-scraper and two simple frontal ones (Fig. 18.7c). This kind of tool is usually associated to more recent Upper Paleolithic industries (Bordes 1961). Nonetheless, considering the existence of some retouched tools typical of more modern chronologies, the morpho-technical characteristics obtained for the level G lithic industry (Menéndez 2005a, 2005b, 2006; Menéndez et al. 2008, 2009) allows us to place this assemblage within the typical Middle Paleolithic strategies of knapping as in other archeological sites (Terradas et al. 1993; Maroto 1994; Jordá et al. 1994; Maroto et al. 1996; Vaquero 1999a, b; Mora et al. 1992, 2004, 2008; Martínez-Moreno et al. 2004, 2010; Martínez et al. Martínez et al. 2005; Casanova et al. 2009).

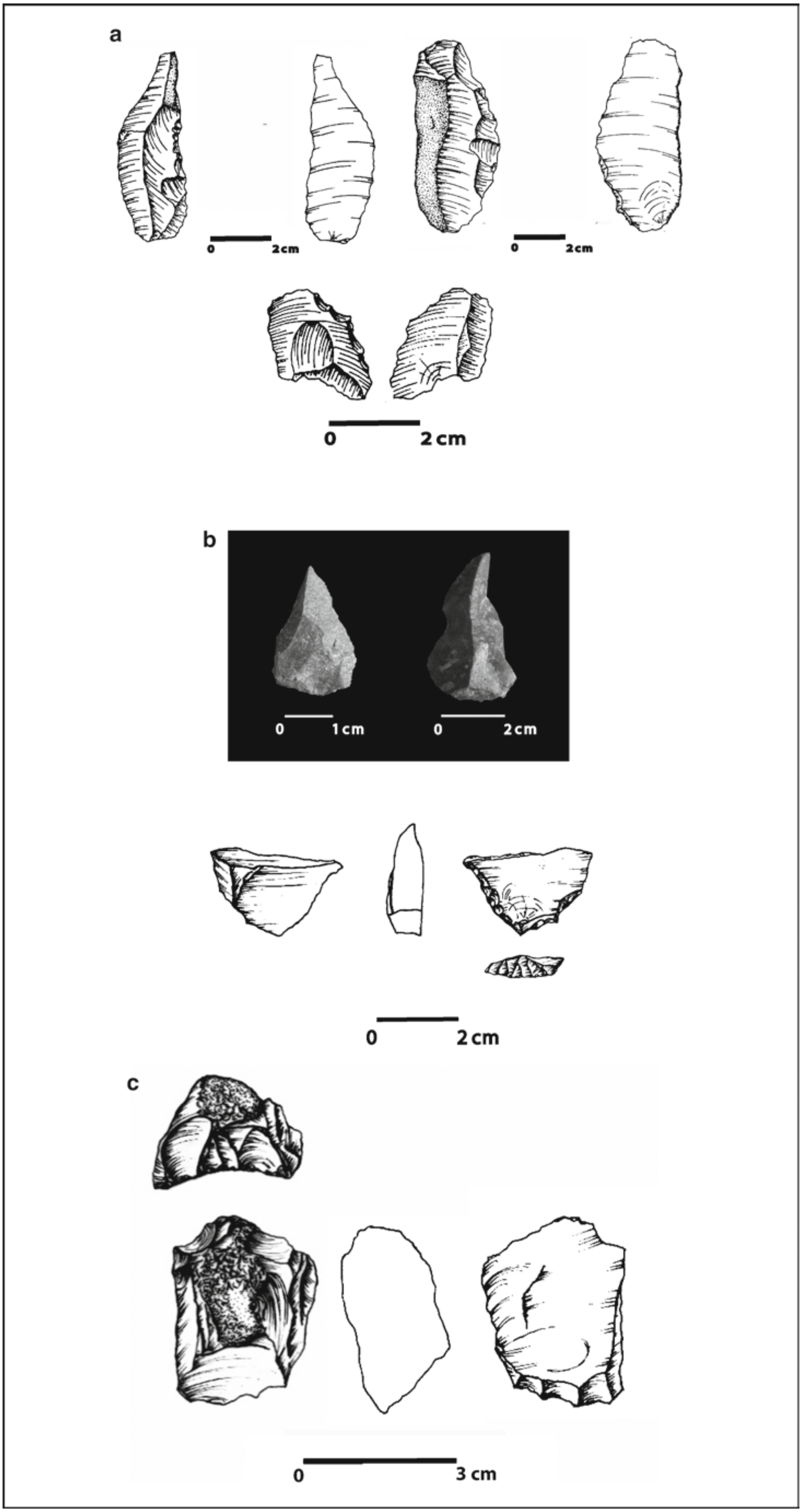

Fig. 18.7 Level G lithic industry (*a*: denticulates; *b*: flakes; *c*: end-scrapers)

Fig. 18.8 Location map of the potential raw material resources

Discussion and Conclusion

The hominin groups that dwelled in the Las Fuentes de San Cristóbal archeological site exploited local and semi-local raw materials (Geneste 1988). The exploitation of mainly semi-local raw material has been identified and this is an important indicator of true mobility in the territory. The local provisioning mainly focused on pebbles of fluvial origin, collected in the Isábena terraces close to the site. Those terraces contain porphyry, quartzites and limestones, but not flint (only occasionally lidyan stone). The case of limestones is different, because a large proportion discovered at the site have their origin in the Égea flint *chaîne opératoire*. The close connection between the limestone bedrock and the Égea flint imply that limestone must have been removed from the flint blank before it could have been exploited. For this reason their origin is also semi-local. Apart of this specific kind of limestone, the semi-local raw materials are only flint. This includes the two identified types. Both, the La Canal and Égea flint types, entail some degree of mobility for their procurement. The secondary deposits near the site do not contain flint. The exception is the Rialbo stream, but there is a closer primary outcrop (Égea) which is located at 9 km from the site (Fig. 18.8).

The Égea flint is a very frequently used raw material. The cores of this kind of raw material tend to be exhausted and they predominate in the lithic assemblages. Their presence is not accidental. It is evidence for a provisioning strategy and a thorough knowledge of the geographic environment and the lithic resources. The other semi-local stone is the Capella flint, but it is very scarce in the lithic assemblage. It is the raw material used that occurs the furthest from the site. Therefore a predetermined strategy exists which was focused on a provisioning territory of about 24 km radius. Two intersecting circulation axis have been differentiated based on the locations where the two semi-local kinds of flint were in primary position. The first circulation axis has a northeast-southwest direction following the Isábena valley. The direction of the second one is northwest-southeast following the Villacarlí stream which is connected with the Rialbo valley. This axis links the Isábena and Ésera basins. It possibly represented a corridor (*Campo corridor*) crossed by human groups during hunting seasons. It comprises a mid-altitude marly zone with active streams flowing into the Isábena and Ésera rivers. The watershed is located near the town of Égea (Fig. 18.8). The animal resources exploited (Rosell et al. 2000b) in level G are related to the steppic woodland with a predominance of *Pinus* sp. and *Juniperus* sp. (Llácer 2005). This fact describes a mobility pattern adapted to obtain several subsistence resources at the same time. In this way, it is possible to economize energy during the group movement (Morala and Turq, 1990, 2000). This behavior has been observed in other seasonality short-term occupations, for example in Abric Romaní level I (Vallverdú et al. 2005). According to the "embedded procurement theory" (Binford 1982) the direct procurement of raw materials is related to the daily subsistence activities and lead to define the exploited territories. This kind of mobility has been described in the Haut-Agenais (Aquitanian basin) Mousterian sites (Turq 1988). The Campo corridor (Fig. 18.8) seems to be the most frequented area by the human groups that dwelled in the Las Fuentes de San Cristóbal site. It is possible that the Capella flint shows the initial mobility of the group going upstream along the Isábena River to follow the animal migratory influxes. This provisioning territory shows a limited raw material circulation similar to other Western European Middle Paleolithic sites as Grotte Vaufrey, VII and VIII levels (Geneste 1988; Féblot-Augustins 1997).

Before raising the issue of the interpretation of the lithic assemblage we have to emphasize that a part of the site (exterior part) was damaged, but that all the lithic assemblages studied come from the remainder of the total surface of the level and is associated with hearths and faunal remains. We also have to point out that in sites of this chronology, for example Abric Romaní (Vaquero 1999a; Vallverdú et al. 2005; Martínez et al. 2005), Tor Faraj (Henry 1998; Henry et al. 2004), Roca dels Bous (Martínez-Moreno et al. 2004; Mora et al. 2008), the archeological remains are normally more abundant in the interior zones than in level G. Taking this into account the result of the level G lithic technological study has permitted the inclusion of the lithic assemblages in the classical Mousterian. The general characteristics of the lithic assemblage show that the discoidal method is the main knapping method used, although there are two cores which could be attributed to the Levallois methods (Boëda 1993, 1994). The retouched tools are essentially denticulates as well as some side-scrapers and end-scrapers.

To contextualize the level G lithic assemblages in the Upper Pleistocene of the north-eastern Iberian Peninsula, we have undertaken a comparison with sites located in two different areas:

1. Hydrographic Ebro basin (until now all the comparisons were only made with the sites located in this area)
2. Middle Pre-Pyrenees depressions (mountainous area)

The study of the Ebro basin Mousterian lithic assemblages from Gabasa, Fuente del Trucho or Peña Miel (Utrilla 1992, 2000; Balldellou 2001; Utrilla and Montes 1996; Blasco et al. 1996; Montes 1988; Montes et al. 2001) shows that the preferential knapping methods employed are discoid and "formless" cores (cores in the final stage of reduction with a maximal exploitation of all the surfaces). The Levallois method is rarely present. The number of facetted butts is very low in most of the cases. This fact is maybe related with a non-existence of predetermination. Authors do not have the same concept of this knapping method. Some of them (e.g., Montes 1988) consider that the "real Levallois" method would be the one involving only one single preferential flake. Consequently, the same colleagues would classify recurrent, centripetal schemes within the Levallois concept (in our sense) as "discoid". Therefore, they encounter problems in distinguishing the discoid (in our sense) from the Levallois methods (in our sense).

Regarding retouched tools we have to point out the predominance of side-scrapers, with a very high percentage of Quina retouch and *retouche scalariforme* in general. Denticulates are not a representative type within the Mousterian lithic assemblages in this geographical area. Considering these characteristics, we observe certain similarities and differences between these sites and Las Fuentes de San Cristóbal (Menéndez 2005a, b). The importance of Levallois method is relatively low in all the sites whereas the discoid one would have been the preferred knapping method. In most of the sites we observe an optimal exploitation of flint, as well as the local or semi-local collecting areas as in Las Fuentes de San Cristóbal. This pattern is confirmed by the small percentage of cortex, the small size of cores and the presence of a high number of cores on flakes in most of these archeological sites. The percentage of retouched tools is low in all the sites. However, we find significant differences in the percentages of retouched tool types. In the Ebro sites, side-scrapers are the most important type (Quina), while in Las Fuentes de San Cristóbal, denticulates are the predominant type. The raw material management, the territory mobility, and the lithic technology show that Las Fuentes de San Cristóbal has a pattern more similar to the middle Pre-Pyrenees depression sites (second geographical area) for example Roca dels Bous, Estret de Tragó, Cova 120, Cova Gran, Ermitons, L´Arbreda and Abric Romaní (Casanova et al. 2009; Mora et al. 1992, 2004, 2008; Terradas et al. 1993; Jordá et al. 1994; Terradas and Rueda 1998; Morant and García-Antón 2000; Vaquero 1999a, b; Martínez-Moreno et al. 1994, 2004, 2010; Martínez et al. 2005; Casanova et al. 2009). We observe in all the sites the presence of discoidal and Levallois methods and the importance of denticulates. However, in L´Arbreda, Abric Romaní, Cova 120 or Roca des Bous, the discoidal method is predominant. Nowadays, there are few specific studies about raw material procurement and management in both areas, so it is difficult to undertake regional studies as it occur in other European geographical areas (Turq 2000; Tarriño 2001; Bernard-Guelle 2002; Slimak et al. 2005; Fernándes et al. 2006). Therefore Las Fuentes de San Cristóbal archeological site share some similarities and differences with the two geographical areas described. The evidence from Las Fuentes de San Cristóbal archeological site supports the idea that the human occupation of the pre-Pyrenean valleys, during the Middle Paleolithic, would have been quite intense. This idea is confirmed by the existence of other similar chronological and cultural sites found in this area such as the sites cited above.

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Part V
Cultural Adaptation Among the Last Neanderthals

Chapter 19
The Demise of the Neanderthal Cultural Niche and the Beginning of the Upper Paleolithic in Southwestern Germany

Nicholas J. Conard

Abstract The karst landscape of the Swabian Jura of southwestern Germany preserves an unusually complete record of Paleolithic prehistory. Many caves in the region contain evidence for Middle Paleolithic occupations. These find horizons are usually classified as belonging to the Swabian Mousterian. The find densities of lithic artifacts and anthropogenically modified fauna are typically low. Roughly 40 ka, the Upper Paleolithic began with the Aurignacian, which corresponds to the time of the arrival of modern humans in the region. At several key sites, Aurignacian find horizons overlie sterile geogenic deposits, and nowhere are Middle Paleolithic and Upper Paleolithic deposits interstratified. The material culture of the Aurignacian is characterized by numerous new forms of lithic and organic artifacts and much higher find densities than those usually documented in the Middle Paleolithic. While the resources used in both the Middle and Upper Paleolithic reflect a degree of continuity, the overall picture indicates that the start of the Upper Paleolithic represents a radical break in the history of settlement in southwestern Germany. With the arrival of modern humans in Eurasia, the cultural niche of Neanderthals was no longer viable. Rather than drastically changing their social and cultural patterns of behavior, Neanderthals may have been locked into their systems of behavior that had served them well in numerous contexts over millennia.

Keywords Neanderthals • Modern humans • Extinction • Technology • Subsistence • Symbolic artifacts

Introduction

The history of Paleolithic research in the Swabian Jura of southwestern Germany extends back to the 1860s with the work of Oscar Fraas at Schußenquelle and at Bärenhöhle in the Lone Valley (Müller-Beck 1983; Conard and Bolus 2006). In the decades following this pioneering research, Paleolithic archaeologists and Quaternary scientists continued excavations in the caves of the Swabian Jura. Subsequently, multiple generations of researchers, mostly based at the University of Tübingen, have conducted systematic excavations in the Swabian caves. The most important excavations have focused on the caves of the Ach Valley 15 km west of Ulm between Schelklingen and Blaubeuren and the Lone Valley 25 km north of Ulm (Fig. 19.1).

This long tradition of research and the presence of data from multiple well-studied sites provide the basis for a reconstruction of the events associated with the end of the Middle Paleolithic and the start of the Upper Paleolithic. The celebration of the sesquicentennial of the discovery of the original Neanderthal remains in 1856 provides an opportunity to examine the processes that accompanied the end of the Middle and the beginning of the Upper Paleolithic in Swabia. This paper builds on ideas discussed in recent papers on this topic and provides new data from ongoing fieldwork in the Ach and Lone Valleys (Conard and Bolus 2003; Conard et al. 2006; Bolus and Conard 2009). Based on limited local data and assumptions founded on results from other regions, researchers usually assume Neanderthals produced the region's Middle Paleolithic assemblages, while modern humans produced the region's Upper Paleolithic assemblages. While the caves of Swabia preserve a wide range of archaeological materials, they rarely contain human bones. Given the excellent organic preservation of faunal remains from the caves, we can be certain that neither the local Neanderthals nor modern humans regularly buried or otherwise disposed of their dead in these caves. Excavations at Hohlenstein-Stadel recovered a Neanderthal femur with both proximal and distal ends destroyed by carnivores in Mousterian deposits (Völzing 1938; Kunter and Wahl 1992). The rare finds of human skeletal remains from the Aurignacian, the first Upper Paleolithic cultural group in the region, are highly fragmentary and non-diagnostic (Czarnetzki 1983; Conard and Bolus 2003). Recent radiocarbon dating has shown that the human bones from Vogelherd, which were long

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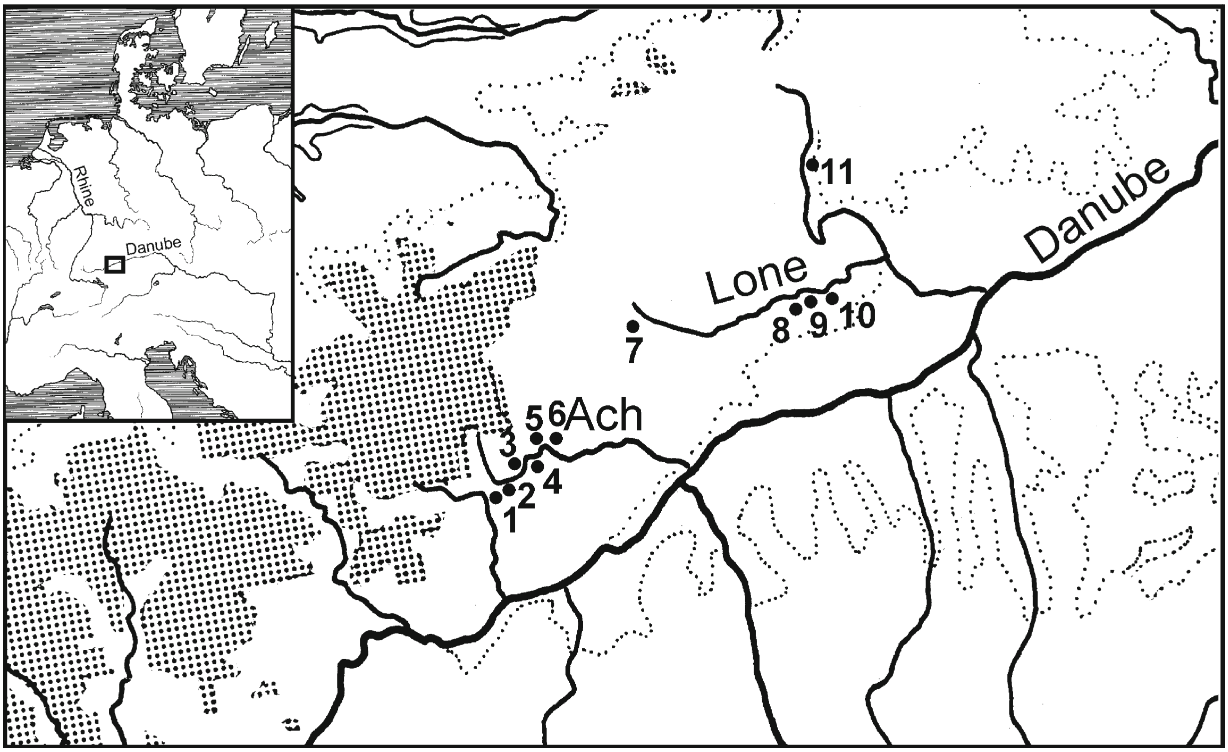

Fig. 19.1 Map showing the major Middle Paleolithic and Aurignacian sites in the Swabian Jura. *1*: Kogelstein; *2*: Hohle Fels; *3*: Sirgenstein; *4*: Geißenklösterle; *5*: Brillenhöhle; *6*: Große Grotte; *7*: Haldenstein; *8*: Bockstein (Bockstein-Höhle, Bocksteinloch, Bocksteinschmiede, and Bockstein-Törle); *9*: Hohlenstein (Stadel and Bärenhöhle); *10*: Vogelherd; *11*: Heidenschmiede

considered to originate from the site's rich Aurignacian deposits (Riek 1934), actually date to the Neolithic and have no direct relevance for Paleolithic research (Conard et al. 2004a). This paper examines the Middle Paleolithic record in the Swabian Jura in relation to the Aurignacian with the goal of developing culturally-based explanations for the extinction of Neanderthals. While anatomical and biological differences separated Neanderthals and modern humans, the causes of Neanderthal extinction may have lain as much in the realm of cultural adaptations than in the area of "hard-wired" biological or cognitive differences between the two taxa.

Paleoenvironments

The events associated with the spread of modern humans across Europe and the extinction of Neanderthals took place in the volatile environmental context of Marine Isotope Stage (MIS) 3. Numerous marine and terrestrial records from around the world demonstrate that major climatic oscillations characterize this period dating to between ca. 60 and 25 ka BP (Heinrich 1988; Dansgaard et al. 1993; Severinghaus et al. 2009). In Swabia, as in most parts of the world, the study of the causal relationships between past environments and human biological and cultural evolution suffers from a lack of well-dated, high resolution archaeological and paleoenvironmental data. The best environmental archives for the climates and environments of MIS 3, such as low energy lacustrine deposits, are not the places in the landscape where archaeological materials are typically recovered. In the Swabian case, nearly all of the archaeological record for the Middle and Upper Paleolithic comes from cave deposits, which normally lack high resolution microstratigraphic units. Faunal preservation is usually excellent in the calcium carbonate-rich deposits of clay, silt and limestone rubble. Flora in the form of charcoal and pollen is also preserved in these cave sediments (Riehl 1999). Thus the raw materials for environmental reconstructions are often preserved in abundance in the Swabian caves.

The problem for such reconstructions lies typically in the taphonomic and stratigraphic contexts of these materials. As Hahn (1988) demonstrated in his monograph on Geißenklösterle using refitting and multiple lines of taphonomic arguments, the rates of sedimentation in the caves usually are too slow to isolate individual occupations at the sites. Bioturbation, most notably from cave bears, can lead to the movement and redeposition of sediments and the archaeological finds they contain. Cultural processes can also lead to redeposition (Hahn 1988; Schiegl et al. 2003), and numerous geological processes including erosion, downslope creep and freezing and thawing can damage the stratigraphic context of find horizons (Hahn 2000; Scheer 2000; Goldberg et al. 2003). This situation is exacerbated by the nearly ubiquitous presence of decimeter-sized limestone clasts that hinder researchers in identifying microstratigraphic units and high resolution archaeological events. Although a wealth of environmental data are available (Waiblinger 2001; Conard et al. 2006), we still have problems generating reliable interpretations of how past environments affected the settlement history of the region. This problem comes in part from uneven nature of the sedimentary deposition and the many taphonomic processes mentioned above that hinder the recognition of clear climatic signals. This situation is made more complicated by stratigraphic disconformities documented between the late Middle Paleolithic and the earliest Aurignacian deposits at Geißenklösterle (Conard et al. 2003a; Goldberg and Conard, In press). The observations from Geißenklösterle suggest that the earliest Aurignacian at the site correlates with a cool climatic phase characterized by the deposition of aeolian loess. At present we are awaiting additional paleoenvironmental results from Geißenklösterle and from Hohle Fels, where preliminary results indicate a more complete record of the change from the Middle to the Upper Paleolithic.

Chronostratigraphy

The caves of the Swabian Jura are among the best studied sites in Europe. The chronostratigraphy of these caves has played a prominent role in the debate about the age and cultural context of the early Aurignacian and the late Middle Paleolithic (Hahn 1995; Housley et al. 1997; Richter et al. 2000; Zilhão and d'Errico 1999, 2003b; Conard and Bolus 2003, 2008). While fewer absolute dates are available for the Middle Paleolithic find horizons, many dozens of radiocarbon and several TL dates have been published for the Aurignacian find horizons in the region. The late Middle Paleolithic deposits at Geißenklösterle have been dated with ESR to ca. 43 ka BP (Richter et al. 2000). Over a dozen radiocarbon dates from the Middle Paleolithic layers at Geißenklösterle fall between 42 and 33 ka BP (Conard and Bolus 2003, 2008). All of these dates, unless otherwise stated, are uncalibrated radiocarbon ages. The other relevant absolute dates include ten radiocarbon dates from the Middle Paleolithic deposits at Hohle Fels. These dates fall between 40 and 33 ka BP. Most of the radiocarbon dates are on bone collagen measured at the Leibniz Laboratory in Kiel and the radiocarbon Laboratory at Oxford. At Geißenklösterle the dates do not show a clear pattern of increasing age with depth, and chronological inversions are clearly present in the sequence. The cause of these inversions could relate to variations in atmospheric radiocarbon (Beck et al. 2001; Conard and Bolus 2003; Hughen et al. 2004; Giaccio et al. 2006), to taphonomic disturbances at the sites, or to problems with sample preparation (Brock et al. 2007; Hüls et al. 2007), and imperfect reproducibility of measurements. In general these radiocarbon dates lie at the limit of method and should be treated with caution.

The age of the Swabian Aurignacian has been placed under intense scrutiny in connection with the debate over possible acculturation of Neanderthals by incoming populations of modern humans (Richter et al. 2000; Zilhão and d'Errico 1999, 2003b; Conard and Bolus 2003, 2008; Teyssandier et al. 2006). The best studied sites are Geißenklösterle and Hohle Fels, where over 30 radiocarbon dates for the Aurignacian of each site have been published. The radiocarbon dates from these sites and many other dates from the caves of the Ach and Lone Valleys range between 40 and 30 ka BP, with the ages between 30 and 35 ka BP being more common than the earlier dates. Given the many obvious problems obtaining reliable and reproducible radiocarbon dates, the excavation teams at Geißenklösterle and Hohle Fels have gone to great lengths to establish the best possible stratigraphic data to help limit our dependence on the noisy radiocarbon signals, and where possible have used independent dating methods. Numerous studies show that radiocarbon dates in this range significantly underestimate the actual age of samples due to the presence of unusually high levels of atmospheric radiocarbon. Estimates of the extent of this dating off-set vary greatly, but can fall in the range of one or even more radiocarbon half-lives (Conard and Bolus 2003; Giaccio et al. 2006; Weninger and Jöris 2008 and references therein). Taken at face value, TL dates on burnt flints from the lower and upper Aurignacian at Geißenklösterle reflect ages of roughly 40 and 37 ka BP (Richter et al. 2000). These ages are consistent with the generally younger radiocarbon ages when we consider that the radiocarbon system leads to underestimates of the true age of samples in this time range. The specific ages of the Aurignacian strata from Swabian will probably remain a matter of debate until the ambiguities and problems obtaining reproducible radiocarbon ages have been solved.

The absolute dates for the late Middle Paleolithic suggest a calendar age of slightly greater than 40 ka BP. The age of the earliest Aurignacian remains a topic of intense debate, but the evidence from the TL and radiocarbon dates indicates an age of roughly 40 ka BP in calendar years for the earliest Aurignacian of the region. As I have pointed out before, these ages are relatively early and suggest an early migration of modern humans into Swabia via the Danube Corridor about 40 ka (Conard and Bolus 2003). As we will see below, the Swabian Jura seems to have supported extremely low populations of Neanderthals at the time the makers of the Aurignacian arrived in the region (Conard et al. 2003b, 2006).

Cultural Stratigraphy

While in many parts of Eastern, Central, Western, and Mediterranean Europe assemblages considered to be transitional between the Middle and Upper Paleolithic have often been described (Bolus 2004), in the Swabian Jura such assemblages are rare and when present they are poorly dated. The most important so-called transitional assemblage in southwestern Germany is the *Blattspitzen* Group (Bosinski 1967; Müller-Beck 1983; Conard and Fischer 2000; Bolus 2004). Bifacial leaf points, the characteristic artifact of this assemblage type, are known from unstratified open-air contexts as well as from stratified cave deposits. Isolated and mostly irregularly shaped bifacial forms and artifacts with surface retouch that could possibly be classified as belonging to the *Blattspitzen* Group are known from stratified cave sites including Vogelherd in the Lone Valley (Riek 1934), and Große Grotte (Wagner 1983) and Geißenklösterle (Conard et al. 2006) near Blaubeuren. The best examples of stratified *Blattspitzen* are two finely worked and complete specimens from Haldenstein Cave near the source of the Lone River (Riek 1938) (Fig. 19.2). Unfortunately, this small but important assemblage has never been dated. In the German research tradition the *Blattspitzen* Group has usually been classified as belonging to the Middle Paleolithic rather than to the Upper Paleolithic or a transitional assemblage type (Bosinski 1967).

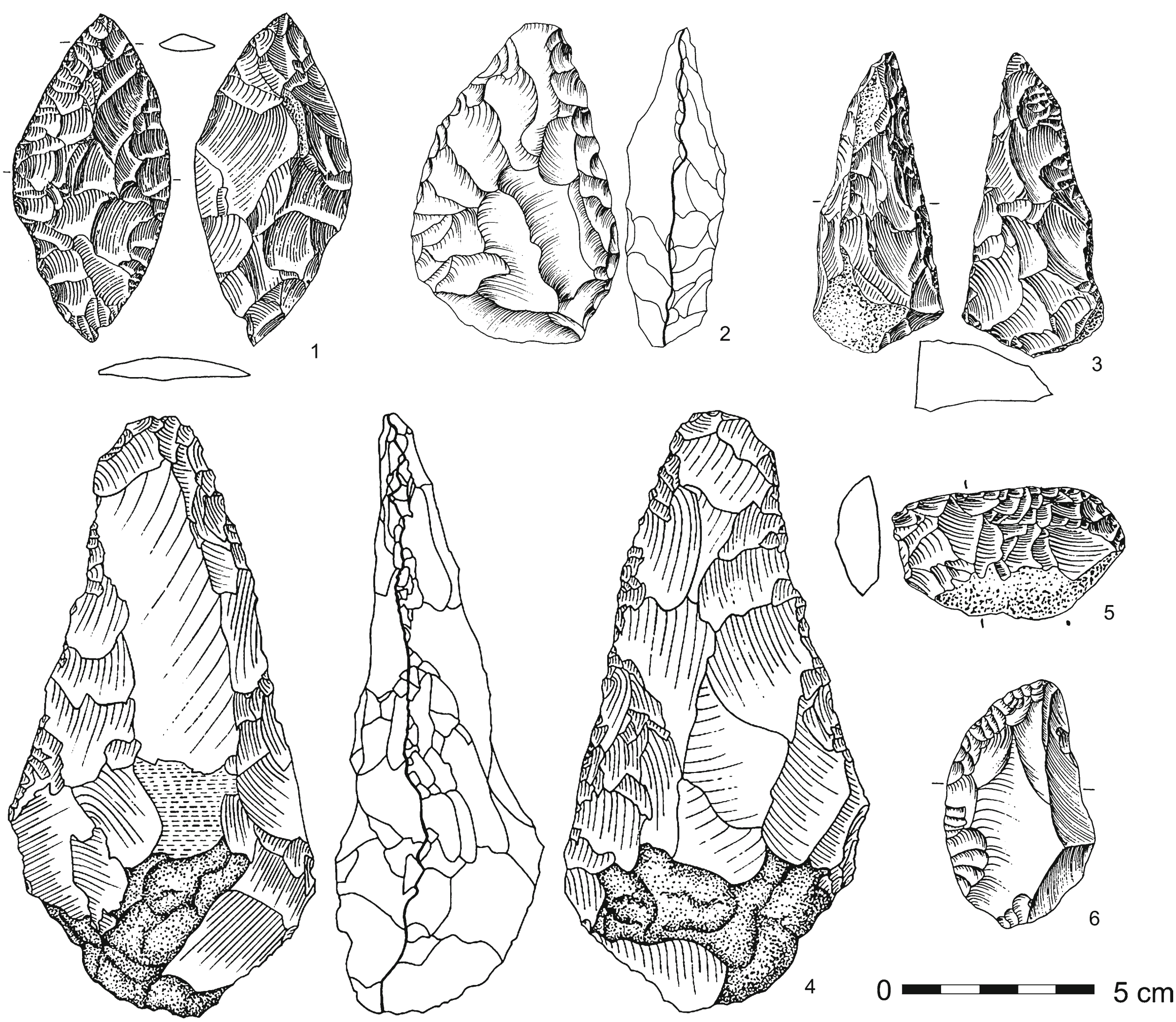

Fig. 19.2 Middle Paleolithic stone artifacts from the Swabian Jura. *1*: Haldenstein; *2*, *5*, *6*: Heidenschmiede; *3*: Bocksteinschmiede; *4*: Winterhalde. *1*: *Blattspitze*; *2*: small handaxe (*Fäustel*); *3*: *Keilmesser*; *4*: handaxe; *5*, *6*: sidescraper

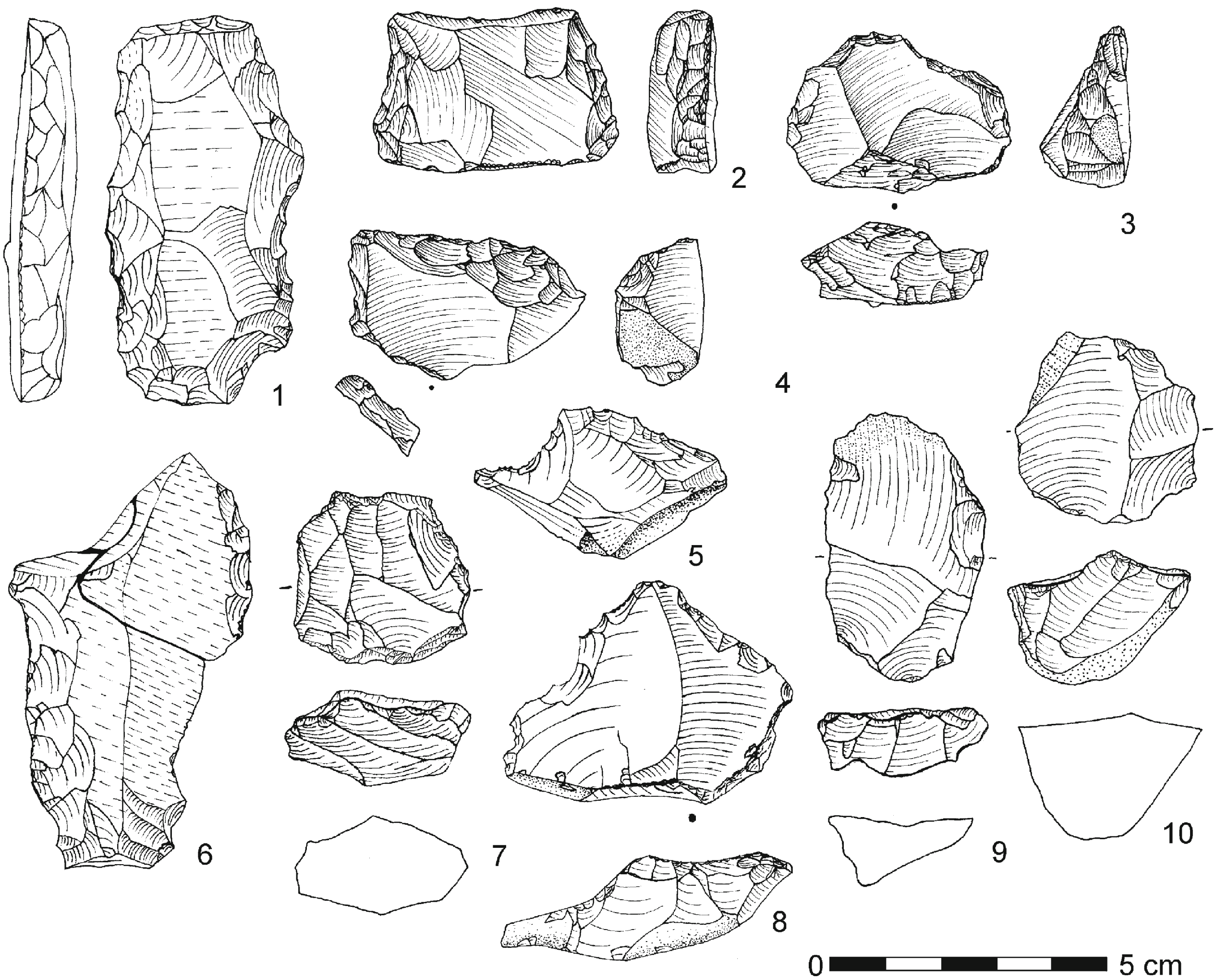

Fig. 19.3 Late Middle Paleolithic stone artifacts from Geißenklösterle (*1–4*) and Hohle Fels (*5–10*). *1*, *2*, *4–6*: sidescrapers; *3*: flake with faceted platform remnant; *7–10*: Levallois cores

Based on the available stratigraphic information in the Swabian Jura and in connection with data from other regions, *Blattspitzen* assemblages usually overlie both typical Swabian Middle Paleolithic assemblages, with their small Levallois cores and diverse flake tools, and assemblages of the *Keilmessergruppe* (Micoquian/Pradnikian). The chronostratigraphic status of the Swabian *Keilmessergruppe*, most notably at Bockstein (Wetzel and Bosinski 1969) and Heidenschmiede (Peters 1931), has not been established beyond doubt (Fig. 19.2). Based on correlations with other regions, scholars including Richter (1997) and Jöris (2002) assume that the assemblages with *Keilmesser* (backed bifacial knives) and other diverse bifacial forms date to late in the Middle Paleolithic. Considered from this point of view, the *Blattspitzen* group can be seen as a last stage of this tendency toward bifacial lithic technology in the late Middle Paleolithic. Interestingly, rich *Blattspitzen* assemblages are absent in the Swabian caves, and the Middle Paleolithic sequences often end with nondescript, non-standardized assemblages with highly reduced Levallois components usually classified as belonging to the Swabian Mousterian (Fig. 19.3).

The long history of research in Swabia provides a variety of precedents for discussing the cultural stratigraphic relationship between the late Middle Paleolithic and the early Upper Paleolithic. The most important work on this relationship was conducted by Robert Rudolf Schmidt (1912) at Sirgenstein, by Gustav Riek (1934) at Vogelherd, and by Joachim Hahn (1988) at Geißenklösterle. All of these researchers concluded that archaeological sterile deposits separated the uppermost Middle Paleolithic deposits from the lowermost Upper Paleolithic deposits. These early Upper Paleolithic assemblages clearly belonged to the Aurignacian. Based on ecological arguments indicating that Neanderthals were well-adapted to diverse environmental conditions (Müller-Beck 1988; Conard 1992; Roebroeks et al. 1992), I was initially skeptical of the proposed stratigraphic break between the latest Middle Paleolithic and the Aurignacian. New fieldwork, however, at Geißenklösterle and Hohle Fels

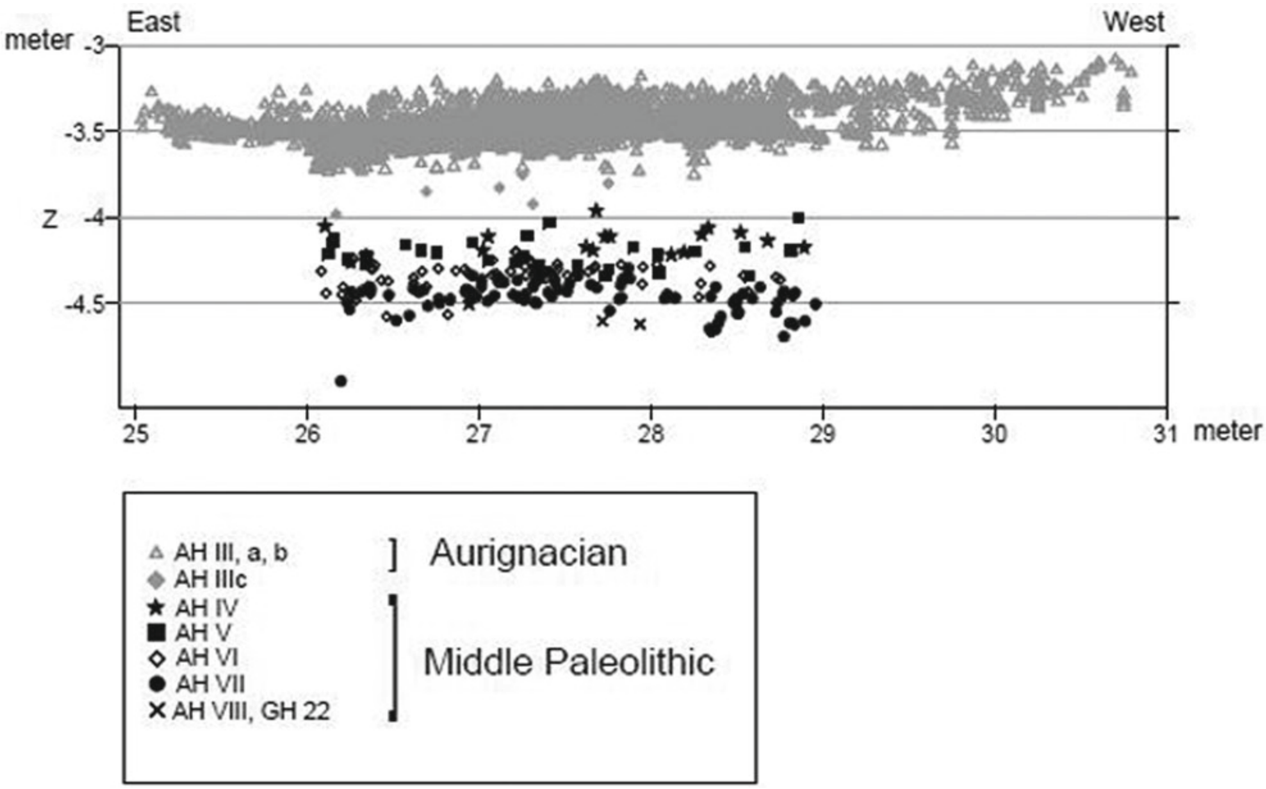

Fig. 19.4 Geißenklösterle. Vertical distribution of lithic and organic artifacts from the lower Aurignacian and the Middle Paleolithic deposits. After Conard et al. (2006)

also confirmed that a stratigraphic break characterized by archaeologically sterile deposits separated the Middle and Upper Paleolithic deposits (Fig. 19.4). This led to the formulation of the "Population Vacuum Model" that postulates a rapid arrival of modern humans in the Swabian Jura at a time when few if any Neanderthals inhabited the region (Conard et al. 2003b). Initially, the most plausible formulation of this model argued that the first arrival of modern humans in the region took place during or immediately after the terrestrial cold climatic phase correlating to the Heinrich 4 cold period documented in sedimentary records from the North Atlantic and in Greenland ice. This model is currently being tested by using geoarchaeological data obtained using sediment micromorphology.

Although around the turn of the millennium considerable debate surrounded the status of the earliest Upper Paleolithic of the Swabian Jura, recent research at the well-studied sites of Geißenklösterle and Hohle Fels has served to clarify this question (Bolus 2003; Conard and Bolus 2006; Teyssandier et al. 2006). The basis of this debate hinged on a combination of factors including Hahn's (1988) use of the term Proto-Aurignacian to describe the lower Aurignacian of archaeological horizon (AH) II at Geißenklösterle. This suggestion by Hahn related to his observation that AH III at Geißenklösterle lacked split-based bone points, which he considered the hallmark of the early Aurignacian. Subsequent research has demonstrated that the initial phases of Aurignacian occupation in Swabia fit well within the early Aurignacian (*Aurignacien ancien*) as defined in southwestern France and is clearly dissimilar to the Proto-Aurignacian, sometimes referred to as the Fumanian, with its geographic focus in Mediterranean Europe (Bon 2002; Teyssandier and Liolios 2003; Bolus 2004; Conard and Bolus 2006). Researchers working in Swabia have demonstrated that nearly all features of the Aurignacian are in place from the start of the Swabian Aurignacian. As discussed above, the TL dates from Geißenklösterle indicate and age of roughly 40 ka years for the beginning of the Aurignacian, while the highly variable radiocarbon dates can be interpreted to reflect this or a younger age. Regardless of what specific age one favors for the beginnings of the Aurignacian, abundant data from Geißenklösterle and Hohle Fels show that a wide spectrum of new practical and symbolic artifacts existed in the material culture of the early Aurignacian of the region. Claims to the contrary by Zilhão, d'Errico, Jöris and Street (Zilhão and d'Errico 1999; Jöris and Street 2008) have largely been put to rest on the basis of technological analyses of organic and inorganic artifacts and the discovery of evidence for personal ornaments, figurative art and musical instruments in the Lower Aurignacian of the region.

Fig. 19.5 Hohle Fels. Female figurine and flute from the radius of griffon vulture from the basal Aurignacian of archaeological horizon Vb (After Conard (2009) and Conard et al. (2009a). Photos by H. Jensen; copyright University of Tübingen)

New finds of figurative art and musical instruments from the basal Aurignacian of AH Vb at Hohle Fels have served to clarify this discussion (Conard 2009; Conard et al. 2009a) (Fig. 19.5). Thus, it now appears that the Aurignacian was fully developed and contained all classes of organic artifacts around the time that modern humans arrived in the Upper Danube region. Michael Bolus and I have been working on the question of whether or not the variations in the material culture of the Aurignacian reflects a cultural sequence or functionally dictated variation in assemblages. At present, we cannot provide a definitive answer to this question. What is, however, clear is that the developmental sequence, based on data from sites including La Ferrassie in southwestern France, proposed by authors including Delporte (1984, 1998), does not apply to the Swabian Aurignacian. Given that many artifact forms, most notably certain personal ornaments, mobile art and musical instruments, are exclusively limited to the Swabian Jura, this region can be viewed, within a polycentric framework, as one key center of cultural innovation during the early Upper Paleolithic (Conard 2008; Conard and Bolus 2003).

Subsistence and Settlement

One key to explain the spread of modern humans and the decline of Neanderthal populations in western Eurasia is provided by a comparative analysis of the subsistence patterns of the two taxa. Subsistence behavior, diet and nutrition are fundamental factors that lead to biological and demographic success or failure of any organism or population. Researchers have studied these variables in the context of the Swabian Middle Paleolithic and the Aurignacian to identify patterns of continuity and change during the period of the late Neanderthals and early modern humans in the Upper Danube region (Münzel and Conard 2004a). Unfortunately, very little data exist that would permit a reliable examination of changing patterns of plant use in this period (Riehl 1999), thus the main sources of data are assemblages of artifacts and faunal material. Here I briefly consider to what extent the archaeological record documents changing prey selection and changes in technology between the late Neanderthals and early modern humans in southwestern Germany.

The well-documented cycles of climatic change in Europe during MIS 3 must have had a dramatic effect on the distribution of plant and animal resources in the Swabian Jura (Müller and Schönfelder 2005). These climatic and environmental fluctuations, however, are difficult to identify with high resolution in the complex sedimentary contexts of find horizons of the Swabian caves (Conard et al. 2006). The poor resolution and poor reproducibility of radiometric dates prohibits using dates to establish high resolution correlations with climatic oscillations. Nonetheless, we see a surprisingly robust signature in the structure of game animals in the Middle Paleolithic and the Aurignacian (Münzel and Conard 2004a). At most sites in the region horses and reindeer are the key species hunted during both of these periods. There are some differences in the species representation, with wooly rhino more abundant at Middle Paleolithic sites and mammoth more common in the Aurignacian (Niven 2006; Münzel In preparation). The greater abundance of mammoth remains in Aurignacian deposits could be as much a reflection of the importance of mammoth bones and ivory as a raw material in the Aurignacian as a reflection on increased levels of hunting mammoth (Münzel 2001).

Middle Paleolithic deposits typically include a higher portion of cave bear bones, but this observation is probably more indicative of the lower occupation intensity of Neanderthals at most sites in the region than anything else. Over tens of millennia Neanderthals occupied caves in the Swabian Jura without exerting pressure on the cave bear populations. In contrast, during the Upper Paleolithic cave bears went extinct, probably due in part to human predation (Münzel and Conard 2004b). Neanderthals and cave bears seem to have coexisted in a dynamic equilibrium with both species able to survive in the same region over long periods of time. With the arrival of modern humans this dynamic equilibrium was disturbed. Cave bear hunting was intensified and more bones show anthropogenic modifications and even direct evidence of hunting (Münzel et al. 2001; Münzel and Conard 2004b). Modern humans utilized the Swabian caves more intensely and eventually, perhaps in combination with the harsh environmental conditions, put so much stress on the cave bear populations that they went extinct in the region during the Gravettian (Hofreiter et al. 2004, 2007). This is one of several indicators that human population densities in the Middle Paleolithic were maintained at a lower level than in the Aurignacian.

We have little data from open-air sites, so there is some danger in extrapolating about the behavior of Neanderthals and modern humans using only data from the region's caves. Seasonality data, particularly the presence of bones of fetal horse and infant mammoths, point to the winter and spring as the main periods of occupation of most of the cave sites of the Swabian Jura (Münzel and Conard 2004a). This signal is consistent with the idea that people would tend to use caves in times of the year in which the conditions in the open-air were worse than inside the dark, cool caves. Deposits of both the Middle Paleolithic and Aurignacian are characterized by concentrations of burnt bone, indicating that the environment did not always contain sufficient quantities of wood for the heating and lighting needs of both populations.

The role of small game in Paleolithic subsistence economies has been a popular research topic in recent years (Stiner et al. 1999). Without citing any concrete faunal data from the Middle Paleolithic or the Aurignacian of the region, Hockett and Haws (2005) have suggested that small game played a key role in the subsistence strategies of Aurignacian people in the Swabian Jura, and thereby allowed modern humans to out-compete the indigenous Neanderthals. We are currently studying the faunal remains of fish, small mammals and birds from Geißenklösterle and Hohle Fels to test this hypothesis.

One major shift lies in the area of new technologies, including multiple forms of lithic and organic projectiles. These new projectiles would have provided modern humans with a competitive advantage against Neanderthals, who had far less well-documented projectile technologies at their disposal (Hahn 1977; Conard and Bolus 2006). Thus it seems that Neanderthals were less well able to adapt to the changing environmental setting and the human population dynamics in MIS 3 compared to the newly arrived populations of modern humans. When confronted with the innovative technologies and behavioral patterns of the populations of early modern humans in Europe, Neanderthals found themselves at a competitive disadvantage. Modern humans were better able to extract animal resources from the environment. This advantage probably helped contribute to the increased reproductive fitness of the Aurignacian populations relative to the indigenous Neanderthals. Without the arrival of modern humans, Neanderthals and their direct line of offspring would probably still occupy Europe today. The culturally more conservative Neanderthals were unable or unwilling to compete successfully under the new selective circumstances reflected in the changed social-cultural landscape of Europe at the time of the arrival of modern humans. Neanderthals "low impact" behavioral strategies that had served them so well over the late Middle Pleistocene and early and middle Late Pleistocene, now put them at a disadvantage when they found themselves competing against larger populations of modern humans using new and innovative technologies and "higher impact" strategies to extract more dietary resources from their environment (Conard et al. 2006). Without venturing a value judgment in such evolutionary conflicts, it seems that modern humans out-competed the smaller culturally more conservative populations of Neanderthals and drove them to extinction. Only the slightest advantage in the survival of offspring or reduced levels of mortality would be sufficient to allow modern humans to extend their range at the expense of the Neanderthals.

Burkert and Floss (2005) have pointed out that the patterns of lithic raw material use show that modern humans used a slightly broader spectrum of raw materials than did the Middle Paleolithic inhabitants of the Swabian Jura. The larger networks of raw material are also suggestive of a higher degree of territorial mobility and perhaps more flexible and dynamic exploitation of the available lithic resources. The increased presence of Bavarian tabular flint from downstream on the Danube can be seen as an indication of the importance of larger social and economic networks along the Upper Danube. This observation, taken together with the important early Upper Paleolithic sites in Austria (Nigst 2006) and Romania (Trinkaus et al. 2003) is consistent with modern humans using the Danube Corridor (Conard 2002; Conard and Bolus 2003) as their main route of migration into the Swabian Jura and into Central Europe as a whole.

Examination of the find densities in Middle Paleolithic and Aurignacian deposits from the Swabian Jura clearly demonstrate the shift in occupation intensity. The best data sets for these comparisons come from Geißenklösterle and Hohle Fels, where over a period of decades all the deposits have been carefully excavated and water screened (Table 19.1). These data are cannot be viewed as precise measures of occupation intensity because we do not have rigorous control of key variables such as rates of deposition. Also other sites dug with less precise methods, such as Bockstein-Schmiede and Sirgenstein, preserved richer Middle Paleolithic find horizons than did Geißenklösterle and Hohle Fels. Still the data clearly demonstrate that the numbers of lithic artifacts, burnt bone, wood charcoal, anthropogenically modified faunal remains all show much greater densities per unit volume in the Aurignacian than in the Middle Paleolithic. If we were to include other classes of artifacts, such as the symbolic artifacts discussed below in the analysis, the differences in occupation intensity would appear even more pronounced. Most of these data indicate a factor of 10 or even 100 times more cultural debris per unit sediment volume during the Aurignacian versus the Middle Paleolithic. Even if we view these figures as rough approximations, the intensity of occupation at Geißenklösterle and Hohle Fels was far lower in the Middle Paleolithic than in the Aurignacian. Taken at face value, the data presented in Table 19.1 indicate that the occupation density during the Aurignacian was typically about one order of magnitude greater than during the Middle Paleolithic. Values vary from layer to layer, but the overall increase of cultural debris in Aurignacian deposits from Geißenklösterle and Hohle Fels reflect an increase in population densities relative to the Middle Paleolithic.

Symbolic Artifacts

The most radical shift in the archaeological record between the Swabian Middle and Upper Paleolithic lies in the realm of symbolic artifacts. While Neanderthals at times buried their dead, used pigments, and shortly before going extinct made

Table 19.1 Densities of lithic artifacts; burnt bone; charcoal; and anthropogenically modified fauna in the Middle Paleolithic and Aurignacian deposits at Hohle Fels and Geißenklösterle

Hohle Fels	AH	Cultural group	Excav. area (m²)	Approx. thickness (cm)	Lithic artifacts (n)	n/m³	Burnt bone (g)	Charcoal (n)	Modified fauna (n)
	IId	G/A	27	35	2,570	272	1,406	17	74
	IIe	G/A	22	15	1,000	303	400	20	17
	IIIa	A	30	20	2,800	467	919	303	38
	IIIb	A	20	5	741	741	462	36	11
	IV	A	28	20	15,414	2,753	8,362	244	84
	Va	A	8	20	10,503	6,564	825	126	20
	Vb	A	23	25	1,615	281	147	28	10
	VI	MP	11	30	109	33	111	0	4
	VII	MP	10	30	230	77	253	2	5
	VIII	MP	10	30	239	80	327	0	1
	IX	MP	8	5	281	702	148	0	2
Geißenklösterle	**AH**	**Cultural group**	**Excav. area (m²)**	**Approx. thickness (cm)**	**Lithic artifacts (n)**	**n/m³**	**Burnt bone (g)**	**Charcoal (n)**	**Modified fauna (n)**
	II	A	43	35	2,781	185			
	IIIa, b	A	39	20	12,856	1,648			
	IIIc	A	13	20	198	76			
	IV	MP	13	10	74	57			
	V	MP	12	10	97	81			
	VI	MP	12	15	196	109			
	VII	MP	9	30	259	96			
	VIII	MP	7	35	39	16			
	AH	**Cultural group**	**Total lithics/ Volume (n/m³)**	**Total burnt bone/ Volume (n/m³)**	**Total charcoal/ Volume (n/m³)**	**Total modified fauna/ Volume (n/m³)**			
Hohle Fels	IIIa-Vb	A	1,558	537	37	8			
	VI-IX	MP	89	42	0,1	0,6			
Geißenklösterle	II-IIIc	A	622						
	IV-VIII	MP	70						

The lower part of the table is the combined values for each of the major periods. *G/A* Transition between the Aurignacian and the Gravettian, *A* Aurignacian, *MP* Middle Paleolithic

personal ornaments, they manufactured few non-utilitarian, symbolic artifacts (d'Errico et al. 2003; Conard 2007). A small number of bone artifacts are known from the Middle Paleolithic sites of Vogelherd (Riek 1934) and Große Grotte (Wagner 1983) (Fig. 19.6), but excavators have recovered no convincing examples of personal ornaments from Middle Paleolithic find horizons.

The material cultural record of the Swabian Aurignacian stands in sharp contrast to that of the Middle Paleolithic. The long and productive history of research in the region has led to the recovery of numerous examples of diverse personal ornaments from sites including Vogelherd (Conard et al. 2009b) and Hohlenstein-Stadel (Hahn 1977; Schmid 1989) in the Lone Valley and from Hohle Fels (Conard 2003), Geißenklösterle (Hahn 1988) and Sirgenstein (Schmidt 1912) in the Ach Valley between Schelklingen and Blaubeuren. These ornaments include multiple forms such as perforated teeth of fox and numerous examples of three-dimensionally carved ornaments of mammoth ivory (Fig. 19.7). The most common of the numerous personal ornaments made from mammoth ivory are oval-shaped, double perforated beads, which are well documented at the sites mentioned above. The presence of this form at sites in the Ach and Lone valleys is one of many indicators that the Aurignacian inhabitants of these valleys belonged to the same cultural group. Although the modern excavations at Geißenklösterle and Hohle Fels initially gave the impression that these sites are particularly rich in ornaments, the re-excavations at Vogelherd have altered this impression. At present it is Vogelherd that has yielded the greatest number and variety of personal ornaments in the Swabian Aurignacian (Conard et al. 2009b). Other important classes of symbolic artifacts in the Swabian Aurignacian that are lacking in the Middle Paleolithic include multiple examples of figurative representations, depictions of mythical creatures that did not exist in the natural world, and musical instruments. Excavations at in the Ach and Lone Valleys have now yielded roughly 50 examples of carvings on mammoth ivory (Riek 1934; Hahn 1986; Floss and Rouquerol 2007) (Figs. 19.5 and 19.8). Many of the figurines are too fragmentary to identify, but roughly two dozen are complete

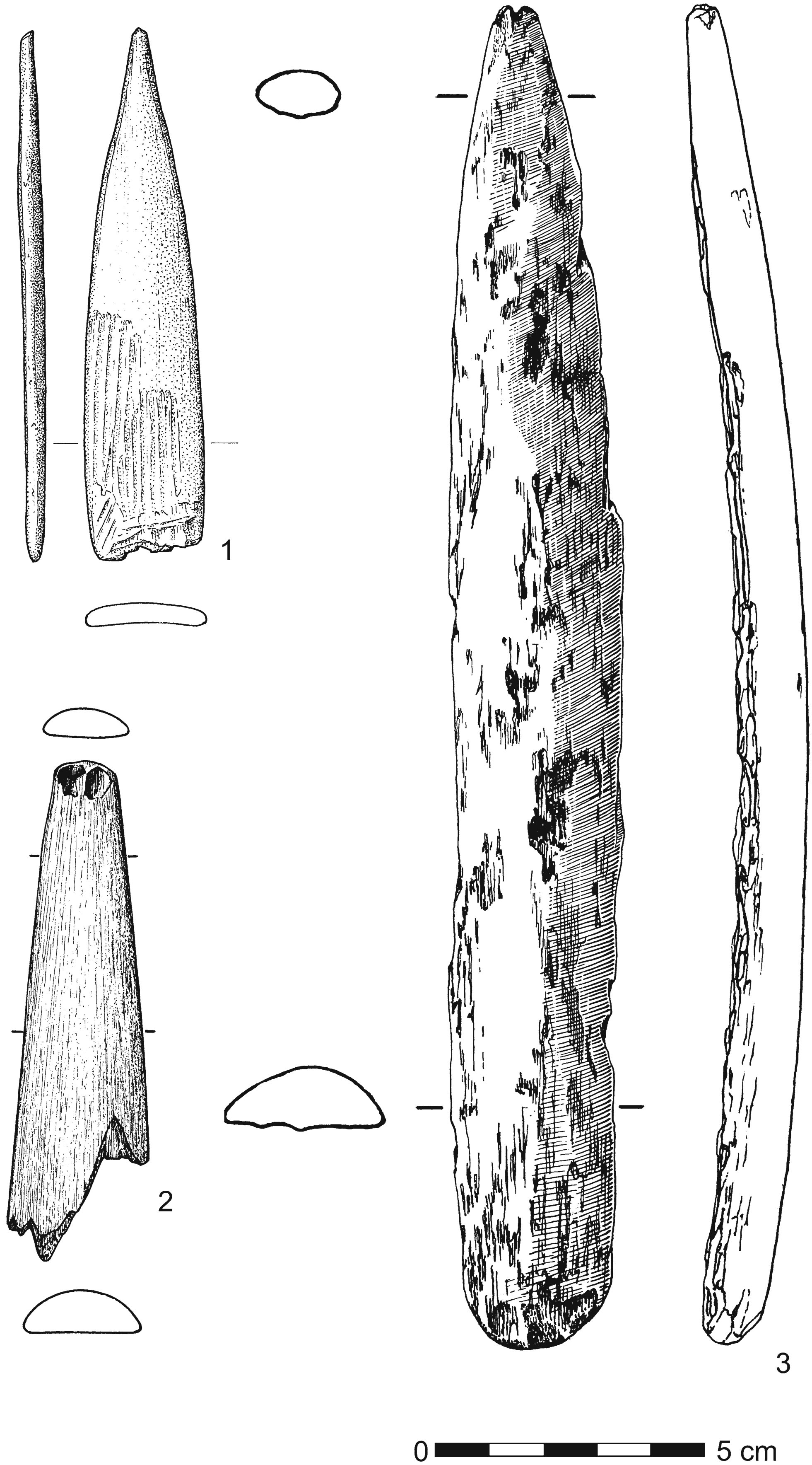

Fig. 19.6 Organic artifacts from the late Middle Paleolithic of the Swabian Jura. *1*, *3*: Vogelherd; *2*: Große Grotte. *1*, *2*: bone points; *3*: pointed rib (After Riek (1934) and Wagner (1983))

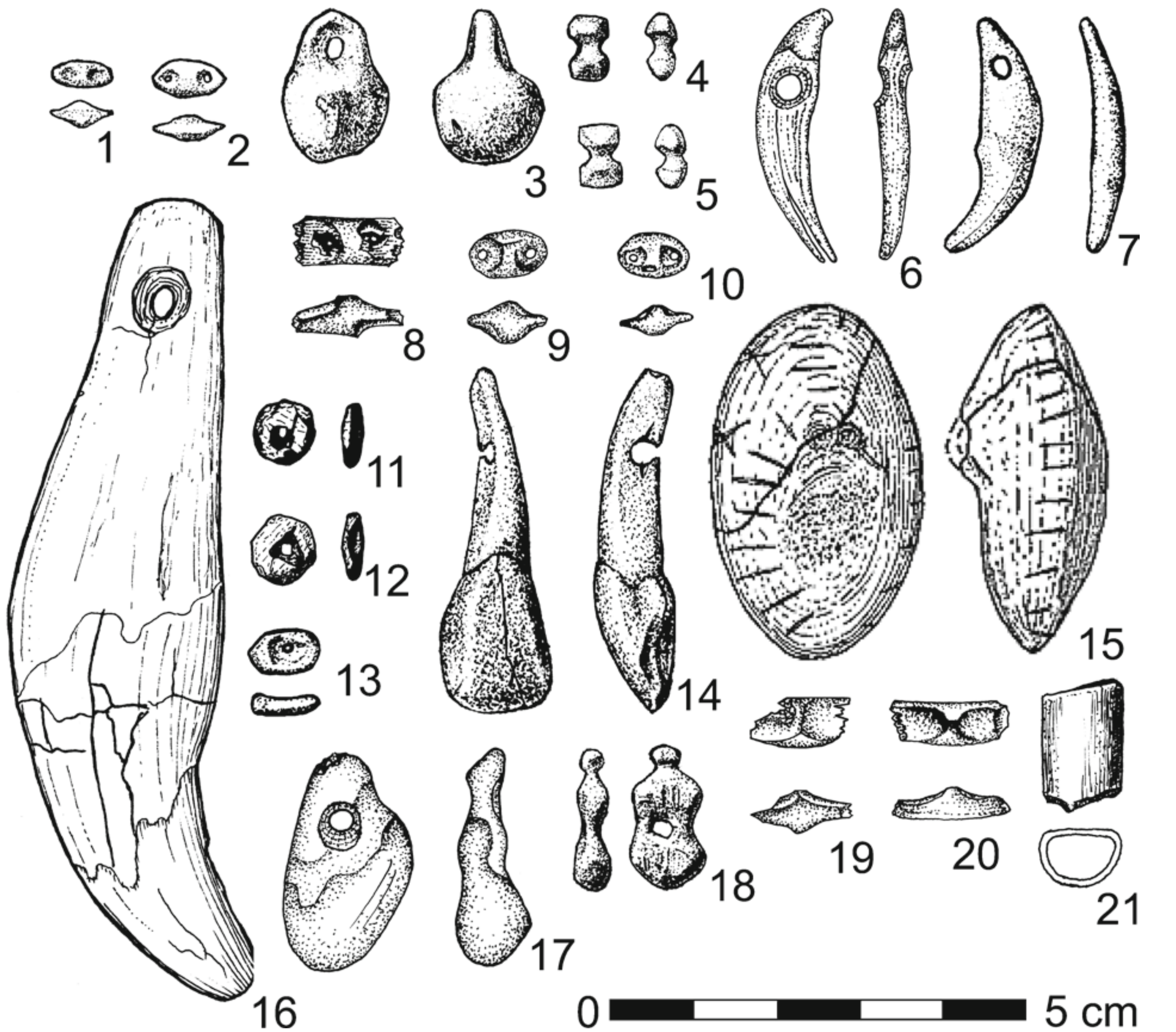

Fig. 19.7 Personal ornaments from the Swabian Aurignacien. *1*, *2*: Hohle Fels AH V; *6–14*, *17–20*: Hohle Fels AH IV; *3–5*: Hohle Fels AH III; *21*: Geißenklösterle AH III; *15*: Geißenklösterle AH II; *16*: Bocksteinhöhle. *1*, *2*, *9*, *10*: double perforated ivory beads; *3*: basket-shaped ivory bead; *4*, *5*: toggle shaped ivory objects; *6*, *7*: perforated fox canines; *8*, *19*, *20*: unfinished ivory beads; *11*, *12*: disc-shaped ivory beads; *13*: ivory bead; *14*: perforated tooth; *15*: retoucher of antler used as pendant; *16*: perforated cave bear canine; *17*: perforated red deer tooth; *18*: violin-shaped ivory pendant; *21*: bone bead

enough to determine what they depict. The figurines included in roughly decreasing order of abundance mammoths, large felids, horses, bison, a water bird and a female figurine (Conard 2003, 2009; Floss and Rouquerol 2007). Additionally, excavations at the sites of Hohlenstein-Stadel (Hahn 1986; Schmid 1989), Geißenklösterle (Hahn 1988) and Hohle Fels (Conard 2003) have all produced clear examples of therianthropic animals that include characteristics of lions and humans that are often referred to as *Löwenmenschen* (lionmen).

Recent work at Geißenklösterle, Vogelherd and Hohle Fels has led to the discovery of a total of eight flutes from the Aurignacian (Hahn and Münzel 1995; Conard et al. 2004, 2009b; Conard and Malina 2006). These instruments include fragments of four flutes carved from mammoth ivory and examples of flutes with between three and five holes carved from the radii of swans and vultures (Figs. 19.5 and 19.8). These flutes are sophisticated musical instruments that allowed musicians to produce complex and beautiful music between 30 and 40 ka (Tarasov 2005). Even the oldest of the flutes, the well-preserved giffon vulture flute from Hohle Fels, preserves a carefully made mouthpiece and five precisely placed finger holes. These features allow a remarkably wide range of tones and nearly unlimited musical possibilities. It is no coincidence that the flutes have been recovered in caves.

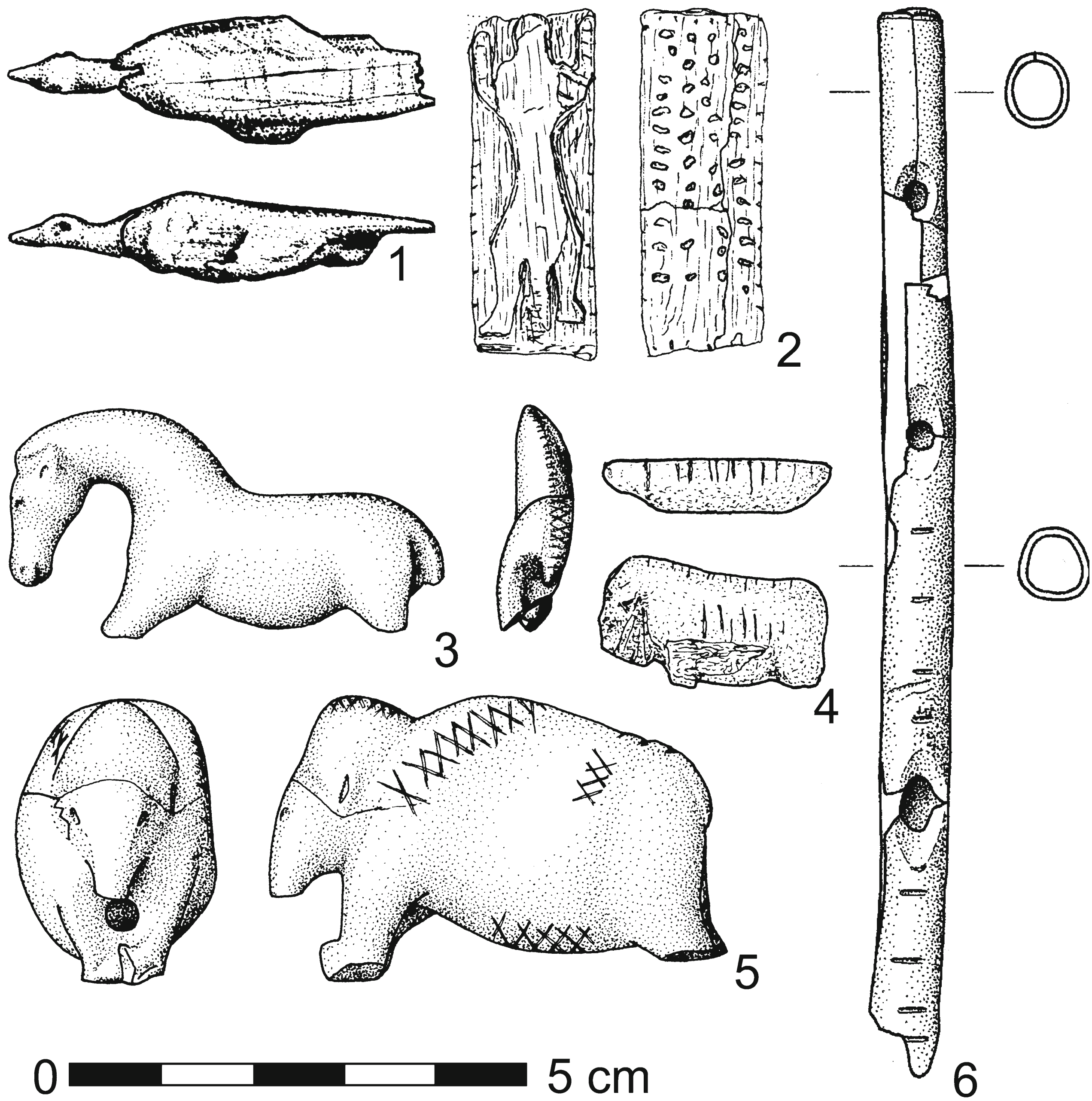

Fig. 19.8 Figurative art and a bone flute from the Swabian Aurignacian. *1*: Hohle Fels AH IV; *2*, *4*, *6*: Geißenklösterle AH II; *3*, *5*: Vogelherd V. After Hahn (1986) (*2*, *4*); Conard and Bolus (2003) (*3*, *5*, *6*); Conard and Bolus (2006) (*1*)

The music produced by these instruments is not loud. Thus the favorable acoustics of the caves provided a natural concert hall for musical performances. Like many of the figurines carved from mammoth ivory, excavators recovered most of the flutes in deposits containing multiple classes of artifacts and domestic refuse suggesting that these finds were used in daily life rather than being contextually isolated or used and discarded only in special settings.

After 15 seasons of excavation in the region, I am increasingly gaining the impression that these kinds of symbolic artifacts are not as rare or unique as researchers originally thought. On the contrary with nearly each passing year new examples of symbolic artifacts are recovered, suggesting that a broad range of symbolic artifacts can be expected from major Aurignacian sites in the region. Such finds have never been recovered in Middle Paleolithic deposits of the Swabian Jura. Clearly symbolic artifacts played a far greater role in the lives of early modern humans than in the lives of the earlier Neanderthals, who occupied the Swabian Jura. While reliable access to calories and other essential resources may contribute directly to good health and biological success, it seems that the presence of artifacts that we by convention classify as art and musical instruments contributed to the development of social-cultural systems that put modern humans at a biological advantage relative to the indigenous Neanderthals. These expanded symbolically mediated social systems would have served to expand mating networks and to have reduced risk through larger networks of reciprocal obligations (Wiessner 1982). We can view the manipulations of images and playing music as mechanisms to help maintain larger and more complex social networks. These new social networks placed the groups of late Neanderthals in a tenuous position and eventually contributed to their extinction. Based on what we know today, these kinds of symbolic artifacts did not exist in the material cultural of Neanderthals. While evolutionary success ultimately depends on biological and demographic parameters, the archaeological record documents a clear selection for the expansion of the repertoire of symbolic artifacts as populations of modern humans grew and moved across the geographic range of Neanderthals (Conard 2008).

Conclusions

Neanderthals are often viewed as the hominin form that by contrast to modern humans helps to define modern *Homo sapiens*. Often Neanderthals are viewed as inferior to modern humans, but I prefer to avoid value judgments when assessing organisms, including humans. Organisms come and go in nature and surely at some time in the future modern humans will go extinct. Neanderthals were neither primitive nor dumb (d'Errico 2003). Over many tens of millennia they persisted in many regions of the Old World after modern humans evolved in Africa (Conard 2008). From this point of view archaic Neanderthals and modern humans were on nearly equal evolutionary footing, and the outcome of the evolutionary processes that led to a world today in which only modern humans persist was not predetermined. In theory, at least, variables could have played themselves out differently leaving Neanderthals here and modern humans as our curiously extinct nearest relatives.

Neanderthals were well adapted to the Ice Age landscapes of western Eurasia and had developed effective technologies that put them at the top of the food chain and provided reliable caloric and nutritional intake in diverse regions with diverse environmental conditions. They also mastered an extremely wide range of settings dictated by successive glacial and interglacial cycles, as well as shorter term shifts between stadials and interstadials. Prior to the arrival of anatomically and culturally modern humans in western Eurasia, groups of Neanderthals always showed the resiliency to survive and in some settings prosper in the inhabitable parts of Ice Age Eurasia (Roebroeks et al. 1992). Ranges and population densities varied, but Neanderthals almost certainly would not have gone extinct had modern humans not arrived in their territories. This arrival initiated a biological and cultural conflict that contributed to a sharpening of the contours between these human taxa.

Many anatomical features distinguish Neanderthals from modern humans, but my concern here is with the behavioral differences that characterized the two taxa. Although a hiatus separates the last Neanderthal occupation of the region from the arrival of modern humans, evidence from both periods allows a reliable comparison between the adaptations of the two groups. The Swabian Jura is only one case study of this evolutionary shift toward modernity, but this case study points to clear differences in the material culture, technology, organization of settlement, social behavior and symbolic context of the lives of Neanderthals and modern humans. While the Swabian model need not apply to other regions, we can clearly document a far greater intensity of habitation of the cave sites used by modern humans relative to Neanderthals. We can document how Neanderthals coexisted with cave bears, while modern humans hunted them and displaced them until they became extinct. Numerous new organic and lithic artifacts helped improve access to resources and allowed modern humans to compete successfully against Neanderthals. This being said, the faunal records from Geißenklösterle and other sites in the region show a similar spectrum of game (Münzel and Conard 2004a). Hockett and Haws (2005) suggestion that modern humans of the Swabian Jura exploited more small game than Neanderthals has yet to be substantiated in the Middle Paleolithic and Aurignacian fauna. On the contrary, both human taxa primarily hunted the same game, with horse and reindeer being particularly common game species. Small game, birds and fish, while present, appear to play a secondary role in the Middle Paleolithic and Aurignacian faunal assemblages. Modern human populations experienced a positive selection and positive feedback for the innovation of new technologies that aided the extraction of the additional calories from their environment. The increased populations of modern humans could only be sustained by employing either more effective technology, or by investing more effort to extract resources from the landscape. While Neanderthal adaptations, both technological and social, worked well in a setting in which they were the only hominin, with the arrival of modern humans in their range, the situation fundamentally changed.

Neanderthal adaptations in Swabia typically seem to reflect low population densities and small social groups. Social interaction was often face-to-face, and Neanderthals probably knew most of the people in their social groups through direct interaction and shared activities (Gamble 1999). Modern humans in Swabia lived in larger groups using material cultural that explicitly documented their social identity. This identity expresses itself archaeologically in numerous examples of carved ivory ornaments and more standardized organic and lithic artifacts. Artifact assemblages from multiple caves in both the Ach and Lone valleys document identical forms of complex tools, ornaments, abstract and figurative depictions, and musical instruments. These artifacts document the existence of many new behavioral forms and more complex symbolic interaction than existed among the smaller populations of Neanderthals only a few millennia earlier.

There are at least two ways of interpreting these changes in the material culture. One could argue, as many researchers have, that Neanderthals practiced fundamentally different patterns of behavior and that they were unable to compete in this new setting with the arrival of relatively high populations of technologically and symbolically more complex modern humans. Alternatively, one could argue that with the arrival of modern humans in Eurasia Neanderthals saw their behavioral and cultural niche being pinched out and no longer viable. Rather than changing their social and cultural patterns of behavior they were conceptually locked into their conservative system of behavior that had served them well in numerous contexts over millennia. Their "low impact" adaptations that had evolved and been refined over many generations in many settings generally maintained low population densities and put little stress on their environments (Conard et al. 2006). Culturally, the "higher impact" adaptations of Aurignacian populations and their increased symbolic complexity and larger social networks represented systems of behavior that contradicted the cultural norms of Neanderthals. Even if they could have adopted some of these innovations, considered from a social and cultural point of view, such changes, which may well have been cognitively possible, were not compatible with the cultural traditions of Neanderthals. Similar arguments have been made based on archaeological, ethnohistorical and ethnographic data from case studies across the Old and New Worlds (Lear 2006; O'Connell 2006).

Out of necessity studies such as O'Connell's analysis of the Hadza or Lear's assessment of the fate of the Crow are drawn from populations of modern humans. Nonetheless, these case studies inform us about the importance of the cultural niche in human evolution. A society's cultural codes will more likely dictate patterns of behavior than the strictly defined biological needs of the individuals living within the group. In the paleoanthropological literature, biological variables are often seen as the key factors that determine the success and failure of human populations. Thus it is not surprising that biological arguments so often dominate the discourse on Neanderthal extinction. Populations of hominins are often seen as being innately distinguishable as "superior" or "inferior." Such emphasis on biological dichotomies between hominin taxa may in some cases distract attention away from critical cultural variables that may have played a still greater role in the course of human evolution.

While I explicitly do not wish to equate the Hadza or the Crow with Neanderthal cultures, analogous cultural processes may well have shaped the fate of the Neanderthal populations as modern humans expanded across western Eurasia. Just as the last great chief of the Crow, Plenty Coups, assessed the emptiness of Crow society in a world without herds of buffalo in which traditional forms of battle and honor ceased to exist (Lear 2006), the traditional cultural niches of Neanderthals may well have become non-viable as modern humans increasingly impinged on their land, game and raw materials. As I have argued previously (Conard 2007, 2008), over many tens of millennia Neanderthals and modern humans lived on fairly even footing. How else can we explain the gap of roughly 160 kyr separating the presence of anatomically modern humans in East Africa 200 ka and their colonization of western Eurasia only 40 ka?

As we gain better data from additional regions, researchers should be able to refine the arguments put forward here. While the evolutionary processes may show significant patterning, I would expect considerable regional variation. Already today the archaeological record shows a relatively wide range of specific regional signatures (Bar-Yosef and Pilbeam 2000; Conard et al. 2006) that with time will yield a diverse evolutionarily and historical picture of the fate of the last Neanderthals. This paper advocates developing culturally based models that seek a balance between biological and cultural variables. Clearly researchers need to consider both cultural and biological variables and the interplay between the two. This being said, the most plausible explanations for the extinction of Neanderthals may have more to do with the demise of their cultural niche than any innate biological differences between Neanderthals and early modern humans.

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Chapter 20
Level 14 of Bajondillo Cave and the End of the Middle Paleolithic in the South of the Iberian Peninsula

Miguel Cortés Sánchez, Juan F. Gibaja Bao, and María D. Simón Vallejo

Abstract Bajondillo Cave is located in the south of the Iberian Peninsula. The stratigraphy of the cave comprises a long chrono-cultural sequence (Middle Paleolithic, Aurignacian, Gravettian, Solutrean, Magdalenian, Epipaleolithic and Neolithic). One of the outstanding elements of this site is the presence of Aurignacian levels overlaying late Mousterian levels, unknown in other sites of the region. In this paper we present new data (techno-cultural, chronological, environmental, landscape usage and use-wear analysis of lithic tools) from the late Middle Paleolithic level Bj/14. We also compare this information to previous knowledge of the late Middle Paleolithic from Southern Iberia. Available data suggests that there is little change within the local Middle Paleolithic and that an abrupt transition to the Upper Paleolithic took place between 3.5 and 7 kyr later than in the northern Iberian Peninsula.

Keywords Mousterian • Aurignacian • Chronology • Technology • Micro-wear analysis • Transition

Introduction

Bajondillo Cave is a large rock shelter in the travertine formation of Torremolinos (Málaga, Southern Iberian Peninsula), located between 10 and 20 m above sea level (Fig. 20.1) and 200 m away from the present shore line.

The discovery of the cave took place in 1989 and a test excavation was immediately carried out by archeologists of the Department of Prehistory of Málaga University, Spain. In 2000 and 2002, samples were taken for ^{14}C dating, pollen analysis, isotope analysis and micromorphological studies. The long stratigraphical sequence comprises 6 m at Bajondillo (Bj) (Fig. 20.1) can be divided into four chrono-cultural phases (Cortés Sánchez and Simón Vallejo 1997; Cortés Sánchez 2002):

(a) Neolithic: 2 levels (Bj/2 and Bj/1);
(b) Epipaleolithic: 2 levels (Bj/4 and Bj/3);
(c) Upper Paleolithic: 7 levels (Aurignacian, Bj/11; Gravettian, Bj/10; four Solutrean, Bj/9 to Bj/6 and the last one, Bj/5, probably Magdalenian);
(d) Middle Paleolithic: 6 levels (Bj/19 to Bj/14) with Mousterian industries.

Twenty-seven dates have been obtained from this archeological sequence, using different dating methods (AMS, TL and U/Th) (Cortés Sánchez 2007). Elsewhere, we have documented the paleoenvironmental evolution of the coast between MIS 5 and the Early Holocene (Cortés Sánchez 2007).

The Late Mousterian Industries from Bajondillo Cave

Bj/14 is the uppermost Mousterian level in Bajondillo. The lithic technology in this layer is dominated by recurrent Levallois, centripetal and discoidal reduction sequences (Cortés Sánchez 2000, 2004; Cortés Sánchez and Simón Vallejo 2001) and therefore clearly belongs to the Middle Paleolithic. Bj/14 yields a TL date of 28.5 ka and stratigraphically underlies level Bj/11. Level Bj/11 is the only Aurignacian, and also the oldest Upper Paleolithic level known in the south of the Iberian Peninsula, and only by stratigraphic means it appears younger than level Bj/14, which delivered a very similar TL-date (see Table 20.1).

The characteristics of lithic production of the Bj/14 lithic sample seem to follow the general trend of other Mousterian industries. In terms of typological variability (essential count after Bordes 1953) the lithic assemblage of Bj/14 shows a very low Group II (sidescraper index <15%), characterized by a lower

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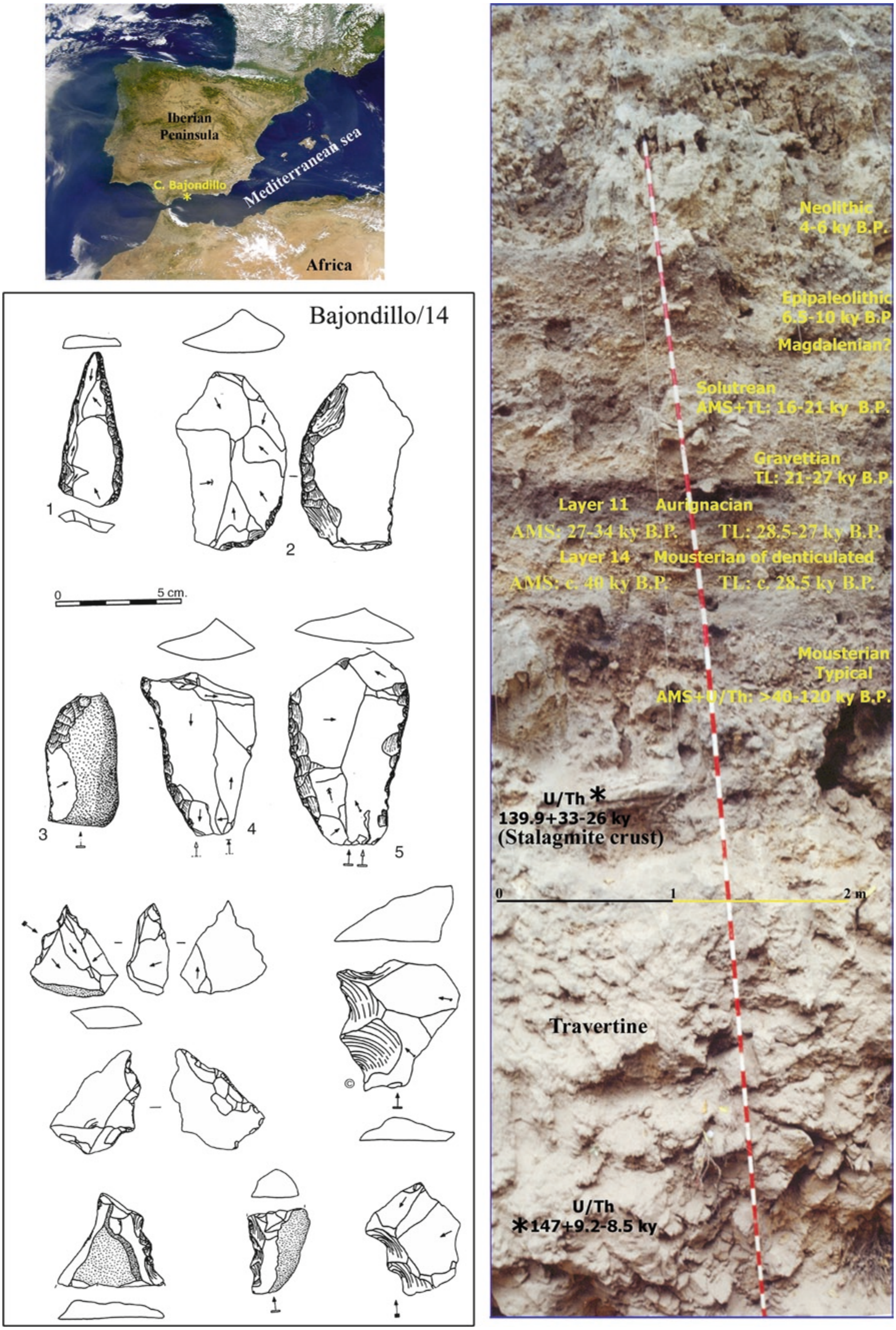

Fig. 20.1 Location and stratigraphical and cultural sequence of Bajondillo Cave

Table 20.1 AMS and TL dates for Bajondillo Cave levels 14–10

Layer	^{14}C AMS	TL	Sample	Laboratory
Bajondillo/10	–	24,344 ± 2,653	Flint	Ua-2470
Bajondillo/11	–	26,013 ± 2,777	Flint	MAD-2482
	–	28,019 ± 2,334	Flint	MAD-2559
	33,690 ± 1.195	–	Carbonaceous sediment	Ua-17150
	32,770 ± 1.065	–	Carbonaceous sediment	Ua-18050
Bajondillo/12–13	–	28.532 ± 5,319	Carbonates	MAD-2377
	37,005 ± 1.790	–	–	Ua-18270
Bajondillo/14	–	28,551 ± 2,909	Flint	MAD-2463
	> 40,000	–	Charcoal	Ua-16859

degree of diversity compared to the preceding assemblages, and higher frequencies of laterally retouched types. Group III (index of Upper Paleolithic types) displays throughout the Mousterian sequence at Bajondillo a moderate but continuous rise of nearly 10%. It is evident that throughout the whole Upper Paleolithic section burins are always more frequent than endscrapers except for the Aurignacian level Bj/11 (For more detailed information on this topic see Cortés Sánchez and Simón Vallejo 1997; Cortés Sánchez 2002, 2007). The first technological evidence of the Upper Paleolithic in southern Iberia may be found in Bj/13–12, but the sample is very small and poor. Because of this, we have considered Bj/11 as the first clearly Aurignacian layer, in terms of technological, chronological and stratigraphical criteria (Cortés Sánchez 2007). Seven AMS and TL dates were obtained for levels Bj/13 to Bj/11 (Table 20.1). We observe a clear divergence between the AMS and the TL dates, which are, however, internally coherent, dating these layers by AMS around 37–32.7 ka (uncalibrated) and by TL around 28.5–26 ka.

The evidence from Bajondillo Cave shows that the transition from Middle Paleolithic to Upper Paleolithic in this area took place later than in other northern areas of the Iberian Peninsula. This supports the hypothesis put forward by some scholars that the Middle Paleolithic and the Neanderthal populations in the southwest of Europe continued and survived for a longer time period than in other areas of Europe (Cortés Sánchez 2004). This area would have been a refugia until the Aurignacian innovations appear in the Málaga bay, and would be relevant in terms of both the AMS (3.5 millennia) or TL dates (7 millennia). Recent dating of Gorham's Cave show that Neanderthal populations would have survived up to c. 28 ka BP (Finlayson et al. 2006), and this can also be confirmed by the data of Zafarraya (Barroso and de Lumley 2006). In this sense, we have proposed a model of a mosaic transition from the Middle to Upper Paleolithic (Cortés Sánchez 2004). Bajondillo/14–11 is the only example representative of the Málaga coast. It seems that the low density of Modern Human populations (if we assume that they were the originators of the oldest Upper Paleolithic industries) indicate an avoidance of Southern Iberia, until the end of MIS 3, when the first Gravettian industries are found in the area (Cortés Sánchez 2004).

Paleoenvironmental data, including sedimentology (cryoclasts), palynology (dominance of arid steppe) and isotopic analysis, indicate that the late Mousterian occupations in Bajondillo cave took place during a very cold climatic phase. This concurs with the oceanic record (Cortés Sánchez 2007). The presence of this cold period could reinforce the hypothesis that the cooling of MIS 3 was the cause of extinction of the Neanderthals in the Southern Iberian Peninsula. However, when this problem is dealt with in a regional perspective, the hypothesis seems too mechanic and simplistic. In our opinion it is necessary to provide better descriptions (or characterizations) of the last Neanderthal occupations to improve insight into this historical problem. Therefore, we have carried out a use-wear analysis of the lithic tools recovered in Bajondillo 14, to understand the technical activities of the last Neanderthal populations at the site.

Use-Wear Analysis of Lithic Tools

In general the preservation of lithic tools in Bajondillo is very good, lacking the alterations (soil gloss, thermal alteration, white patina etc.) that usually affect archeological sites of this age. The analysis of the active edges of the tools was carried out using a binocular Nikon microscope, with between10× and 90× magnification, and with a metallographic Olympus BH2 microscope, with between 50× and 400× magnification. A sample of 296 lithic artifacts was analyzed. The results indicate clear use-wear traces on 123 objects (41.5%), 53 objects (18%) do not have any use-wear traces whilst 120 objects (40.5%) have been classified as undeterminable, because of their weak and ambiguous traces. Butchery and woodworking are the most common activities identified in the analysis, while hide working is less important (Fig. 20.2). For an important group of tools ($n = 58$), we have only identified the motion of the tool and the relative hardness of the worked material, because the criteria for inferring a precise worked material were not clear enough. Most of these tools were used for working soft and medium materials, while only two tools were used on hard materials.

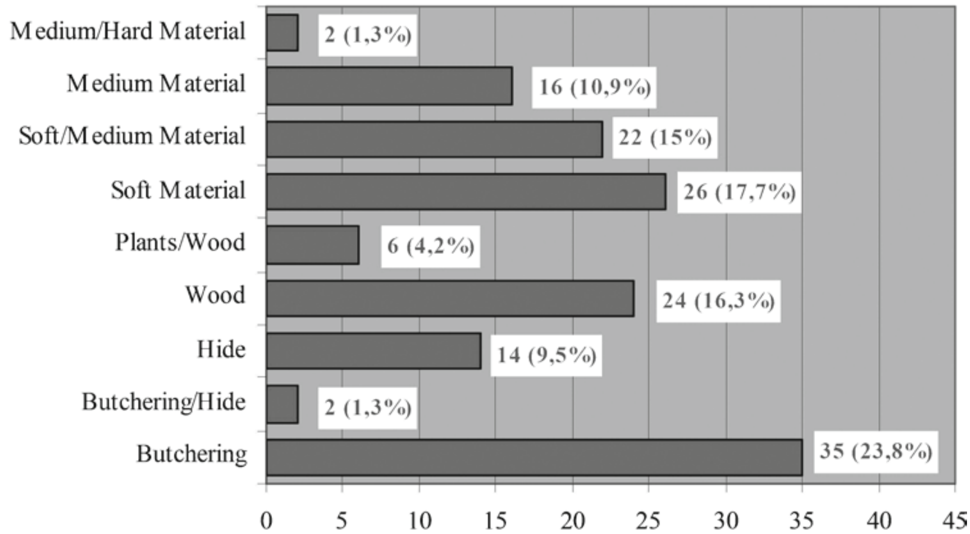

Fig. 20.2 Results of the use wear analysis for the Bajondillo tools, level 14

Butchery activities were most often executed with unretouched flakes and sometimes also with blades – only two of the retouched tools show butchery traces. Since the use traces are present on the unretouched edge, opposite to the retouched one, we infer that the retouch may have been intended for hafting or handling purposes (Fig. 20.3: 1–2). The selection of unretouched tools for butchery has also been documented in other Mousterian sites, e.g. El Salt, Abric Romaní, Riencourt-lès-Bapaume, Les Tares, Grotte Breuil and la Combette (Beyries 1993; Geneste and Plisson 1996; Lemorini 2000; Rodríguez et al. 2002; Martínez 2005).

Three of the hide working tools were used for scraping fresh hide and two for scraping dry hide. For 8 tools the state of the hide when worked could not be identified. These tools were used for scraping ($n=7$) and cutting ($n=1$). Hide processing tasks were carried out with sidescrapers, endscrapers and unretouched flakes in Bajondillo 14 (Fig. 20.3: 3–4). This diversity of hide working tools has also been documented in other Mousterian sites, as Marillac, Arcy-sur-Cure, El Salt, Grotte Breuil or La Combette (Beyries 1987; Lemorini 2000; Rodríguez et al. 2002), where sidescrapers, endscrapers and even notches and denticulates were utilized for this activity. Despite this diversity, the active edges show consistent characteristics: high edge angle (94% between 40º and 80º), convex morphology (77%) and straight longitudinal section (23%).

Wood was worked with a variety of lithic tools and both scraping ($n=14$) and cutting ($n=4$) activities are indicated. Cutting was carried out with one denticulate, one sidescraper and two unretouched flakes, while scraping was undertaken with sidescrapers and, less often, with notches, denticulates and burins (Fig. 20.3: 5–6). Similar wood working tools are also found in other Mousterian sites (Anderson 1981; Beyries 1987; Lemorini 2000).

Among the artifacts for which only the relative hardness of the worked material was inferred, we found:

- 23 unretouched flakes with very acute active edges used for cutting soft materials;
- 19 artifacts used on soft or medium hard materials; cutting activities were carried out with the acute edge of unretouched flakes, while scraping motions were executed with unretouched flakes, sidescrapers and denticulates;
- 14 artifacts for scraping and cutting medium hard materials; unretouched flakes were chosen for cutting activities and unretouched flakes, denticulates and notches for scraping.

Only two artifacts were used on a hard or medium hard material; the relative low numbers of Mousterian tools used for working hard materials has already been observed in a number of sites, as El Salt, Abric Romaní, Abri Pie-Lombard, Marillac, Arcy-sur-Cure, Pech de l'Aze I and IV, Corbiac, Grotte Vaufray, Combe Grenal, and Riencourt-lès-Bapaume (Anderson 1981; Beyries 1987, 1993; Rodríguez et al. 2002; Martínez 2005).

We found a total absence of lithic projectile points in Bajondillo. This type of tool is not usually found in Mousterian sites, although some occur in the sites of Axlor in Spain or Yaglar and Sakajiase in Russia (Shchelinskij 1993; Ríos 2007). It seems that local Neanderthals preferred hunting tools made exclusively on wood. However, it is also possible

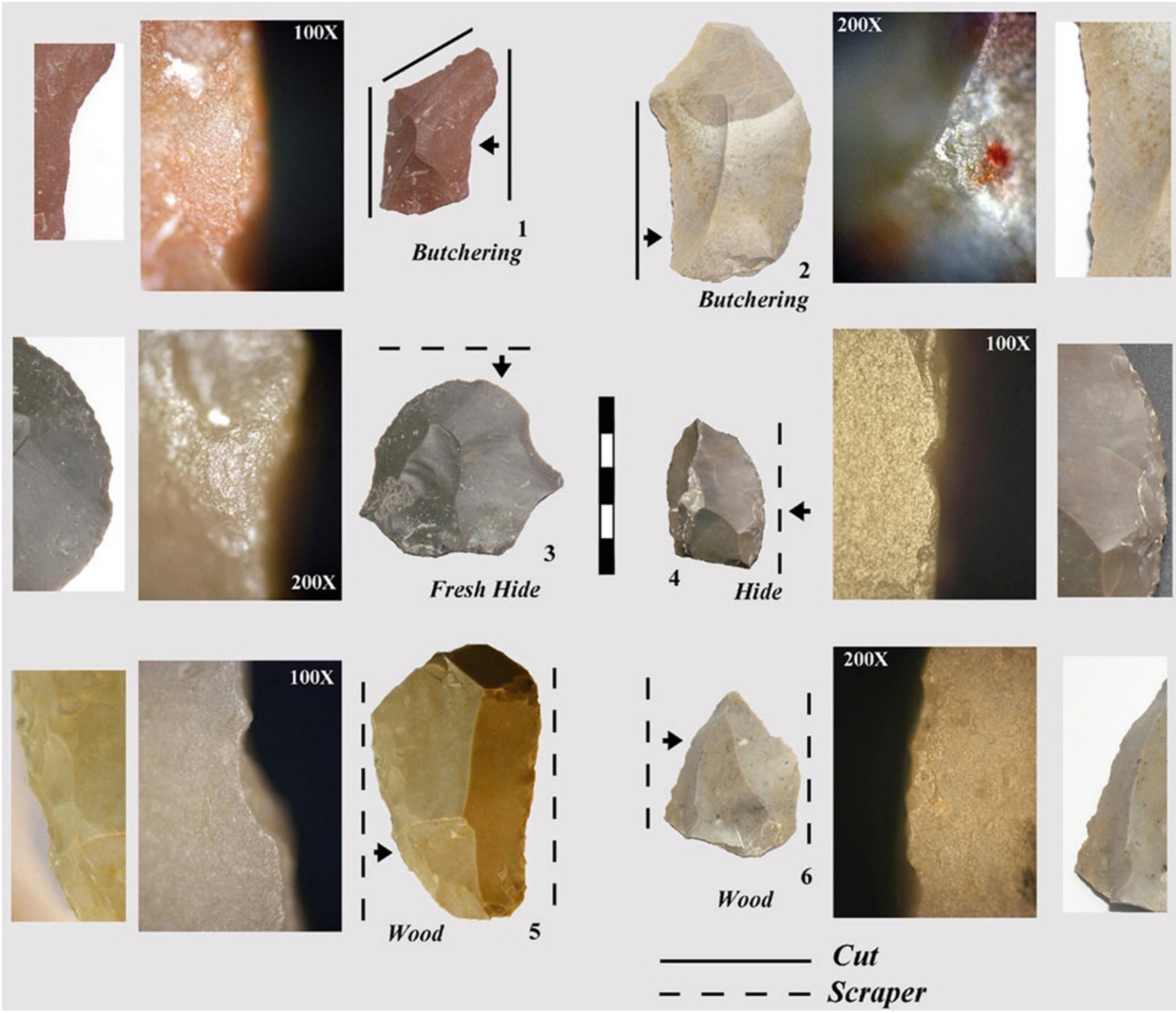

Fig. 20.3 Use wear analysis for the Bajondillo tools, level 14

that perhaps flint points are not present in Bajondillo because the activities around the discard of points (i.e., hunting tool maintenance) were not carried out at the site. The use of stone projectiles among Neanderthals is still a subject of debate. In general the use traces (micropolish and rounding) are scantly developed, indicating a low intensity of use of the tools. It seems that the activities carried out at the site were not very intensive, and may have been related to the finishing or maintenance of different types of objects. We have to point out, however, that this low intensity of use could be partially explained by the abundance of lithic raw material near the site. The relative abundance of butchery and hide processing tools could indicate that, in Bajondillo 14, the processing of hunted animals was a primary activity. The tasks carried out on wood could have been aimed at repairing objects such as hafts or wooden points, that is, activities that were complementary to the animal tissue processing.

Discussion and Conclusions

In the context of the Middle Paleolithic in the southern Iberian Peninsula, Bajondillo cave belongs to a group of sites that were occupied at the end of MIS 3 (Complejo del Humo, Gibraltar and Zafarraya), in the period between 35 and 28 ka. The occupation of this area began in MIS 5. At the end of MIS 3, the number of sites and the density of archeological items within the sites began to go diminish up to the point of an apparent sudden collapse. Bajondillo cave offers relevant information of the end of the Middle Paleolithic in southern Iberia, a period that shows the following characteristics:

- Lithic technology based on Levallois methods, though discoid methods are also present;
- Late chronology (circa 28 ka) in comparison to other European areas (Finlayson et al. 2006);

- Lithic raw material procurement in local outcrops (Simón Vallejo and Cortés Sánchez 2007);
- Expedient usage of lithic tools;
- Stability during the local Middle Paleolithic and an abrupt transition to the Upper Paleolithic industries (Cortés Sánchez 2004, 2007);
- The occupation of Bajondillo 14 seems to be less intense in comparison to the underlying levels.

This could be explained in several ways: The dropping of the sea level would have provoked the emergence of a band of 8 km of continental platform. A number of points can be made with regard to the decline in population density at Bajondillo:

(a) The occupation of the western area of the Málaga bay could have been in decline and other nearby areas may have been preferred for the more stable settlements (i.e., east of the Málaga bay or Algeciras bay);
(b) The first Upper Paleolithic innovations, Aurignacian industries, appear circa 32 ka (AMS) or 28 ka (TL) ago in Bajondillo (level Bj/11). The definite and intensive Upper Paleolithic occupation takes place during the Gravettian period;
(c) Up until now, the coexistence of Neanderthal and Modern Human populations has not been documented;
(d) The end of the Middle Paleolithic and the extinction of the Neanderthals should not be explained by a single factor, but by interaction of environmental, anthropological, cultural and economic factors.

For these reasons a further investigation of the transition of the Middle to Upper Paleolithic is very important. At Bajondillo there is a clear discontinuity between the reduction sequences of the Middle and Upper Paleolithic. Thus, it is necessary to understand and study the detailed aspects of the Late Mousterian horizon, such as the subsistence patterns, landscape use and mobility patterns and to compare this to that of the early Upper Paleolithic (Aurignacian) and the industries that develop from then (Gravettian) in Southern Iberia. Also, during the Upper Paleolithic the first evidence for art in this region occurs at the caves of Ardales and La Pileta, where the representation of hands is very common (Cantalejo et al. 2006; Fortea Pérez 2005).

As data for Southern Iberia increases with new research at Gorham's Cave, Zafarraya and Bajondillo Cave (Cortés Sánchez 2002; Finlayson et al. 2006; Barroso and de Lumley 2006), the scenario becomes more complex than one would have expected. The historical context from this fairly wide time slice and from a large region cannot be described as a single entity, but as a mosaic marked by diverse environmental and cultural conditions. From our point of view, the research carried out in Bajondillo in the next few years will focus on a re-evaluation of the dating results (correlating the AMS to the TL data) as well as on a comparison with the other regional sequences. From a cultural point of view effort will be aimed at the study of land use and subsistence patterns (e.g., the importance of marine resources in the diet), the raw material economy and use, and use-wear of the lithic assemblages.

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Chapter 21
The End of the Middle Paleolithic in the Italian Alps

An Overview of Neanderthal Land Use, Subsistence and Technology

Marco Peresani

Abstract The Italian Alps were a familiar region for the last Neanderthals. Evidence from several sheltered and open-air sites prove that these humans exploited mineral and animal resources, and that these ways of organizing economic activity were deeply rooted in their social systems since early times. Human occupation spans from lowland to highland in the fringe between the Alps and the plain, a belt where the geographic and ecological contexts differ at a very small scale. Chronometric, ecological, economic and cultural evidence reveal how archaic humans adapted to climatic shifts, used different sites for different targets, and above all improved and refined lithic technology at the very end of their existence.

Keywords Landscape • Geographic conditions • Hunting economy • Lithic economy • Seasonality

Introduction

Numerous scientific contributions in Italy concerning the Neanderthals during the Middle Paleolithic (MP) discuss human behavior in relation to distinct geological, ecological and cultural factors that influenced human occupation throughout this peninsula, extending from the Alps to the middle Mediterranean Sea (see for instance contribution in Bietti and Manzi 1991; Guidi and Piperno 1992; Stiner 1994; Kuhn 1995; Bietti and Grimaldi 1996; Milliken 2000; Mussi 2001). Authors highlight the role played by the most relevant geographic thresholds, like the Alps and particularly the Apennines, in creating a marked contrast between the Thyrrenian region, subjected to the effects of the Mediterranean climate, and the Adriatic-Po regions, more likely integrated in a context where climate shifted towards typical continental conditions as a result of the cyclic continental shelf emergence during glacial expansions. Reconstructing human ecosystems is thus a target as complex as depicting their boundaries, which shifted from highlands to lowlands as a result of the glacial-interglacial cycles. Becoming more intense from the onset of the Middle Pleistocene than in earlier times, such global climate forcing affected the spatial-chronological distribution of resources, with dramatic implications for human dispersal phenomena.

Extremely full of gaps in the earlier phases, evidence of human behavior becomes more detailed during the Late Pleistocene and particularly in Marine Isotope Stage (MIS) 3, a period relatively better known throughout the peninsula, given the high number of locationally – and economically – differentiated settlements (Kuhn and Bietti 2000; Milliken 2000; Bona et al. 2007). Research in the last 10 years has produced new data on settlement dynamics, mobility and economic strategies implemented by Neanderthals between the MIS 4 and the Middle Paleolithic (MP) to Upper Paleolithic (UP) transition. In some cases research has specifically focused on this period. However, these advances are still at an inadequate level of detail to interlace human evidence with the intense climatic variability recorded for this specific interval (e.g., Bond et al. 1992; Dansgaard et al. 1993) and the latter's effects on the ecosystems in Mediterranean Europe (Watts et al. 1996; Allen et al. 1999; Sánchez-Goñi et al. 2000). As a whole, these advances represent a powerful tool to draw comparisons with human behavior in the early Upper Paleolithic, a phase sometimes recorded at sites previously visited by Neanderthals. The insufficiently-debated comparisons that involve the economic and cultural ambits of Paleolithic societies over the MP-UP transition imply anthropological repercussions when looking at the substitution of Neanderthal species by anatomically modern humans (see papers in Conard 2006; Trinkaus 2011; Zilhão 2011). Rather than making comparisons, the present contribution describes Neanderthal behavioral ecology in the Pre-Alps, a particular region bounded by the Alps to the north and the Po Plain to the south.

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Apart from a few generic or targeted contributions published during the last decade (Milliken 2000; Peresani 2001), settlement dynamics around the MP-UP transition did not receive detailed attention or regional integration. A few works, mostly based on the data gathered from Grotta Fumane (Broglio 1995; Broglio et al. 2003a), aimed to highlight differences and similarities between Neanderthal and anatomically-modern human (AMH) behavior. However, some of these reports discussed field evidence that was not confirmed by subsequent analytical verification (i.e., Broglio 1995; Gala and Tagliacozzo 2005). This approach arises from the traditional convention to consider modern behavior as an exclusive phenomenon of *Homo sapiens* – given for instance the exponential increase in art, ornaments and technological markers (bone artifacts) so undeveloped in previous contexts – regardless of a proven correlation between biology and culture.

In spite of the potential high scientific value inherent in some key sites (Grotta Fumane, Riparo Tagliente), investigating this topic requires us a more integrated approach than evident until now. At same time it is necessary to increase data from the final Middle Paleolithic, an archive currently represented by a handful of sites set in the belt between the alluvial plain and the Pre-Alps. This is the area in which both Neanderthals and modern humans lived.

Landscape, Sites and Hunting Economy

The Italian Pre-Alps and the sub-alpine zones are a combination of reliefs that succeed one another, forming a discontinuous series composed of short chains and mountain groups from the Lago Maggiore to Istria. This combination encompasses a 40 km-wide belt, oriented west-east in the western-middle sector and progressively turns to the north in the eastern transect where it arches, facing the plain to the south. The landscape in the central Pre-Alps, and particularly between the Como and Lugano lakes, is dissected by deep and narrow valleys, steep slopes and mountains peaking at 1,800–2,000 m. Conversely, the Eastern Pre-Alps are limestone massifs and karstic high plateau set at 1,000–1,200 m altitude, together with summits above 2,000 m intercalated with gorges, deep and large valleys or wide basins, through which the main rivers flow or are occupied by the most important glacial alpine lakes. To the east, the Trieste karstic plateau forms a typical flat landscape that extends to the Danube Basin. The subalpine zone comprises hills of different origin, such as the Monti Berici karst-plateau and the Colli Euganei cone-shaped reliefs, two groups isolated from the alluvial plain that is composed of large gravelly fans.

In the pre-alpine belt, climate during the first Würm Pleniglacial produced freeze-thaw rock-fall degradation, recorded at caves and rock-shelters (Cremaschi 1990), and supported the establishment of continental grassland-steppe on the plain (Cattani 1990; Donegana et al. 2008) with typical Asiatic fauna (Sala 1990). The MIS 3 period saw continuous oscillations in relative percentages of *Pinus*, *Picea*, *Betula*, Graminae and xerophytes as a result of alternations between steppe and taiga. According to Donegana et al. (2008), climate never reached temperatures that could support broad-leaved forests on the plain, even if local anthracological spectra reveal that broad-leaves wood was used to light fires in caves (Cattani and Renault-Miskowsky, 1984). Pedogenesis affected undated aeolian deposits (Lanzinger and Cremaschi 1988; Cremaschi 1990). In the 50–30 ka interval, the environment was mainly covered by trees, even if some cooler and drier periods promoted steppe and grassland expansion with ibex, chamois and marmots at low altitude alongside steppe-dwelling micromammals and tundra-dwelling birds. On the middle Po Plain, mammoth and Irish elk, in association with woolly rhinoceros, steppe bison and elk, confirm the occurrence of cold steppes (Sala 2001). The transition from the Mousterian to the Early Upper Paleolithic (Aurignacian at Grotta Fumane) coincides with a clear climatic shift, leading conditions becoming cooler and drier than in earlier phases (Fiore et al. 2004). Humans used prealpine caves at middle altitude in a context of open-spaced forests where vegetation adapted to thin soils. Such conditions were probably transitive to discontinuous alpine grasslands or pioneer vegetation on carbonate rocks. Alternation between humans and cave bears in using caves has been recorded at middle altitude (Bona et al. 2007). Climatic oscillations thus produced correlative shifts in the transitional mountain belt driving alternations between open and barely-arboreal, and arboreal-brush with small open-spaced contexts that can probably be correlated to variations in associated dominant ungulate species.

In spite of the numerous Middle Paleolithic sites (Fig. 21.1), only few fall within the above-defined time interval, and this group further reduces when we focus on the chronometrically-dated assemblages. Numeric ages are currently available for Grotta Fumane (Peresani et al. 2008), Grotta San Bernardino (Gruppioni 2003), Grotta Broion (Peresani and Porraz 2004), Caverna Generosa (Bona et al. 2007) and Grotta Rio Secco (Peresani and Gurioli 2008). Moreover, three undated sites, Riparo Tagliente (a single unpublished 54 ± 11 ka TL date was provided at Gliwice Laboratory in 1989), Grotta Ghiacciaia (Bertola et al. 1999) and Riparo Broion in proximity of the namesake cave (De Stefani et al. 2005), should fall within the 50–30 ka period. This assumption is based on the direct stratigraphic overlapping of the Mousterian sequences by levels containing Aurignacian implements or lithic assemblages that can be attributed to a generic Initial Upper Paleolithic (i.e., Riparo Broion). Among them, only Riparo Tagliente provides

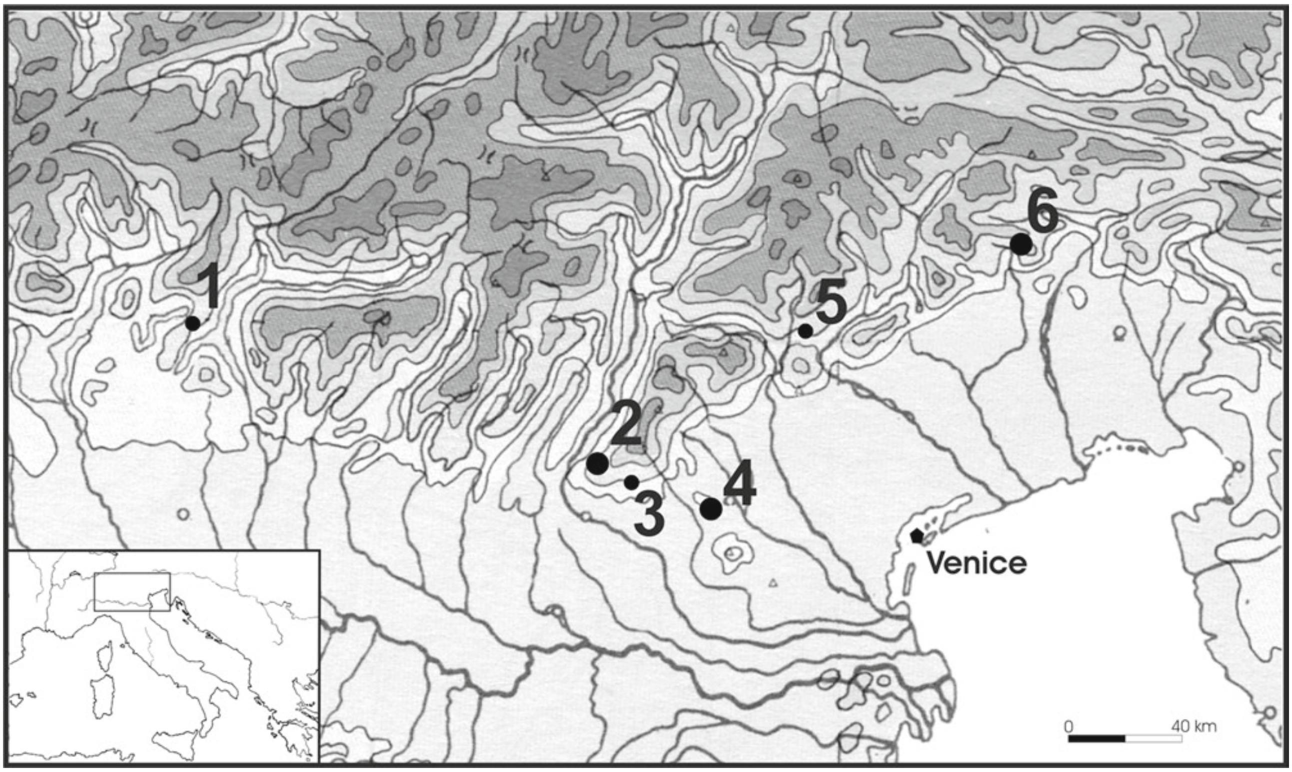

Fig. 21.1 Map of Northern Italy showing the Middle Paleolithic sites mentioned in the text (*1*: Caverna Generosa; *2*: Grotta Fumane and Grotta Ghiacciaia; *3*: Riparo Tagliente; *4*: Grotta Broion, Riparo Broion, Grotta San Bernardino; *5*: Monte Avena; *6*: Grotta Rio Secco)

archaeozoological and cultural data significant for promoting comparisons and tentative correlations with the dated sequences. All the considered sites are located in morphological, geological and ecological contexts. Monte Avena, at 1,500 m altitude, is the single open-air site that might fall within the time interval at the end of the Middle Paleolithic. A few Levallois cores and flakes have been recovered in proximity to flint outcrops from a paleosol attributed to MIS 3 (Lanzinger and Cremaschi 1988).

Human remains have been found at Grotta Fumane, Grotta San Bernardino and Riparo Tagliente. Neanderthals at Grotta Fumane are represented by one deciduous lower molar at the base of layer A11 (Giacobini 1992); at Riparo Tagliente by one phalanx and two deciduous teeth, an upper right second molar and an upper left canine in levels 36 and 37 (Villa et al. 2001). At Grotta San Bernardino, the size and morphological features of three remains recovered in unit II, one distal hand phalanx, a probable third lower right molar and a second left lower incisor, do not contradict a possible attribution to the Neanderthal group, even if these features alone do not permit certain taxonomic attribution (Vacca and Alciati 2000).

Grotta Fumane is one of the most important Italian sites for studying human behavior in the Middle Paleolithic, as much as for the MP-UP shift. This cave lies at 350 m altitude along one of the narrow valleys that dissect the Western Lessini plateau, positioned in the middle, between the Adige alluvial plain a few kilometers south and the overhanging high plateau at 1,000–1,200 m with its gentle landscape originated by karstic and periglacial processes. Although known since the nineteenth century, Grotta Fumane has been subject to modern excavation since 1988. The main cavity and few side galleries cover almost 80 m² at the cave mouth, and preserve the 12 m-thick cave fill and many Mousterian (Peresani and Sartorelli 1998), Uluzzian (Peresani et al. 2008) and Aurignacian (Broglio et al. 2003a, 2003b; 2006; Broglio and Dalmeri 2005) levels embedded in the four macro-units that frame the overall sequence (S, BR, A and D). Sedimentary aggradation occurred during the main climatic events of the last glacial cycle, from Early Weichselian to the second half of the Middle Weichselian. Such events drove both pedosedimentary processes and human occupation (Ferraro 2002). Regarding the MP-UP transition, a highly-detailed sedimentary succession covers the final Mousterian, the Uluzzian and the first Aurignacian in an excellent state of preservation, embedded in levels formed by frost-shattered breccia, aeolian silt and sands. Final Mousterian and Uluzzian levels have been investigated in 6–20 m^2 sectors and yielded lithic and faunal remains densely (units A11, A10, A9 and A8, A6) or sparsely (units A5, A4, A3) scattered on the living floor. Estimates using chronometric, lithological and biological data seem to support the idea that the entire late Mousterian-Uluzzian sequence from A11 to A5 (Mousterian) and from

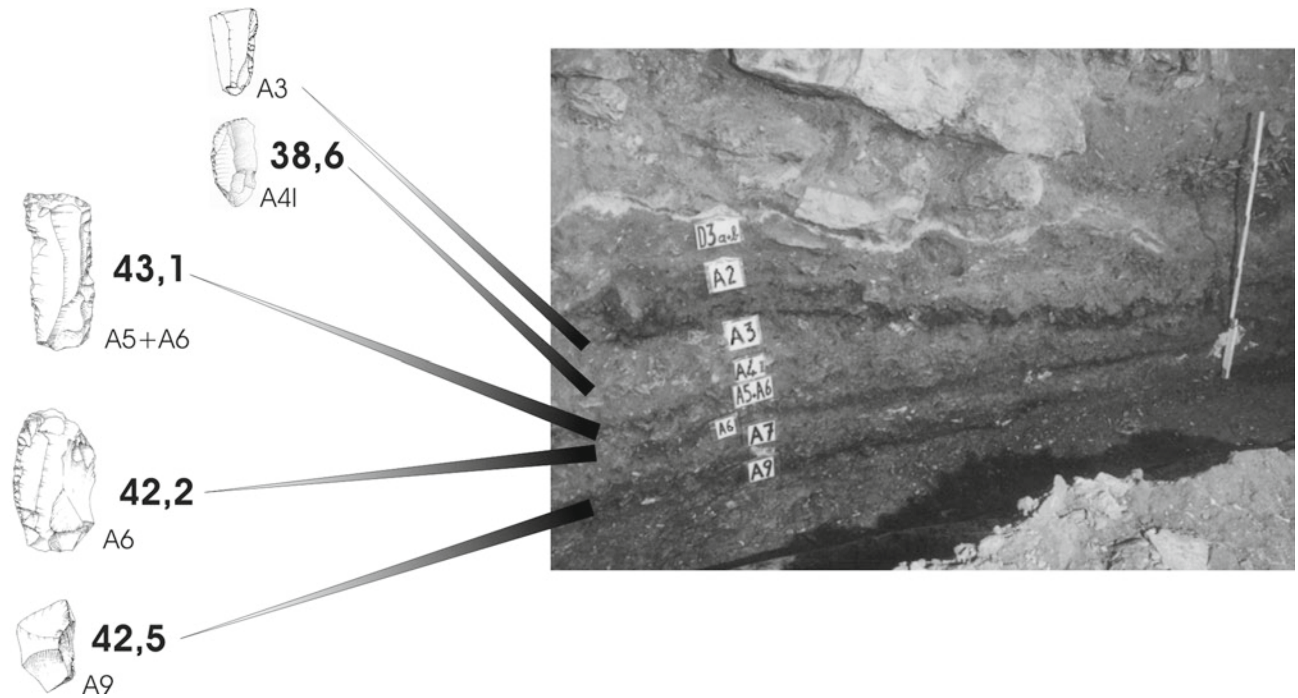

Fig. 21.2 The MP-UP transition visible on the main section at Grotta Fumane with the dominant technological outline reported for each LMP layer (see also Peresani et al. 2008 for details on the chronological layout)

A4 to A3 (Uluzzian) may cover a few thousand years interval between 42.8–32.5 (uncal.) kyr BP (Peresani et al. 2008) (Fig. 21.2).

Grotta San Bernardino, Grotta Broion and Riparo Broion lie in the Berici Hills, a low karstic plateau gently dipping to the south-west and abruptly connected to the alluvial plain along its eastern slope, and dotted with caves and rock shelters. Grotta San Bernardino was discovered and first excavated almost 50 years ago, and subsequently investigated between 1986 and 1993. At the entrance between the cave mouth and the external slope, the sedimentary succession includes eight litho- and pedostratigraphic units composed of gravels, freeze-thaw breccia, aeolian dust, and organic matrix-supported breccia, arranged in accordance with three main paleoclimatic cycles shifting from damp-temperate to cooler and drier climatic conditions. Several human occupation levels are recorded in this sequence, dated to a large time interval spanning the late Middle Pleistocene and the Upper Pleistocene. One of the most intense human occupations recorded from MIS 3 can be recognized in unit II, attested by dates, hearth remains, temperate-type associated faunal remains and lithic implements scattered on the ground (Gruppioni 2003; Peresani 1996).

Grotta Broion and Riparo Broion face the alluvial plain at 135 m above sea level and are overhung by an Oligocene reef limestone on the edge of the Berici Hills karst plateau. Grotta Broion displays a particular situation within the context of north-eastern Italian Mousterian settlements. Initially originated from a large karstic pit, this cave comprises a squared entrance extending to a gallery, which becomes wider in its inner zone and terminates with a vast 15 m-deep pit. In this pit, a small cavity named Grotta del Leone was intensively used as cave bear den. Modest in size and uncomfortable, the inhabitable space in the main cavity and in Grotta del Leone changed over time as a result of the sedimentary aggradation. Low densities of lithic artifacts (almost 10 pieces/m^3), embedded in a more than 5 m-thick stratigraphic sequence, have been recorded. Integrated studies and radiocarbon dates place the top Mousterian sequence in the 50–30 ka interval (Peresani and Porraz 2004). Grotta Broion corresponds to a particular type of human occupation in an area poor in lithic raw material sources.

Riparo Broion is in the process of being excavated. Its deposits are mostly composed of fine sediments, stones and carbonate concretions, and number 16 lithological units. The lowermost Mousterian levels (units 13, 9, 7 and 4), still uninvestigated, are separated by sterile layers from the overlying unit 1 with early Upper Paleolithic and Gravettian assemblages (De Stefani et al. 2005). Undated and unexplored, the Middle Paleolithic sequence seems to provide evidence of repeated human occupation.

Discovered in 1958 and currently still under excavation, Riparo Tagliente lies on the left side of the Pantena valley at 250 m altitude, in the middle Lessini Mountains. Late Pleistocene deposits at this site form two main sequences separated by an erosional discontinuity: the uppermost one is Epigravettian, and the lowermost one includes several Mousterian levels with a few Aurignacian artifacts at the top. Huge amounts of faunal remains and lithic implements have been recovered in the still undated and poorly explored uppermost Mousterian levels. Lithic raw material sources abound at surrounding sites in the valley bottom (Arzarello and Peretto 2005).

Caverna Generosa sets at 1,450 m altitude, on the steep southern slope of the Monte Generoso Massif. This cave comprises a group of cavities that form a 200 m long system in which stratified deposits are preserved in the first 70 m. The entrance constitutes an initial tunnel through which one enters a first chamber, to the side of which it is possible to pass through a narrow siphon and reach a larger chamber named "Sala Terminale", where a huge accumulation of *Ursus spelaeus* remains was found. Discovered in 1988, this cave-bear deposit induced paleontologists to organize investigations from 1991 until the present-day. Cave fill deposits number nine lithological units, which in some cases bear marked taphonomic features originating from faunal turbation, compounding a complicated stratigraphy in the "Sala Terminale". The radiocarbon dataset obtained from *Ursus spelaeus* bones defines the uncalibrated 18 kyr interval, bracketed between the latest age measured for level 2 and the earliest from level 6 (Table 21.1; Bona et al. 2007). A handful of lithic artifacts – a few flakes and two Levallois flakes – have been found scattered in the tunnel and in the "Sala Terminale". No human remains have been identified.

Grotta Rio Secco opens at 580 m on a karstic gorge wall in the Pradis Plateau, Carnic Pre-Alps – a region in the middle of diverse ecologic and geomorphic zones: the Veneto area rich in flint to the west, and the Julian Alps, the Trieste Karst, Istria and the Dalmatian coast to the east, where lithic raw material sources are available during different conditions. Due to its intermediate position between the upper alluvial plain in western Friuli and the Pre-Alps, the Pradis Plateau played a pivotal role for human groups adapted to enter the inner Alpine region and the upper Tagliamento river basin. Such a role is further supported when we consider the notable paucity of flint in this region. Investigating the raw material acquisition patterns associated with Grotta Rio Secco may provide new perspectives on, human mobility, territorial occupation and lithic raw material exploitation. The site is a vast and high shelter, with one large tunnel in the middle wall almost totally closed off by a rock-fall at the entrance. Two pits excavated in the summer of 2002 at the cave-entrance have exposed a 1.7 m-thick sedimentary succession. Four units comprise sterile mega-breccia, reworked deposits, and a lowermost loose breccia (unit 5) with lithic artifacts, faunal remains and an indeterminable fragmented cut-marked diaphysis. This specimen provided the radiocarbon age 37,790 ± 360 BP (LTL429A; Peresani and Gurioli 2008). The varied ecological site conditions in this region are related to very different economic situations in terms of flint and nutritional sources, as well as in lithic implement circulation.

Hunting and related activities are recorded at Fumane, Riparo Tagliente and San Bernardino, whereas no evidence for food provisioning has been revealed at Caverna Generosa and Grotta Broion. No data have yet been provided concerning Riparo Broion and Grotta Rio Secco. At Fumane, Riparo Tagliente and San Bernardino, faunal composition and taphonomic data indicate that the main hunted ungulates during the 50–30 ka interval were mostly *Cervus elaphus* and *Capreolus capreolus*, with *Rupicapra rupicapra* and *Capra ibex* in lesser quantities. There is a constant low presence of *Bos/Bison*, *Megaloceros giganteus*, *Alces alces* and *Sus scrofa*, as well as other mammals like hare, marmot and beaver. At Grotta Fumane, macromammals, and specifically hunted ungulates from levels A12 to A4, reveal moist-cool climatic phases that encouraged forests to extend onto Alpine grasslands. Nevertheless, *Capra ibex*, *Rupicapra rupicapra*, *Marmota marmota* and some birds – *Pyrrhocorax graculus* and *Lagopus mutus* – indicate that open Alpine environments were still present near caves (Cassoli and Tagliacozzo 1991). Cervidae progressively and clearly increase at the expense of Capridae in levels A11-A10. In the late Mousterian levels 35, 36 and 37 at Riparo Tagliente, the most common species among the ungulates are roe deer, followed by red deer, ibex and chamois that were seasonally (i.e. in springtime) exploited on-site. Marmots were also hunted and processed for their pelts (Thun Hohenstein and Peretto 2005).

The predominant hunted ungulate associations are in agreement with the specific ecological conditions at site surroundings, with shifts occurring as a consequence of climatic oscillations. San Bernardino, Fumane and presumably Riparo Tagliente (Thun Hohenstein, pers. comm.) share similar fauna exploitation models, consisting of the selection of young adult and adult prey and on-site carcass processing. Capture of hare, beaver, marmot and some carnivores (bear, fox, mustelids) is also well documented and might suggest the recovery of pelts. Exploitation of birds is rarely documented, even if it did possibly concern some species of *Galliformes* and *Anseriformes*.

Lithic Economy and Flint Implement Circulation

The geographic distribution of lithic sources (flint, jasper, radiolarites) in the Italian Pre-Alps is extremely varied. Primary and secondary factors contributed to this situation: among the former, the complex paleogeographic structure of Jurassic and Triassic sedimentary basins has to be taken into

Table 21.1 The U/Th-ESR, TL and uncalibrated radiocarbon dataset

Site	Unit/Layer	Method	Lab. number	Date
Grotta Fumane	*A4I*	U/Th – ESR	FU-0003[a]	44,000 ± 7000
	A4II	^{14}C	OxA-8021	33,300 ± 400
	A4II	^{14}C	OxA-6462	33,150 ± 600
	A4II-C1	^{14}C	LTL566A	33,700 ± 350
	A5	^{14}C	OxA-6463	33,700 ± 600
	A6	^{14}C	OxA-11331	34,400 ± 800
	A6	^{14}C	OxA-6464	34,950 ± 700
	A6	^{14}C	LTL-569A	35,450 ± 1180
	A6	^{14}C	LTL-568A	37,300 ± 450
	A6	TL	A6[b]	50,000 ± 8000
	A6	U/Th – ESR	FU-9607[a]	44,000 ± 7000
	A6base-SI	^{14}C	LTL-570A	37,750 ± 400
	A5 + A6	^{14}C	OxA-8022[c]	38,800 ± 750
	A5 + A6	^{14}C	OxA-8023[c]	38,250 ± 700
	A5 + A6	U/Th – ESR	FU-9606[a]	38,000 ± 6000
	A8	^{14}C	LTL-571A	36,650 ± 350
	A9I	^{14}C	LTL-573A	36,450 ± 400
	A9	^{14}C	LTL-574A	38,550 ± 540
	A9	^{14}C	OxA-11346	39,950 ± 550
	A9	^{14}C	LTL-572A	40,150 ± 550
	A9	^{14}C	LTL-376A	42,750 ± 700
	A9	U/Th – ESR	FU-0004[a]	46,000 ± 7000
	A10	^{14}C	LTL-377A	41,350 ± 750
	A10I	^{14}C	LTL-575A	37,100 ± 450
	A11	^{14}C	LTL-577A[c]	36,850 ± 350
	A11	^{14}C	LTL-378A	42,000 ± 750
	A11a	^{14}C	LTL-578A	39,850 ± 500
	A11a	U/Th – ESR	FU-0005[a]	49,000 ± 7000
	A11base	^{14}C	LTL-579A	38,100 ± 600
Grotta Broion	*I*	^{14}C[d]	GrN-4438	40,600 ± 1270
	I base	^{14}C[d]	GrN-4637	46,400 ± 1500
Grotta San Bernardino	*II*	^{14}C[d]	Gd-4528	>28,000
	II	U/Th – ESR[e]	SB0303	54,000 ± 5000
	II	U/Th – ESR[e]	SB0304	49,000 ± 5000
	II	U/Th – ESR[f]	SB1	35,000 ± 4000
	II	U/Th – ESR[f]	SB2 + SB3[g]	38,000 ± 5000
Caverna Generosa	*2*	^{14}C	UtC-10760	51,200 ± 4000
	2	^{14}C	UtC-10761	39,200 ± 1000
	4	^{14}C	UtC-10762	46,700 ± 2400
	6	^{14}C	UtC-10763	47,800 ± 2600
	6	^{14}C	UtC-10764	50,800 ± 5000
Grotta Rio Secco	*5*	^{14}C	LTL429A	37,790 ± 360

The U/Th-ESR, TL and uncalibrated radiocarbon dataset available for the final Mousterian layers at Grotta Fumane, Grotta Broion, Grotta San Bernardino, Grotta Rio Secco and Caverna Generosa

[a] tooth [b] burnt flint [c] samples divided into two, each half was pretreated separately and measured independently [d] conventional dating technic [e] preliminary date on tooth [f] preliminary date on bone [g] average of two samples. Except for Caverna Generosa and Grotta Rio Secco, radiocarbon dates have been obtained from charred wood. Details are given in Leonardi and Broglio 1966; Gruppioni 2003; Bona et al. 2007; Peresani et al. 2008; Peresani and Gurioli 2008

consideration, whereas among the latter, the most important factor is the tectonic activity responsible for dislocating, deforming and fracturing carbonatic and other sedimentary formations.

Primarily in the Veneto Pre-Alps, limestone from Jurassic to Paleocenic age contains huge amounts of finely-textured flint and jasper largely exploited for its high quality and abundance. The grey flint from Biancone and correlated formations were the most frequently exploited sources in a region where other less common varieties also exhibit excellent knapping properties. From west to east, the zones considered to be suitable for supplying finely-textured flints span from the Lombard Pre-Alps to the Belluno area, including Euganean Hills to the south. In spite of such a relative abundance and suitability, these silicates were not at all exploitable: a first reason should be sought in difficulties encountered in accessing the primary exposures that are often scattered on high mountain ridges and far from the main river valleys; the second reason is due to the intense fissuring that affects the flint beds and nodules as a result of tectonic activity. Deposits originated from bedrock weathering, high distance transport and other agents are also varied and well-distributed. They should be considered as possible flint supply localities: blocks, nodules, pebbles and rounded flint cobbles are obtainable for instance in the Oligocene-Miocene and Pleistocene clastic units, paleosols, river and stream gravel plains, as well as glacial and fluvioglacial deposits.

Flint provisioning and lithic raw material economy seem to be already fully organized in the earlier Mousterian. Techno-economic lithic indicators evidence distinct ways of occupying territory in the Venetian region, dependent upon geographical location and function of the site. In the course of the Eemian Interglacial and Early Weichselian, these ways seem to respect a model whereby human movements range over the overall geographic sector in order to accomplish defined tasks and respond to conditions of local raw material availability, revealing how a general social organization coped with the variably distributed and exploited lithic sources (Porraz and Peresani 2006). Through comparison between three sites with distinct techno-economic profiles (Monte Versa, Grotta Broion, Grotta San Bernardino), such organization can be viewed in the way reduction sequences, intensity of exploitation and the timing and type of discard are arranged in space and time. Production phases are also observable, like the planned exploitation of resources during episodic visits at flint supply points (e.g., at the open-air site of Monte Versa), as well as during longer occupations at sheltered sites where lithic raw material was overexploited. This flexibility can also be seen in production goals that imply various adjustments and a major tolerance in incorporating less normalized blanks in tool manufacture (Porraz and Peresani 2006). Whereas sites like San Bernardino or Monte Versa represent typical functional camps (habitation the former, flaking workshop the latter), Grotta del Broion appears more original. Its wide geographic perspective, peculiarities in human occupation and environmental surroundings, suggest that the cave was a specialized site placed at intermediate position between two economic districts.

The final Mousterian occurrences reveal different situations, occurring from excellent flint supply contexts (Lessini Mountains: Grotta Fumane and Riparo Tagliente), to places of scarcity (Monte Generoso: Caverna Generosa) or to those totally devoid of lithic sources (Grotta Broion and Riparo Broion, Grotta Rio Secco). In the latter case, connections between lithic abundance and that of other resources are subtle, with some sites sitting in central (Broion) or marginal (Rio Secco) position within regions that normally enjoy more favorable economic conditions.

At Caverna Generosa, a few flakes and Levallois flakes testify that Mousterians were equipped with end-products and with radiolarite flakes provisioned elsewhere from lowland sources. Levallois flakes and one Levallois by-product prove that lithic reduction sequences were spatio-temporally segmented in the catchment area, and that extremely short flaking processes presumably occurred nearby the cave-entrance (a Levallois core incorporated into the mobile lithic toolkit was previously exploited, introduced into the cave and successively exploited elsewhere outside the cave). Conversely, thin chert slabs easily obtainable from the local bedrock were totally ignored. Radiolarites supplied thick flakes with strong edges geared to accomplishing specific and simple activities.

The lithic industry from Grotta Broion is currently the best example for recognizing the lithic economical processes of earlier Mousterians discussed above. Its geographical and uncommon industrial composition has recently been re-examined from a techno-economic point of view, and had direct implications for modalities of human occupation. As flint was absent within the crucial 5 km distance, humans sought raw material in the Lessini Mountains, the eastern Berici Mounts and the Euganean Hills. This cave seems to have been subjected to repeated short-term occupations during which tool production, shaping and management played a marginal role, tied to territorial organization strategies deeply rooted in this region. Given the very high proportion of exogenous flint, end-products and retouched implements, the series has peculiar features. Contrary to the underlying layers, the lithic assemblage resulting from grouping together the H7, I, J and L/M layers records a decrease in retouched blanks vs. increase in Levallois products. Regardless of the long circulation distance, other indicators (exclusive presence of two cores in comparison to the older groups, refittings and related pieces, morphometric homogeneity of related pieces), in addition to the low quantities of shaped blanks, support the hypothesis that raw material circulated in the form of cores that were introduced onto the site as mobile caches from humans during their transits (Peresani and Porraz 2004; Porraz 2005).

However, Grotta Broion remains a single case among studies of lithic economy in marginal contexts or particularly those with a dearth of flint sources. The other cases considered in this work are devoid of detailed sequences (e.g., Caverna Generosa), or preserve finer-resolution stratigraphies but derive from contexts not marked as useful for verifying differences in raw material exploitation. Whereas Grotta San Bernardino occurs within a specific economic context, Grotta Fumane and Riparo Tagliente occur in areas where flint was largely obtainable in a wide variety of types, the selection of which fulfils technological rather than economic requirements. Preliminary data seem to demonstrate how the A3–A4 Uluzzian industry at Fumane reveals lithological selection to promote bladelet production through the avoidance of exploitation of coarse-textured (oolithic) flint, a material commonly used for flake manufacture in Mousterian levels and blade manufacture in the Aurignacian ones (Broglio et al. 2003a).

The techno-economic layout at Grotta San Bernardino unit II relates to the geographical distribution and provisioning of raw material: abundant flint that differs in quality from that in surrounding areas (1–5 km), high-quality flint from more distant sources (20 km or more) in the Euganean Hills and central-western Lessini (80 km). Complete reduction sequences from locally-provisioned blocks/nodules processed on-site, as well as broken sequences involving partially-exploited cores and in places retouched rough blanks are recorded. Toolkits composed of retouched flakes or Levallois blanks were introduced from the above mentioned distant sources. Flake-manufacture is characterized by the intensive exploitation of raw materials, leading to extreme reduction and to the adoption of technical variants within the most-used modality, recurrent unidirectional Levallois. It has been suggested that such exploitation might relate to prolonged or more complex site human occupations (Peresani 1996).

At Fumane, flint blocks, cobbles and slabs came from local sources on the plateau and down in the stream valleys. Levallois technology is present in almost all the lithic assemblages through the late Mousterian sequence, except in unit A9 and the overlying A8 horizon where the discoid flaking method becomes exclusive. In levels A12, A11, A10, A6, A5 and part of A4, Levallois production does not vary in its exploitation of the diverse lithologies with regard to the structure of the reduction sequence. Techno-functional sequences are complete and all phases are recorded: raw material supply, onset, production and using blanks. The most commonly used modality is the recurrent unidirectional method, rather than the bidirectional technique. It is applied for almost all of the reduction sequence to extract long flakes and just a few points. Viewed in terms of optimized exploitation of the residual core volume, the recurrent centripetal modality is activated at the terminal reduction of the core to detach less regular flakes than in the unidirectional method. Such a shift in flaking aims may also be interpretated as a deliberate choice to obtain short cutting edges to be used for short-term tasks regardless of the complex shape of the artifact. Unidirectional flakes are the blanks most often used for shaping into retouched implements, in comparison to centripetal, cortical and other flakes. Retouched tools mostly comprise scrapers and a few points and notches, rare burins and borers. Among the scrapers, the side-retouched types are more frequent than the transverse, double-side and convergent ones.

An abrupt technological change occurs in A9 and A8, due to the appearance of an exclusively discoidal lithic industry with complete reduction sequences (Peresani 1998). The production system involves a primary and a secondary sequence, both unrelated to the raw material type. Besides the application of the basic predetermination criteria, core reduction frequently required diverse choices and technical solutions that led to modification of the core structure in order to accomplish production requirements and at same time to respect the main technical objectives. Regarding the flint, it has already been noted how some differences that occurred in the degree to which blanks were exploited can probably be ascribed to the diverse textural and mechanical properties of raw materials. Typical discoid products like pseudo-Levallois points, backed flakes with thin opposite edges, and subcircular, quadrangular or triangular flakes were shaped into transverse scrapers, points and denticulates. Functional analyses have demonstrated how these tools accomplished scraping or cutting wood and wet or dry skin (Lemorini et al. 2003).

The Mousterian sequence ends in units A3 and A4. Recently explored over a vast zone, this stratigraphic group provides evidence of repeated short-term occupations in which lithic artifacts and anthropogenically modified ungulate bones were found scattered or clustered near to the combustion structures on the ground. Regardless of the unidirectional recurrent Levallois method in A4, both these levels record lithic production ascribable to innovative technologies unknown in the underlying units. Besides a clearly subordinate manufacture of wide flakes, the lithic industries reveal an ephemeral appearance of the blade volumetric concept and of further methods involving flake-core exploitation. Blade production is organized according to several reduction sequences aimed at obtaining short blades, bladelets and large blades; the latter obtained by exploiting cores with one striking platform. These cores have also been found within product waste from flake manufacture. As for flake technology, innovation can also be seen in the retouched lithic toolkit with the appearance of implements like end-scrapers, splintered pieces and several backed knives unknown in the previous Levallois and discoid assemblages. Backed knives are comparable to Uluzzian-type tools, since they comprise a back opposite to a thin edge. The retouched tools also include sidescrapers and a few Levallois points.

At Riparo Tagliente the Mousterian lithic assemblages recovered from a pit and a trench excavated within the sheltered area demonstrate that flints were supplied from slope waste deposits surrounding the site and the coarse gravel alluvial bed along the bottom valley. It has been pointed out how flint exploitation concerned only some specific types, in conjunction with technological innovations consistent with blade production appearing from arbitrary level 37, and becoming more and more prevalent in the overlying levels.

Blades appear unretouched, even if they reveal presumed use-wear alterations. The Levallois method is still applied in this uppermost sequence, even if the unidirectional and bidirectional modalities become more common from level 37 upwards than the centripetal one, which was frequently used in the lower arbitrary levels. Discoid methods and ones of low conceptual elaboration that were intended to produce flakes have been used throughout the series, and may be ascribed to specific reduction sequences or, conversely, during blade core reduction as well as the terminal Levallois core exploitation (Arzarello and Peretto 2005). Retouched tools are more varied in the upper levels (37–34), where intense, long-term or repeated occupations are suggested by larger amounts of lithic and faunal material than in lower levels.

It has been commonly assumed in Northern Italy that lithic production during the late Mousterian, and particularly in highly-detailed records, remain unvaried throughout the whole stratigraphic sequence and do not reveal any tendency to leptolithization (Peretto 1992; Palma di Cesnola 1996). Diachronic similarities recognized between reduction sequences that are commonly framed by Levallois recurrent uni- and bidirectional modalities, and by recurrent centripetal methods at the end of reduction, reveal how this process is integrated into the most familiar structures of Mousterian lithic production. The goals and significance of such a behavior remain still to be explained. In a wider perspective, it can be suggested that this constant and systematic technological preference in applying uni- or bidirectional recurrent methods was aimed at obtaining elongated blanks to be used for tools and tool-shaping (Peresani 2001). It becomes more frequent in this interval than in earlier times and takes part in a more complex phenomenon showing how variability increases (discoid and other methods) at the end of the Middle Paleolithic regardless of the geomorphological and ecological contexts (Peresani 2001).

Conclusions

The final Middle Paleolithic in Northern Italy is documented in a handful of sheltered sites and rare open-air settlements, which were visited for short-term occupations or repeatedly used for more complex tasks mostly aimed at exploiting mineral, non-mineral and food resources. Large quantities of available lithic raw materials, as well as the geomorphic and ecological variability in the belt between the upper alluvial plain and the Pre-Alps, encompass the context in which Neanderthals lived and circulated with low residential mobility, according to seasonal rhythms (Peresani 2001; Fiore et al. 2004; Porraz 2005). According to their topographic position, some main caves in Venetian Pre-Alps should be considered as reference sites that hosted complex and intense human visitation, where lithic production was intimately integrated with acquisition, processing and consumption of animal resources (Peresani 2001; Fiore et al. 2004; Thun Hohenstein and Peretto 2005). These contexts were associated with ephemeral camps unrelated to the primary mineral sources, and for this reason were used as waypoints and exploitations at the edge of mountain zones. In this case Caverna Generosa can be viewed as a refuge location at which visitation was strongly constrained by high-altitude and bio-climatic conditions. This type of site might well be integrated within the seasonal movements of humans in the western Lombard Pre-Alps area. Poor in lithic implements, Caverna Generosa demonstrates how segmented tool production sequences and the different ways in which these items were circulated are the most useful indicators of planning in human behavior (Peresani and Porraz 2004). Evidence thus demonstrate how the last Neanderthals were familiar with the particular geographical and ecological conditions in this mountain region, and how they coped with the critical distribution of resources. Settlement systems structured their logistical organization according to a vertical adjustment of the economic activities, which visibility nevertheless represents the most uncertain aspect, particularly in the highest contexts where adjustments to the ecological change caused a modification in the familiar scenario.

Remark In these last years since the Bonn meeting research has provided new relevant data on paleoecology, radiocarbon dating and human behavior across the MP-UP boundary. These data lead to a refinement of the current state of art about the climate forcing on vegetation from new pollen records, of the chronometric reference and of the replacements in lithic technology across the sequence of Grotta Fumane (Peresani 2008; Higham et al. 2009; Pini et al. 2009; Pini, in press).

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Chapter 22
Technological Behavior and Mobility of Human Groups Deduced from Lithic Assemblages in the Late Middle and Early Late Pleistocene of the Middle Rhône Valley (France)

Marie-Hélène Moncel

Abstract The Middle Rhône Valley in south-eastern France is a vast corridor bordered by low plateaus and valleys. This area has yielded about 12 sites with one or several human occupation levels, dated to the end of the Middle Pleistocene or the beginning of the Late Pleistocene (OIS 9–3). Most of the human occupation levels are dated to OIS 4 and the beginning of OIS 3, but the (oldest) early sites are rare, e.g., Orgnac 3 (OIS 9–8), Payre (OIS 7–5), Abri Moula (OIS 6–4), and Abri des Pêcheurs (OIS 5–3). The few human remains belong to Neanderthals (Orgnac 3, Payre, Abri Moula, Abri des Pêcheurs, Baume Néron). New geological, stratigraphical, radiometric, palynological and faunal studies of these sites suggest a preliminary chronological and environmental framework for human occupation in this area.

Using this new framework, the lithic assemblages have been analyzed to reconstruct human behavior over time, through raw material gathering and technological and subsistence behavior. Most of the sites show a continuity of technological or subsistence behavior over time, explained perhaps by the function of the settlement or the sedimentation record. The lithic variability among sites cannot be linked with chronological data, except for the appearance of a laminar processing system which is related to the beginning of OIS 4 as in all of southern Europe. Various activities and traditions certainly explain this diversity which cannot, however, be linked to subsistence patterns alone. The data suggest highly mobile human groups, travelling in small territories on plateaus and valleys, along the Rhône corridor for daily subsistence. There is no evidence of human travel into the Massif Central Mountains to the west to collect raw materials; in fact any geographical obstacle appears to have stopped human movements along the south-eastern border of the Massif Central.

The hypothesis of mobile groups, using local raw materials and game during seasonal stops is supported by the data in this paper. The characteristics of this area can be observed in relation to other geographical settings, like the large North European plain or south-western France.

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Keywords Lower and Middle Paleolithic • Regional climate context • Paleoenvironmental framework • Variety of technical behavior

Introduction: The Rhône Valley, Between the Alps and Massif Central Mountains

The Middle Rhône Valley, in southern France, is a long topographic corridor, linking the northern European great plains to the southern European low plateaus and valleys. It is limited by the Alps (eastern border) on one side and by the Massif Central Mountains (western border) on the other. Most of the area is covered by limestone formations, and consequently, we find a great number of karstic cavities (Balazuc 1956–1986; Fabre 1972; Callot 1978; Debard 1988). Most archeological sites were found in caves, the majority of them located on the right (western) edge of the Rhône Valley, along Rhône tributaries and on plateaus (200 m high) (Fig. 22.1). Open air occurrences are rare. Most of the sites are located along the Ardèche canyon, in the same area as the Chauvet cave. Further, in the Massif Central Mountains, a number of Middle Paleolithic sites yield evidence that Neanderthals also occupied the middle mountain environment. The left (eastern) side of the Rhône Valley has produced only a few archeological remains, but we know that humans moved in this district, as shown by high altitude sites in the surrounding Alps area (Vercors Mountains). Archeological sequences occur between OIS 9–8 (Orgnac 3), OIS 7–5 (Payre, Moula, Abri des Pêcheurs) and OIS 4–3 (sites along the Ardèche River). The biostratigraphic patterns are still poorly known in spite of several recent palynological, large mammal and micromammal studies (Moncel et al. 2008a). According to these preliminary results, human occupations were linked to a temperate or cold climatic context, depending on the sites, and give evidence of mosaic landscapes around the caves.

The mentioned data suggests that the Middle Rhône Valley has been inhabited continuously by humans, probably because the climate was milder than in the northern part of

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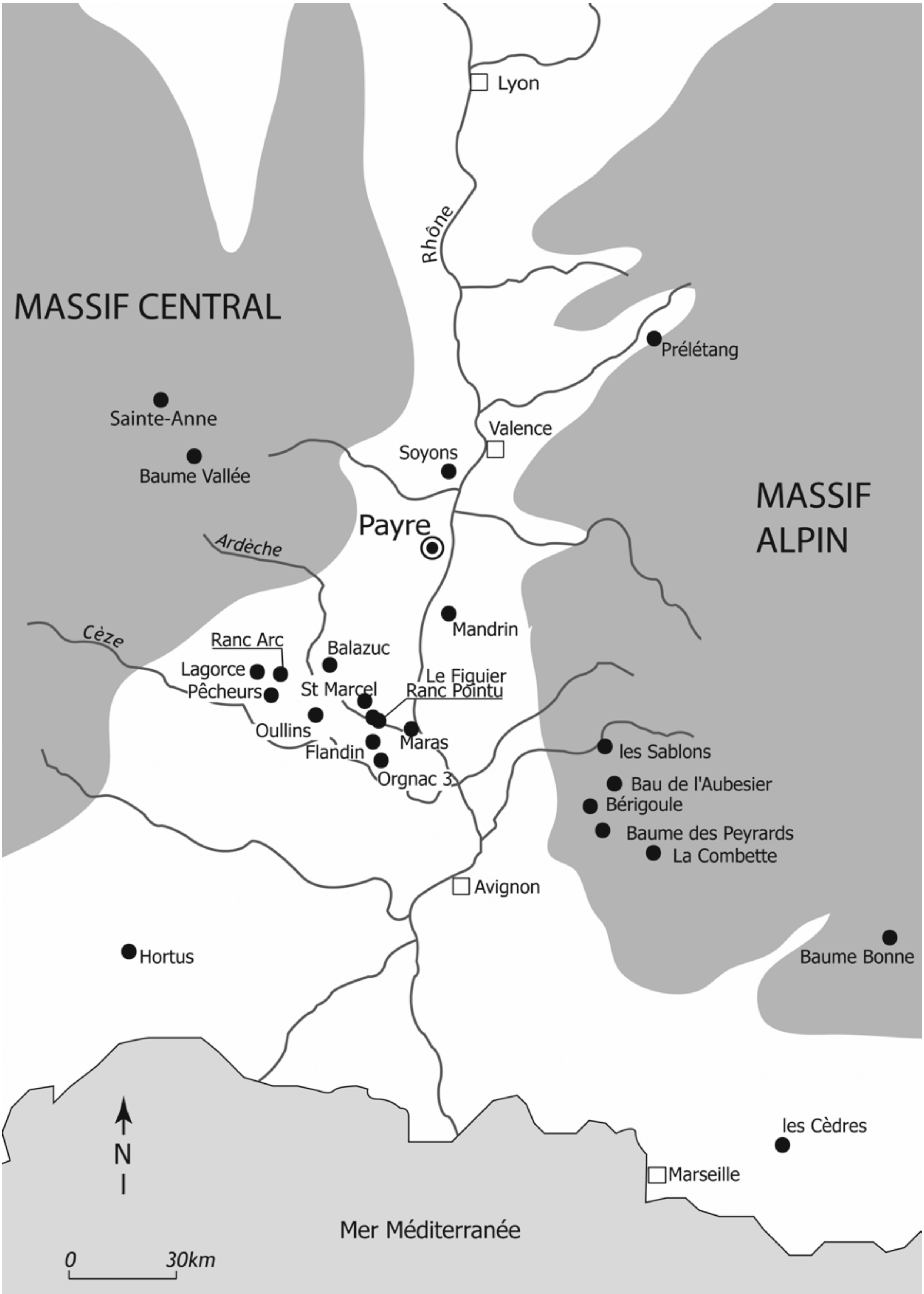

Fig. 22.1 Location of the main Middle Paleolithic sites in the Middle Rhône valley (south-eastern France)

Table 22.1 Neanderthal remains in Pleistocene sites of the Middle Rhône Valley

OIS by ESR–U/Th[a]	^{14}C dates [b]	Sites	Human remains	Lithic assemblages
OIS 9–8		Orgnac 3	7 teeth	Early Middle Paleolithic
		(Combier 1967)	Levels 6, 5b, 5a	Few bifaces
OIS 7		Payre G and F	Parietal and 8 teeth	Early Middle Paleolithic
		(Moncel and Condemi 1996, 1997; Moncel et al. 2002)		Few bifacial tools
OIS 6		Abri Moula c. XVI	1 child	Early Middle Paleolithic
OIS 5		Abri Moula c.XV	90 human remains	Early Middle Paleolithic
		(Defleur et al. 1993, 1994, 1999)		
		Payre E and D	1 tooth in level D; 1 tooth in level E; 3 teeth in level F	Early Middle Paleolithic
		Abri des Pêcheurs, base	7 teeth	Middle Paleolithic
		Abri du Maras, niveau 5		Middle Paleolithic laminar debitage
		Baume Flandin?		Middle Paleolithic laminar debitage
OIS 4	43,000 BP	Baume Néron	2 teeth	Middle Paleolithic
		(Defleur et al. 1992, 1994)		
		Abri Moula		Middle Paleolithic
		Abri des Pêcheurs	6 teeth	Middle Paleolithic
		Ranc Pointu?		Middle Paleolithic
		Le Figuier?		Quina Assemblage
OIS 3		Mandrin		Late Middle Paleolithic
	41,300 BP	Ranc de l'Arc		Late Middle Paleolithic
	30–35,000 BP	Saint-Marcel		Late Middle Paleolithic
	33,200 BP	Abri Moula	Human remains?	Late Middle Paleolithic
	31,750 BP	Baume Oullins		Late Middle Paleolithic microlithic
	39–31,000 BP	Abri des Pêcheurs	4 teeth	Late Middle Paleolithic
		Ranc Pointu?		Late Middle Paleolithic

[a] Falguères et al. 1988; Masaoudi et al. 1994, 1996; Moncel and Michel 2000

[b] Evin et al. 1985

Europe, rather than abandoned by human groups during the coldest periods (Debard 1988; Defleur et al. 2001; Moncel et al. 2002; Moncel 2004) (Table 22.1). The mosaic landscape context certainly favoured this continuous occupation, flint outcrops probably always available in spite of changes in vegetation. We do not know if the Rhône corridor was viable while as endemic diseases existed till the last century (Callot 1947; Bruce-Chwatt and De Zulueta 1980; Ruffie and Sournia 1995). In the south-east of France, two sites have recorded human remains: Bau de l'Aubesier (Vaucluse, OIS 6-4) and Lazaret (Alpes-Maritimes, OIS 6) (de Lumley 1969; Buisoon-Catil 1994; Lebel et al. 2001; Lebel and Trinkaus 2002). The oldest Upper Paleolithic levels are rare in this region, except for some Aurignacian sites such as Chauvet cave. The main occupation is Gravettian.

Regional Climatic Context During Middle and Upper Pleistocene

The greatest glacial formations took place in the Alps Mountains during OIS 8 and 6, and the glacier fronts stopped at the level of the cities Lyon and Grenoble (Montjuvent 1978, 1995; Veyret 1981; Mandier 1988; Bernard-Guelle 2001). Around 70 ka, the Alps recorded the last glacial period (Ancient Würm, OIS 4) (Montjuvent and Nicoud 1988), which seems to have been a intensely cold period in the Middle Rhône Valley, when new species like *Rangifer tarandus* appeared (Defleur et al. 2001). The valleys of the Rhône tributaries probably offered natural refuges or areas of protection far from the Rhône corridor where cold winds blew from northern glaciers. The earliest studies of archeological sequences in this area lead to a proposition of a chronological framework based on the alpine chronology (Combier 1967; Debard 1988) (Table 22.2, Fig. 22.2). Since the 1980s, the use of various radiometric methods (U/Th, ESR, TIMS, TL) yielded new results on the age of the sites and these do not always agree with early chronology (Falguères et al. 1988; Moncel and Michel 2000). Large mammal remains associated with the sites suggest mosaic landscapes and environments (Masaoudi et al. 1994; El Hazzazi 1998; Defleur et al. 2001; Moncel et al. 2002). However, in general, paleoenvironmental studies are still few and the biostratigraphic framework still has to be constructed, especially in this karstic context associated with discontinuous sedimentation (Imbrie et al. 1984; Moncel et al. 2002). Some remains of volcanic tephras were found in the archeological sites:

Table 22.2 Patterns on Middle Paleolithic sites on the right side of the Middle Rhône Valley

Site	Location	Levels	Age	Large mammals	Environment
Grotte de Balazuc ou Barasses		5 levels	Würm II	*Equus*, rhinoceros, *Rangifer tarandus*, carnivores	
Baou de La Sello n°1 et n°2	2 caves near Ardèche River				
Grotte du Figuier	39 m below Ardèche River oriented south	2 levels	End of Würm II (OIS 3?)	*Rangifer tarandus*, bovids, *Equus*, *Ibex*, wolf, *Hyenae*, *Ursus spelaeus, Cervus elaphus*	Lower level: cold and wet, mosaic landscape Upper level: cold event
Baume Flandin (Orgnac II)	Cave oriented west 2 chambers	level 1	End of Riss-Würm?	Cervids, *Equus*, bovids, *Hyenae*	Temperate
Abri du Maras	Shelter Small valley near Ardèche River	8 levels	– Würm II, II/III – level 5: beginning of OIS 4	Base: Cervids > *Equus*, bisons Levels 5 to 1: *Rangifer tarandus*	Forested in levels 8–5 Open vegetation and cold climate levels 5–1
Baume d'Oullins	Cave near Ardèche River	2 levels Rb and Ra	Würm III? Amino acids: 31,750 +−750	*Ibex, Equus,* *Rangifer tarandus*	Rb: cold and fresh Ra: cold and dry
Payre	Cave and shelter Below Rhône Valley oriented south–east	7 phases	D: OIS 6/5 F–G : OIS 8/7 By U/Th, ESR, TL	*Cervus elaphus*, bovids, *Equus* & *Ursus spelaeus,* carnivores	Mosaic vegetation OIS 6: cold, dry, half open OIS 5: more wet, half-forested
Abri des Pêcheurs	Hole-cave Chassezac Valley oriented south–east	7 phases	Base: OIS 5 U/Th: 83,000–118,000 sequence: 39,000–118,000	Base : *Ibex* > Wolf, *Ursus spelaeus*, *Hyenae*	Base: – temperate and wet climate – upper part: OIS 4 Cold and wet, then dry
Ranc de l'Arc	cave Ibie Valley	3 levels	^{14}C level 5: 42,200 + −3000 41,300 + −1900	*Equus*, Cervids	Cold climate
Ranc Pointu n°2	Cave below Ardèche River oriented north–west	C level	Early Würm (OIS 4–3?)	*Cervus elaphus, Ibex capraeolus*	Cold and wet Forested fauna
Saint-Marcel	Cave below Ardèche River oriented south	12 levels	level u: OIS 5 u to f: OIS 3 Level e upper: 29,330 +−650	Level u: Dama & *H. cedrensis* Sequence: *Cervus elaphus*	level u: temperate Sequence: open, forested, wet Spring occupations
Baume Néron	Cave Rhône Valley	4 levels	Würm II ^{14}C: 43,000 + − 1100	*Rangifer tarandus*	Cold and dry
Soyons Trou du Renard	Small chamber Rhône Valley		^{14}C: 31,000	*S. hemitoechus*	
Abri Moula Soyons	Cave Rhône Valley oriented west	21 levels	Levels IV–VII: Early Würm, cold and wet ^{14}C: 33,200 + −1500 Levels XII–XIV: OIS 5e Levels XVI–XV: end Middle Pleist. Levels XIX–XVII: OIS 6	Upper sequence: *Rangifer tarandus Equus*, bovids, *Cervus elaphus*	Open and forested vegetation Level XV: forested and temperate Levels XIX–XVII: cold and steppic

Balazuc 1956–1986; Combier 1967; Debard 1988; Defleur 2000; Defleur et al. 1990; 1994; 2001; El Hazzazi 1998; Evin et al. 1985; Gagnière et al. 1957; Guerin 1980; Kalaï et al. 2001; Masaoudi et al. 1994; 1996; Moncel 1996a; Moncel and Michel 2000; Moncel et al. 2002; Valladas et al. 2008.

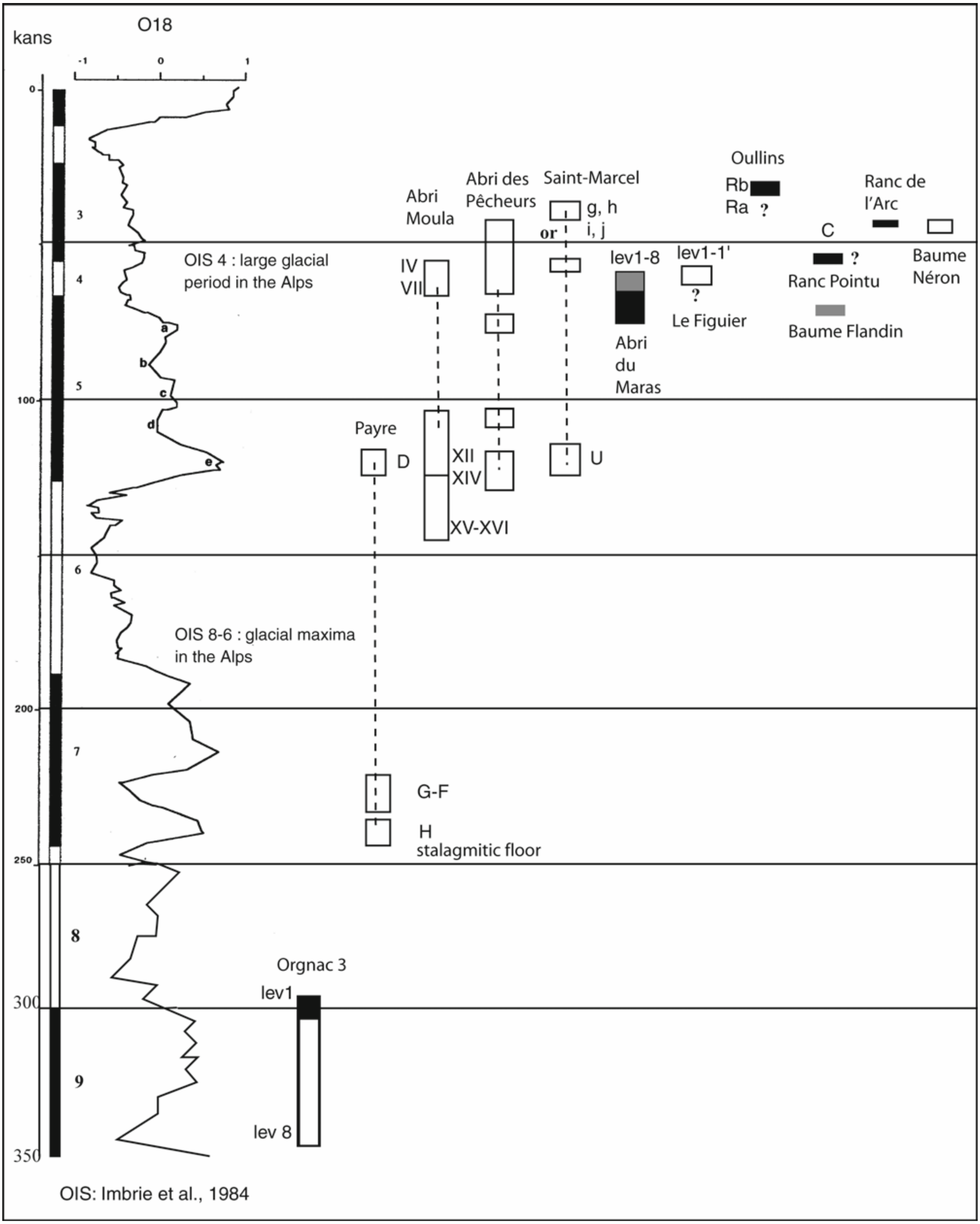

Fig. 22.2 Chronological framework of the Middle Paleolithic sites on the right side of the Rhône valley. Main types of processing systems used in the assemblages. *Black*: Levallois debitage; *white*: discoid and centripetal debitage; *grey*: Levallois and laminar debitage

ashes related to the eruption of Mont-Dore-Sancy volcano around 300 ka in the Orgnac 3 deposits, and ashes dated to 72 ka in Abri Moula (Debard and Pastre 1988). Some bio-markers, especially rodents, have been used to date the occupation levels. Different species of some large mammals have also been used as bio-markers, for example *Ursus spelaeus*, Carnivores, or specific herbivores like *Hemitragus cedrensis* related to OIS 5. *Rangifer tarandus* is considered as an indicator of Würm II in this area, the west side of the Rhône (Debard 1988). *Rangifer tarandus* seems to have inhabited the area in older Würmian stages, in Abri Moula (OIS 5 and 4 levels) and in Abri du Maras (levels dated by U/Th of the beginning of OIS 4) (Defleur et al. 1990; Moncel and Michel 2000; Defleur et al. 2001). This species is rare in eastern parts of the Rhône corridor, except in Bau de l'Aubsesier (ancient Würm) (Buisoon-Catil 1994). It is not present in grotte Mandrin (east Rhône, OIS 3), in Saint-Marcel (west Rhône, OIS 3?), in Ranc Pointu n°2 (ancient Würm) or in Ioton (Gard, Würm II), but present in Baume d'Oullins (end of Würm II or Würm III) (Combier 1967; Meignen 1976; Debard 1988; Moncel 1996a, b; Giraud et al. 1998). It was found in Caune de l'Arago (Pyrénées orientales) during OIS 14 and in the south-eastern part of France at OIS 6 (Buisoon-Catil 1994). This mammal is known to have followed the climatic variations in southern Europe and the Rhône Valley is assumed to have been used as a corridor for northwards movement during favourable periods of OIS 4.

From OIS 9 to OIS 5: The Sites of Orgnac 3 (OIS 9 and 8), Payre (OIS 7 and 5), Abri Des Pêcheurs (OIS 5, Base) and Abri Moula (OIS 5, Levels XIII and XIV)

Isotopic Stages 9 and 8: The Appearance of the Levallois Debitage and the Earliest Occurrence of Middle Paleolithic Behavior

Except for some isolated discoveries in open air sites, the site of Orgnac 3 has yielded the oldest stratified remains in Middle Rhône Valley. The site is located on a plateau, near the Ardèche gorges. First an aven, then a cave and finally a doline, the sequence is 7 m thick (Combier 1967). Environmental data suggest a mixing of forests and open air landscapes (Debard 1988; Gauthier 1992; El Hazzazi 1998). The faunal remains are characteristics of the Middle Pleistocene: *Macaca sylvanus*, *Dama clactoniana*, *Hemitragus bonali* and *Equus mosbachensis*, associated with *Sus scrofa*, *Cervus elaphus*, *Capreolus* sp., *Bison priscus*, *Bos primigenius* and *Stephanorhinus hemitoechus*. The upper levels are composed of remains of open air species (equids and large bovids) whilst *Equus steinheimensis* replaced *Equus mosbachensis* (Forsten and Moigne 1998). As indicated by various dating methods (U/Th, ESR, volcanic ashes), human occupation took place between 350 ka and 300–280 ka, during OIS 9. The cooling recorded in the upper part of the sequence may be an indication of the cooling associated with the beginning of OIS 8 (Falguères et al. 1988).

The debitage system adopted in lower levels (OIS 9) of Orgnac 3 can be related to several methods based on centripetal cores. The first evidence for Levallois debitage is in the middle of the sequence (level 5b) and it becomes dominant in the three upper levels. It is associated with debitage of small flakes from flake-cores or Levallois cores (end OIS 9, beginning OIS 8). A high proportion of very small flakes were produced. Various flakes were produced from the same Levallois core by different and successive methods (unipolar, bipolar, first flake, centripetal), on local flint plate fragments and flakes (Moncel 1999) (Fig. 22.3). The technical behavior can be attributed to the beginning of the early Middle Paleolithic, as is recorded in several European sites dated from OIS 8 to 6 with long and complex reduction processes (Biache, Rheindahlen, Mesvin, Champvoisy, la Cotte de Sainte Brelade, Vaufrey) (Callow and Cornford 1986; Rigaud 1988; Mellars 1996; Gamble and Roebroeks 1999; Moncel 1999; Tuffreau 2001b). Debitage modes are diverse even before OIS 9–8 and sometimes well distinguished (discoid debitage or clactonian debitage; Ashton et al. 1992). In northern France, the Levallois debitage is not observed before 400 ka (Lamotte and Tuffreau 2001a,b). By the Levallois method and presence of few bifaces, the base of the sequence of Orgnac 3 can be attributed to Final Acheulean or *Epi-acheuléen* (Fig. 22.4). Levels 2 and 1 are attributed to the ancient Middle Paleolithic with some bifacial tools (less than 1%) and a Levallois facies. This kind of behavior is restricted to southeastern France for this period, if it is compared with other sites such as Terra Amata, Caune de l'Arago, Baume Bonne, Lazaret, Montmaurin, Aldène, and Observatoire (Villa 1983; Darlas 1994; Gagnepain and Gaillard 2005).

The spatial data show that human settlement first took place in the cave, then in an open air context for the upper part of the sequence as discussed below.

Occupation in the Cave (Which May Represent Level 6), Short Settlements

Initially, the cave was an aven. Carnivore proportions indicate an NMI of 7%, far from the 20% of typical dens (Brugal and Jaubert 1996). The marks on bones and the lack of anatomic connexions of some parts of skeletons of cervids and equids suggest a relationship between humans and herbivore remains. Carnivores lived and died in the cave, as in Vergranne, Coudoulous, Peyre, les Fieux, some levels of Vaufrey, Prélétang, and Galéria in Atapuerca (Brugal and Jaubert 1996; Aouraghe 1992; Bernard-Guelle 2001).

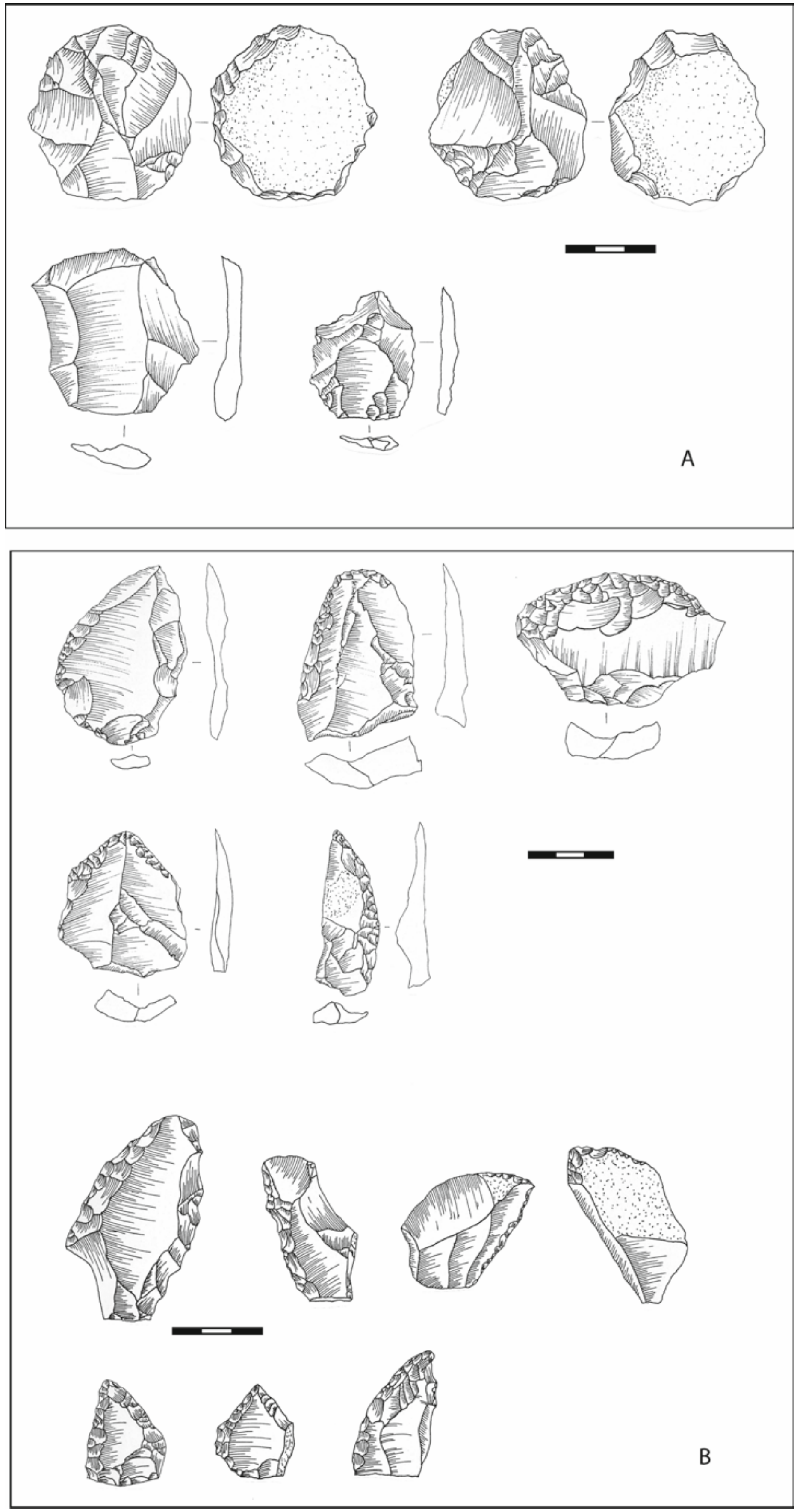

Fig. 22.3 Flint artifacts of level 1 at Orgnac 3 (Drawings by O. Bernardini), (**A**): Levallois cores; (**B**): scrapers and points on Levallois flakes and cortical flakes

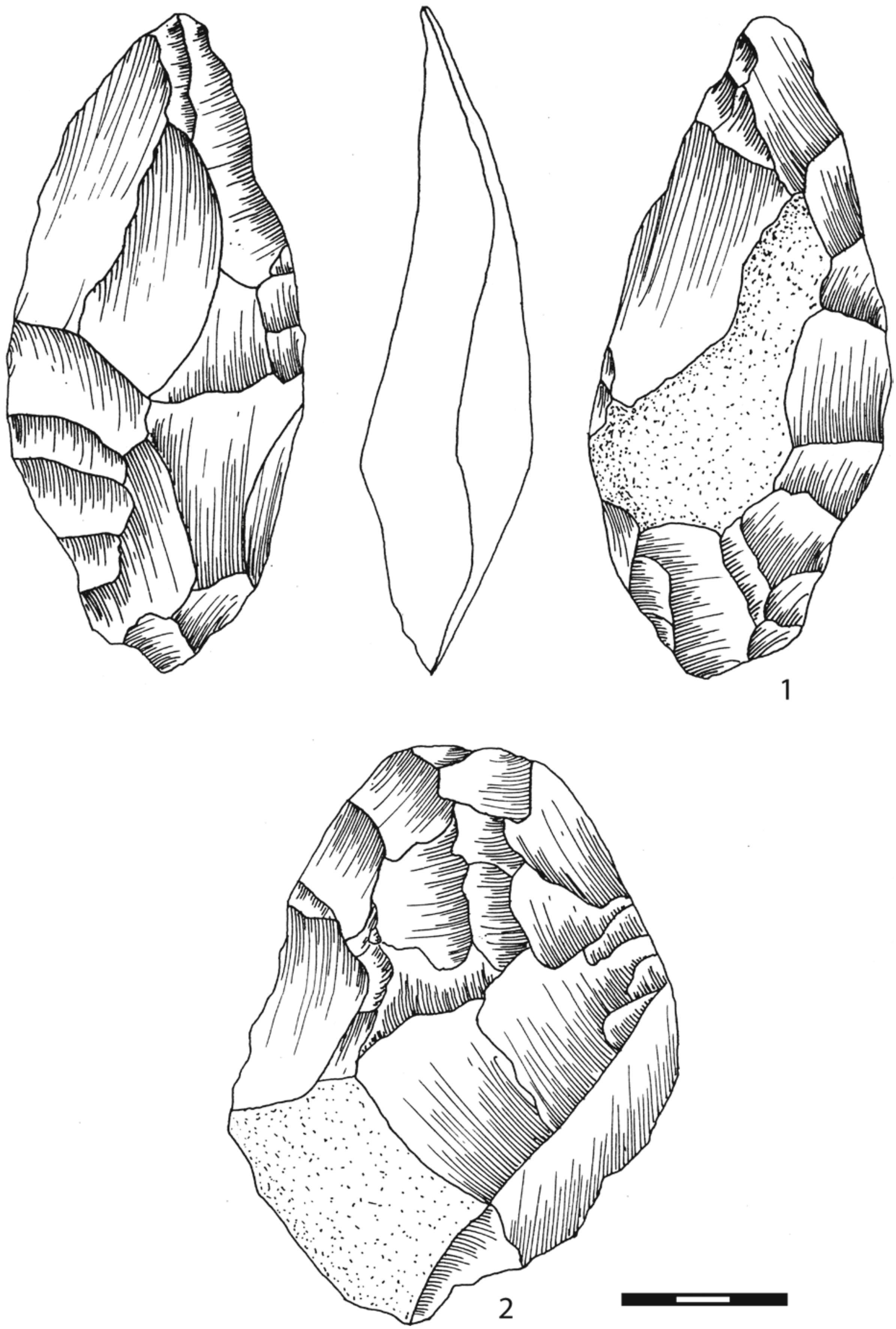

Fig. 22.4 Bifaces on plate fragments in flint (*1*: level 7; *2*: level 5a) in Orgnac 3 (drawings by O. Bernardini)

The only spatial indication of human occupation is that tools from debitage and shaping activities were abandoned along the cave walls, under the ceiling, near large mammal remains and at the opposite to the cave entrance (Moncel 1996a; Moncel et al. 2005). Some bifaces were buried on their edge in the ground, as in Olorgesaillie and Isimila in Africa (Clark 1974; Issac 1977).

Open Air Settlement (Level 1)

The site appears as a 600 m² doline. This topography was favourable for human settlement, perhaps with water pools, rare on a dry karstic plateau. Human occupation took place both in an open air context and in shelter conditions, due to a limestone embankment oriented south-west (Moncel 1998-1999). The climate was steppic and horse remains attest to human occupations in summer (Aouraghe 1992; Forsten and Moigne 1998). Even in the excavated area which is rather limited, the spatial patterns indicate an archeological entity, by the density of the artifacts which decreases toward the center of the doline. This unit 1 has yielded more than 25,000 artifacts mainly related to a Levallois processing system and flaking of flake-cores (Combier 1967; Moncel 1998–1999). No debitage center can be observed inside this entity, and most of the tool flakes are located on the whole excavated surface, contrary to what we observe in Maastricht-Belvédère, Beauvais or Bettencourt open air sites (Roebroeks 1988; Locht 2002).

In conclusion, Orgnac 3 brings evidence of recurrent occupations on a plateau whatever its topographic aspect:

- Caves on the urgonian karstic plateau gave favourable caves and shelters;
- The plateau offered large areas for game and human occupations, and its topography suggests that water was certainly available in dolines or inside caves;
- Flint outcrops were available not far away from the cave, although occupations were not exclusively directed towards flint production.

Isotopic Stages 7 and 5: The Sites Payre, Abri Des Pecheurs and Abri Moula, and the Development of Middle Paleolithic Behavior

Located along the Rhône Valley, the site of Payre occupies a headland position. Humans inhabited a cave, then a shelter. They regularly came back to this site, perhaps interested in its location and the topography of the landscape (Moncel 2008). The Neanderthals seem to have preferred this kind of location, as can also be seen at the northern Soyons caves. The sequence is 5 m thick, dated to OIS 8/7 (G and F levels) and OIS 6/5 (D level) by Uranium-Thorium and Electronic Spin Resonance on bones, teeth and stalagmatic floor (Masaoudi et al. 1996; Moncel et al. 2002), and by Thermoluminescence (Grün et al. 2008; Valladas et al. 2008).

In the three main occupation levels (G, F and D units), large mammal remains belong to *Stephanorinus hemitoechus*, *Stephanorinus mercki*, *Equus* cf. *mosbachensis*, *Bos primigenius*, *Bison* sp., *Cervus elaphus* ssp., *Capreolus capreolus* ssp., *Megaloceros* sp., *Capra ibex*, cf. *Hemitragus* sp., *Rupicapra* sp., *Sus scrofa* ssp., *Ursus spelaeus*, *Ursus arctos*, *Canis lupus* ssp., *Vulpes vulpes*, *Panthera* (*Leo*), *Panthera pardus*, *Crocuta crocuta* ssp., *Meles meles*, *Martes martes*, *Castor fiber*, *Lepus* sp., and unspecified herbivores (*Elephas*) (Guerin 1980; Moncel et al. 2002). Few differences exist between levels, the landscape being composed by forest and open areas with diversified species and ecological zones during all occupation periods. The climate was temperate and wet but drier at the base of the sequence. *Equus* cf. *mosbachensis* (frequent in biozone 21), *Hemitragus* (disappeared before the end of OIS 6) and *Ursus* remains (with resemblance to *Ursus spelaeus*) are good indicators to place levels F and G in OIS 8/7 and level D at the beginning of OIS 5 (Eemian?) or end of OIS 6. The micro-mammals suggest an age of the end of Middle Pleistocene or beginning of Upper Pleistocene to D level (El Hazzazi 1998; Moncel et al. 2002). Four species from G and D levels attest environmental conditions related to the end of Middle Pleistocene (*Pliomys lenki*, *Microtus brecciensis Iberomys*, *Arvicola terrestris* and *Arvicola sapidus*). Pollens indicate a semi-forested environment with Mediterranean trends (Kalaï et al. 2001).

Humans used flint from southern areas (10–30 km away) and occasionally from the Rhône Valley. Some flint outcrops, identified in the Gb level by a microscopic analysis, suggest stone collecting from southern and eastern long distance areas (Fernandes et al. 2006, 2008). The study of raw material indicates human movement on the plateau and its slopes, but also along the fluvial systems. Basalt, quartz and limestone pebbles were collected in the Payre River at the foot of the site. On the contrary, quartzite pebbles came from Rhône beds (Moncel 2002, 2003; Moncel 2008).

Two types of reduction strategies have been recognized in the sequence:

- Shaping on basalt, quartz and limestone pebbles (around 15%). Pebble tools are worked with some removals on one face. The cutting edge often carries crushing marks;
- Debitage production of flakes, especially on flint, secondarily on quartz and limestone within the site; on large quartzite and basalt pebbles outside the site.

The main flaking system can be described as discoid, on flint flakes and nodules or pebbles (unipolar, orthogonal or centripetal). Three to five secondary flaking methods were used on flakes or blocks as *Kombewa* or orthogonal debitages (SSDA cores type High Lodge, prismatic cores). Humans used and abandoned various tools at the site: large and numerous entire pebbles, pebble tools, large tool flakes with crushed cutting edges (in basalt, secondarily on quartz, limestone, quartzite), numerous flint flakes with long cutting edges and points, for example scrapers and points, some thick quartz flakes, some thin flakes in limestone (sometimes retouched), some large unifacial and bifacial flake tools in quartzite (or quartz or basalt) (Figs. 22.5–22.7). Macroscopic traces on the unretouched and retouched artifacts indicate several functional areas on the cutting edges (Plisson and Beyries 1998; Shea 1997; Ellis 1997). The Payre lithic assemblages show specific features that we can relate to activities, such as the high frequency of large tools (pebble tools, bifacial tools on large flakes). Some trends, for example the frequency of elongated blanks, the low number of backed flakes and bifacial retouches, may also be explained by regional traditions (Moncel 2001). Bifacial tools and some tools looking like cleavers may indicate a transitional facies during OIS 5 in the area. However, some of these features cannot be explained, because we do not know if caves were only used for brief visits by some individuals or the whole groups, as south-western France sites seem to attest (Turq 1992; Geneste and Jaubert 1999).

In the sequence at Payre, the subsistence behavior is directed towards hunting of *Cervus elaphus, Equus* and bovids and also scavenging of rhinoceros and elephants (Moncel et al. 2002). Taphonomical data indicate a specific treatment of the large mammals according to their size: middle sized animals were brought into the cave in their entirety while large animals were brought in quarters. G and F levels yielded evidence of recurrent and short occupations or annual occupations, during which one or several species were hunted. Flint may have been gathered in various outcrops during these subsistence activities, as confirmed by the microscopic study of flint in the Gb level. The last human occupation phase (D level) took place during winter and focused on the hunting of adult and male *Cervus elaphus* (end of OIS 6). All mammal bones displaying anthropogenic marks belong to herbivores that lived in the surroundings along the Payre or Rhône valleys, on the plateau or its slopes, depending on climate and seasons. The intense breakage of the bones, the indications for the use of fire in the presence of a lense of ashes at the top of the Ga level, and the diversity of the cutting edge angles of light and heavy artifacts provide evidence of various subsistence activities that took place at the site during seasonal settlements. OIS 5 occupations in Abri Moula display the same features as in Payre sequence (Table 22.3):

1. Situated in a headland location, along the Rhône Valley.
2. Local raw material from Bedoulian formations, but also long distance stone collecting.
3. A main discoid flaking strategy, numerous scrapers and points with non-invasive retouch.
4. Species hunted in the surroundings of the site, with a high frequency of *Cervus elaphus* (Defleur et al. 1999).

However, some differences can be observed between the two sequences which may indicate a difference in various needs or cultural traditions while the environment and the topography were similar:

1. At Payre: few flake tools with a Quina retouch and high frequency of pebble tools.
2. At Moula (level XV): cannibalism on *Homo neanderthalensis* unrelated to environmental reasons.

While various type of flaking methods can be used for butchery activities, some sites show a relationship between the discoid method and the treatment of hunted herbivores for example at Tares, Sous-les-Vignes, Roc-de-Marsal, Mauran and La Borde ou Coudoulous I (Jaubert et al. 1990; Geneste and Jaubert 1999). In Payre and Moula, this is not the case. The archeological data show diversified flaking methods related to a variety of subsistence activities. The only similarity between Payre and La Borde is the proportion of large tools in both Payre and La Borde. At the base of the Abri des Pêcheurs (OIS 5) sequence, the use of quartz is preponderant and also linked to a discoid debitage which explains the high quantity of cubic flakes which stay unretouched. The assemblages are associated with *Ibex* which died naturally in the cave (Prucca 2001).

From the End of OIS 5 to the Beginning of OIS 3: A Variety of Technical Behaviors

From the end of OIS 5 to the beginning of OIS 3, sites are more numerous, but information on the true age of the human occupations and their environmental context is still lacking (Table 22.2). Most of the sequences are grouped along and around the Ardèche and Chassezac gorges. The age ranges from 80 ka to about 35 ka (Defleur et al. 1990; Defleur et al. 1994; Moncel 1996b). The most recent dates (AMS or conventional radiocarbon dates) suggest that Neanderthal groups occupied the area until about 30 ka: level e at Saint-Marcel; level R in Oullins, and Ranc de l'Arc (Evin et al. 1985; Debard 1988; Defleur et al. 1990). Old Upper Paleolithic levels are rare in the area and most of them are attributed to the Gravettian (Gely 2005). The Chauvet cave is one of the few sites with Aurignacian indices, and is dated to 32 ka (Clottes et al. 1995). Aurignacian evidence has also been recorded in the Abri des Pêcheurs and in the Baume d'Oullins, dated to about 29–30 ka. The Gravettian seems to be attested at about 24–23 ka and may be the first large settlement wave of *Homo sapiens* in the area. A Châtelperronian does not exist here, unlike in south-western France.

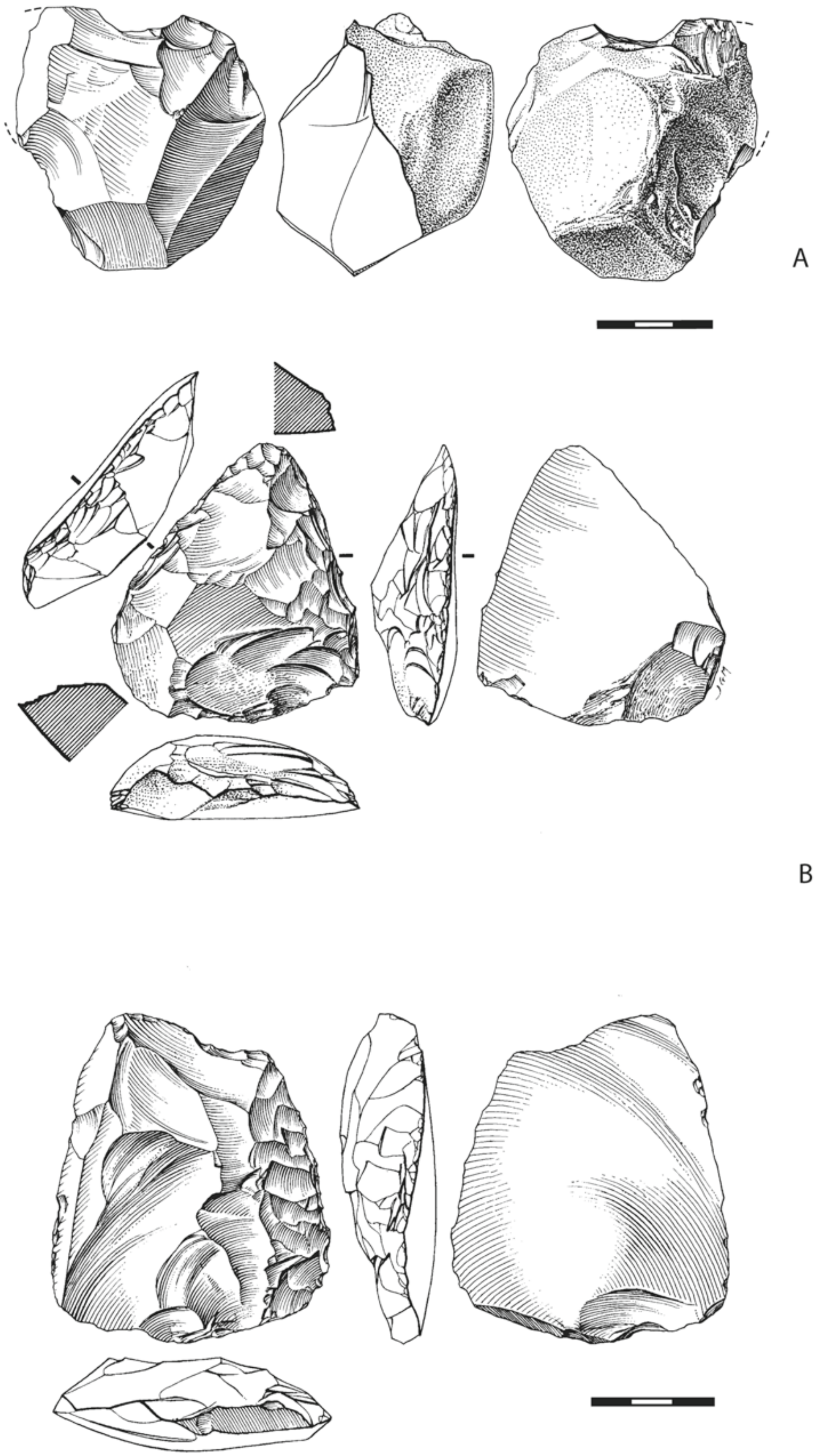

Fig. 22.5 Multidirectional core (**A**: level Ga), point and sidescraper (**B**: level Gb) in flint at Payre (Drawings by G. Marcillaud)

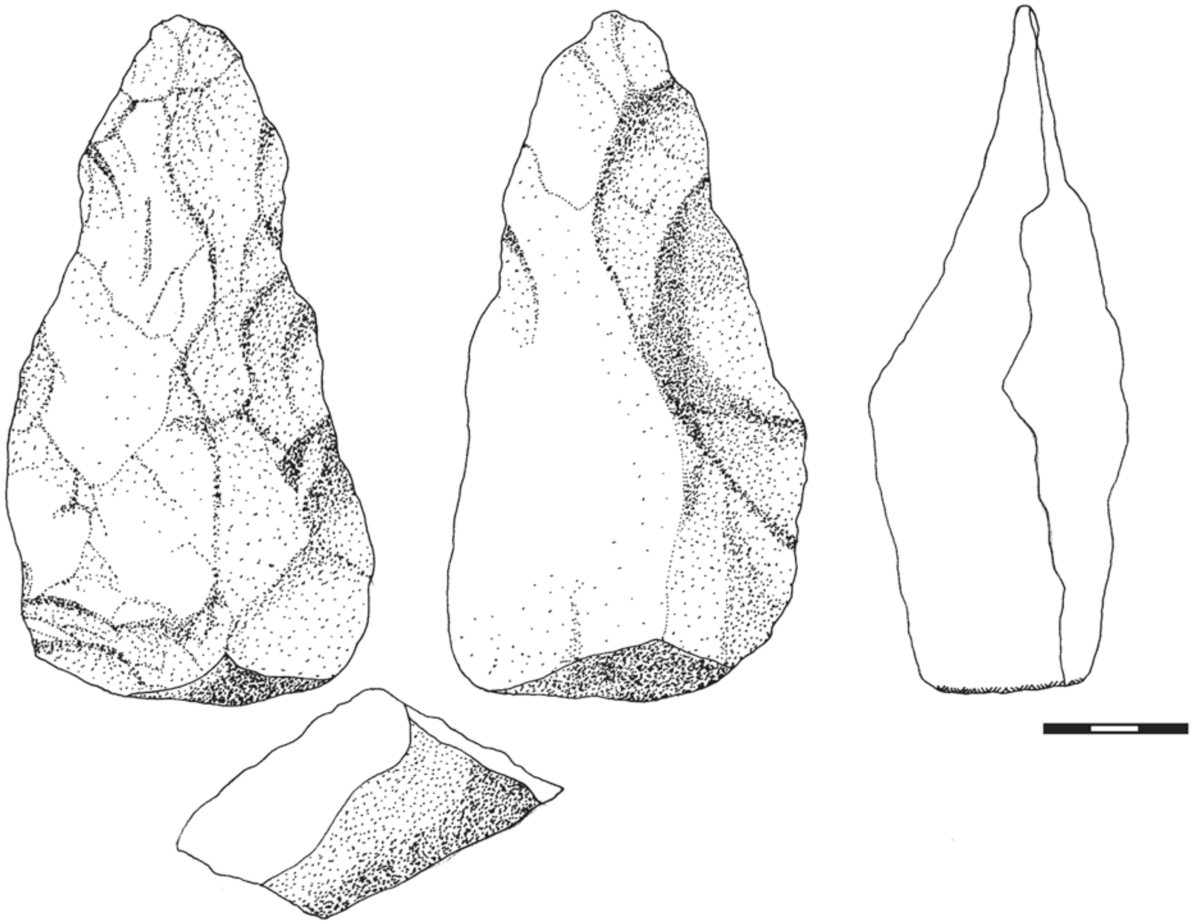

Fig. 22.6 Quartzite biface (level Fa) at Payre

From the 1960s on, lithic studies have shown that younger assemblages in the area resemble the Charentian Mousterian, and especially belong to the Ferrassie type, rarely Quina (Combier 1967). A Denticulate Mousterian and an Acheulean of Mousterian tradition do not exist. Bifaces disappear from assemblages during OIS 8 or 7, but may still be present as isolated artifacts. Human groups employed the same flaking techniques than in previous times, but a main method clearly dominates and technical variability is less attested than in previous periods (Table 22.4). Technical behaviors were not poorer at the beginning of OIS 4, as it is in northern Europe. This is evident in the oldest indices of laminar flaking in the area (Locht Ed. 2002). As in the whole of Europe, high numbers of sites dated to the end of OIS 5 and related to Neanderthal occupation are observed. In southeastern France, there is no evidence of a real change in the subsistence and technical strategies.

Levallois Method

The Levallois method was used in the sites of Ranc de l'Arc, Ranc Pointu, Baume d'Oullins, Abri Maras, Abri Moula (c. IV et VIII), Baume Néron, Mandrin and Baume Flandin (Gagniere et al. 1957; Defleur et al. 1994; Moncel 1996b, 1998a). While most of the Levallois cores are centripetal in the upper levels of Orgnac 3, unipolar and bipolar methods are the methods most often used during OIS 4 and 3. The occurrence of the centripetal method in OIS 9 and 8 seems to be an original feature linked to this area whereas in other regions, the unipolar method was used (Boëda 1993, 1994; Moncel 1996b, 1998; Geneste et al. 1997). Flakes of various sizes are the main products, whatever the raw material collected: small flakes in Baume d'Oullins and Ranc de l'Arc (Defleur et al. 1990; Moncel 2003) and numerous points (e.g., *Soyons* type) at the top of the sequence of Abri Moula and Mandrin (Defleur et al. 1994; Defleur 2000). The main flake tools are often scrapers, which are thin with marginal retouch. Upper Paleolithic type tools are rare (endscrapers, borers). Most of the flakes remain unretouched. The sites of Ranc Pointu n°2 and Oullins show that the Levallois method is associated with *Cervus elaphus* and *Capra ibex*. Herbivores were hunted probably around the cave, or along the Ardèche River and its meanders, both favourable areas for herds to feed and to be protected against cold winds. Various ecological areas were certainly covered by humans for hunting of

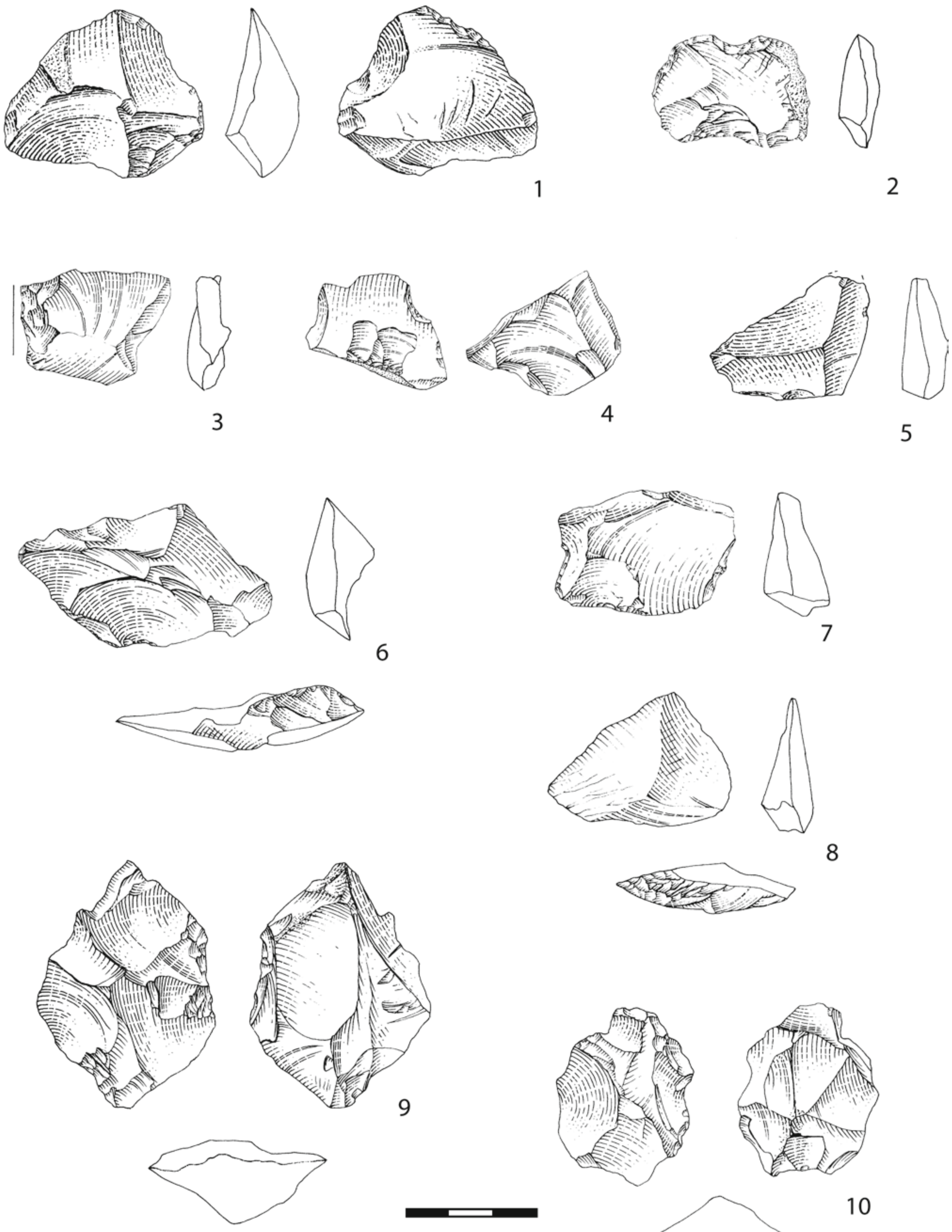

Fig. 22.7 Flint flakes (*1–8*) and discoid cores (*9–10*) in level D at Payre (Drawings by P. Giunti)

Table 22.3 Payre and Abri Moula, seasonal occupations in caves along the Rhône valley

	Topography & environment	Fauna	Subsistence territory	Lithic assemblage
Abri Moula	Cave	*C. elaphus, R. tarandus,*	– Rhône Valley	Bedoulian flint & silicified limestone
XIV & XV levels end of OIS 6 & OIS 5e	Cliff near the Rhône Valley	*Bos-Bison, Equus* sp.	– plateau	Flakes 20–40mm
Payre	Oriented west	*S. scrofa, C. capraeolus, C. ibex*	– cliffs and slopes around the site	Discoid debitage & Levallois & Kombewa
D level	Cave		– plateau	Scrapers & points
OIS 6/5	Shelter	*H. neanderthalensis* (level XV)	– cliffs and slopes	Bedoulian flint & quartz
	Cliff near the Payre and Rhône Rivers	*Cervus elaphus*	– meadows along the Rhône River	flakes 20–50 mm &
	Oriented south–east			
		& bovines, *Equus, Ibex,*		large flakes
		Ursus spelaeus		discoid debitage &
		Occupations in winter		Levallois, Kombewa,
				on flake
				scrapers & point
				thin retouches & semi-Quina
				large basalt & quart zite tools

Defleur 2000; Defleur et al. 2001; Moncel et al. 2002

Table 22.4 Types of processing systems used in assemblages in the Middle Rhône Valley area (names of the directors of the excavations)

Middle Rhône Valley Right side	Flake processing systems	Flake and blade processing systems
By a main Levallois method	– Orgnac 3 (level 1–3) (Combier) *OIS 8* – Ranc Pointu n°2 (Gilles and Combier) *OIS 4* – Baume d'Oullins (Combier) (microlithic) *OIS 4–3*	– Abri du Maras (Gilles and Combier) *OIS 5–4*
By a main discoid method		
**low frequency of retouched flakes*	– Orgnac 3 (lev. 6–4a) (Combier) *OIS 9* – Payre (Moncel) *OIS 8/7–6/5* – Saint-Marcel (Gilles) *OIS 3?* – Abri des Pêcheurs (Lhomme) *OIS 5–4*	
**high frequency of Quina retouch*	– Le Figuier (Huchard and Gilles) *OIS 4?*	
By a main Levallois method and a laminar flaking on plate flint		– Baume Flandin (Gagnières et al.) *OIS 5?*

these herbivores. Flint pebbles and nodules were collected on the southern plateau (Sannoisian plates) and along the Rhône River. Consequently, humans moved on plateaus and along valleys, and raw material gathering took place in territories linked to the Rhône Valley.

Laminar Flaking and the Production of Both Flakes and Blades

Some assemblages yield a higher number of elongated products (Abri Moula). Others, like the Mandrin cave or the Abri du Maras, attest a laminar debitage according to a Levallois method (uni-bipolar) on flake-cores or on cortical surfaces of round pebbles (Moncel 1996b, 2003; Giraud et al. 1998; Yvorra and Slimak 2001) (Figs. 22.8 and 22.9). The two upper levels of the Abri du Maras, dated from a glacial period, certainly OIS 4 according to the U/Th method, have been considered as transitional assemblages by the frequency of blades. At Abri Maras, however, the number of blades is limited to 5–10% of the assemblages, as in most of assemblages including blades (Combier 1967). In the Baume Flandin, a laminar debitage is found associated with a Levallois debitage (centripetal and unipolar) (Gagniere et al. 1957; Moncel 2005; Moncel et al. 2008a). Elongated products (10% of the assemblage) are thick, often unretouched, and some have a partial crest related to the production of debitage from angular flint cubic fragments (Figs. 22.8 and 22.9). No Upper Paleolithic feature can be

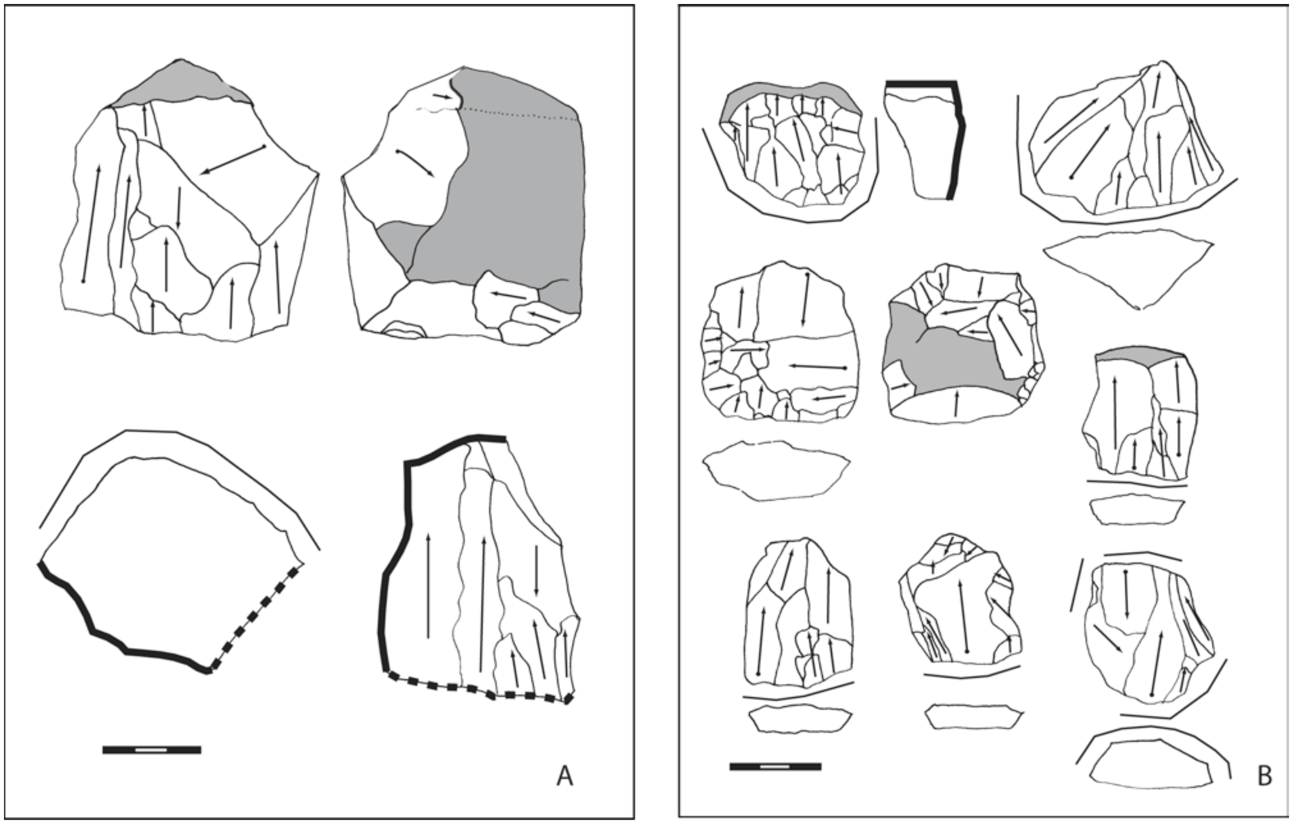

Fig. 22.8 Schematic drawings of flint cores at Baume Flandin (**A**: debitage on flint cubic fragment) and Abri du Maras (**B**: Levallois cores and debitage on cortical surfaces of flint pebbles)

observed (Boëda 1988). In the level n°1 of the Abri du Maras, the main species associated with the blades, is *Rangifer tarandus*, as in the Baume Néron and the top of the sequence of the Abri Moula (Defleur 2000). In some cases a link between butchery activities and blades has been demonstrated in northern France (Tuffreau Ed. 1993). It is not the case in this area. Moreover, different flaking systems have been used in occupations where *Rangifer tarandus* is the main species hunted. The location of the Abri du Maras, in a small valley near the Ardèche River, certainly explains the presence of reindeer herds, and settlement during a cold period can explain the intense breakage of the bones.

Blade manufacture was practiced in northern Europe since 250 ka. During OIS 8 to 6, blades were produced in small quantities by uni-bipolar Levallois methods, or by Upper Paleolithic type prismatic cores (Revillion and Tuffreau 1994). During the late Middle Paleolithic (OIS 5 and 4), blades are always few but methods diversify. Prismatic cores become more frequent (Rocourt, Riencourt-les-Bapaume, Seclin, Saint-Germain des Vaux) (Tuffreau Ed. 1993; Revillion and Tuffreau 1994). In southern Europe, the blade production seems to have been more recent (OIS 4) than in the north. In the Mediterranean area, laminar knapping is especially evident in some Late Mousterian sites (end of Würm II): San Francesco in San Reno, Abri Mochi (Grimaldi) or Tournal cave (Aude) (Moncel 2001a). Blade methods are various: bipolar or centripetal Levallois method, crest blade methods, bladelet debitage on discoid cores. The Levallois method is, however, the main one (Moncel 2001). Specific methods using the shape of blocks, as in Abri du Maras or Baume Flandin, are rare. In our opinion, no generic link can be made between blade production of OIS 4 and 3 and the first Upper Paleolithic blade production in southern Europe (Pelegrin 1986; Slimak 1999). In this area no relationship is observed between debitage and toolkit. Blades are often unretouched, the climatic contexts are various, as the hunted species. Consequently, the blade production could be one technical tradition, a secondary one, among others in Europe, older in northern areas than in southern ones.

Discoid Method

This method was used in the Saint Marcel cave, the Baume Néron, Le Figuier and the Abri des Pêcheurs. Artifacts are diversified: backed flakes, large and triangular flakes, short and thick flakes, elongated flakes. Many cores show one or

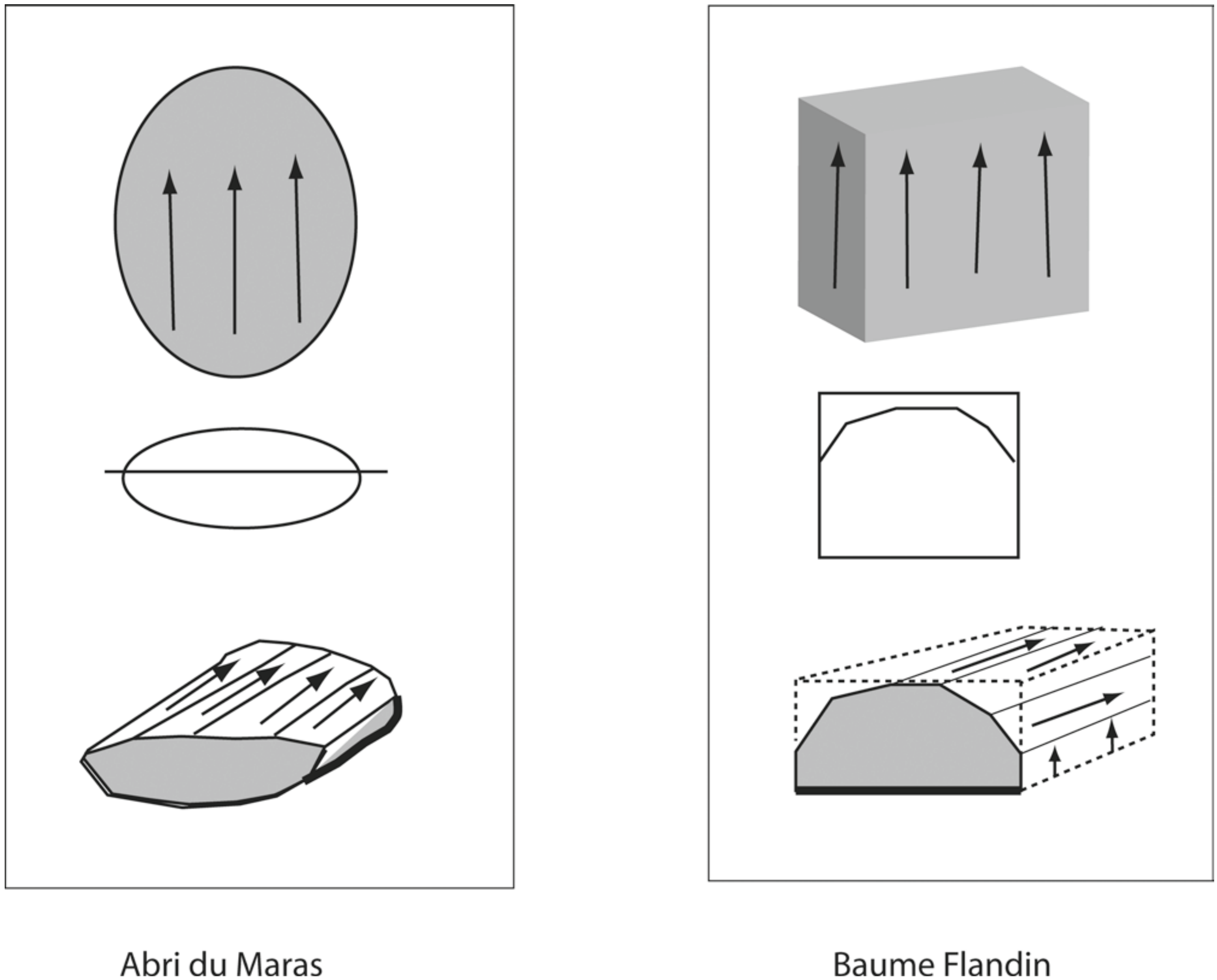

Fig. 22.9 Two types of laminar debitage at Abri du Maras (on flint pebbles) and at Baume Flandin (on flint cubic fragment). Debitage on a surface and debitage of a volume

two flaking surfaces with crossed removals, sometimes with a third orthogonal surface created at the end of the debitage (Boëda 1993). Some cores have a flat flaking surface; others have a pyramidal section, related to the type of blank, flake or nodule, or to the type of raw material.

Assemblages with a Marginal Retouch on Flakes

Saint-Marcel: Example of Seasonal Occupations (Spring) for Hunting of *Cervus Elaphus* Along the Ardèche River

The richest occupation levels (i-j-j′) yield assemblages with a large proportion of *Cervus elaphus* (85% of faunal remains) (Debard 1988; Moncel et al. 2004). Animals were partially worked outside the cave. They were hunted on the plateau near the site or at its foot (Ardèche Valley). Either only one species was hunted in a mosaic landscape, or hunting was oriented toward the main animal living in spring near the cave. Inside the cave, humans broke large quantities of bones for marrow extraction. Marks on the bones show a processing system composed of several phases. The high quantity of very small bones could be related to the voluntary breakage of bones to boil them. Lastly, bones were used for fire as combustible or have been thrown in fire places (numerous burnt bones). *Retouchoirs* on bone carry various stigmata in different levels. The flake production took place inside the cave, on flint nodules and flakes collected on the southern plateau (plate fragments) and the Rhône Valley (alpine and Bedoulian flint). Flakes obtained by the discoid method are various, and the frequency of retouch is low, being marginal in most instances (Lenoir and Turq 1995). In this case, especially the discoid method has been used to produce thin and thick flakes, but backed flakes are also rather numerous (Fig. 22.10). This method is not related to a specific type of occupation.

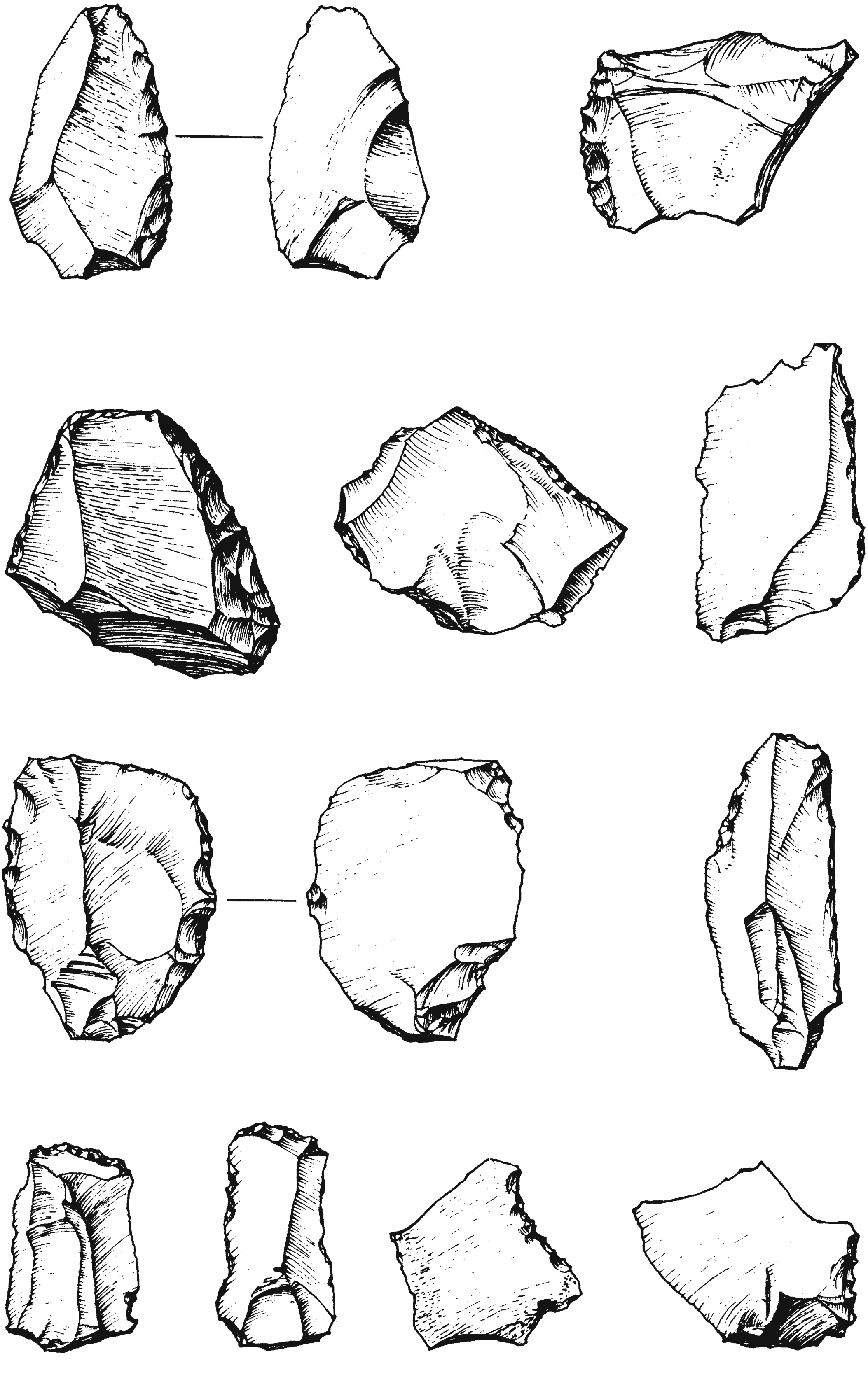

Fig. 22.10 Flint flakes in level f (top of the sequence) at Saint-Marcel (Drawings by R. Gilles)

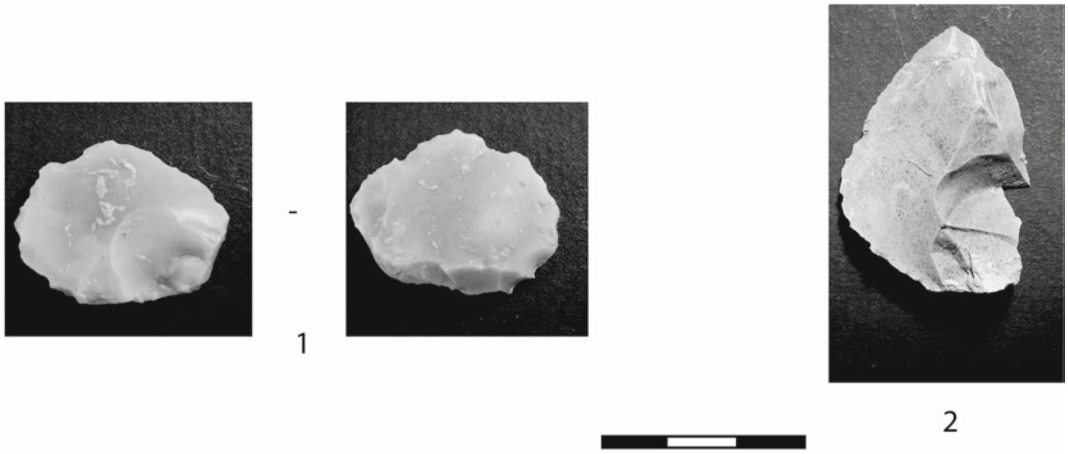

Fig. 22.11 Flint flakes at Abri des Pêcheurs (excavations 2005), *1*: exogen flint; *2*: local flint

In a more southern area, at the site of Ioton (Gard), also associated with a discoid debitage; horses dominate the assemblage, in La Combette (Vaucluse), the location of the cave explains seasonal stops for the hunting of young horses and *Ibex* or for the scavenging of dead animals at the foot of the cliff near the site. The lack of flint around this cave means that artifacts were brought from elsewhere (Buisoon-Catil 1994; Texier and Francisco-Ortega 1995). In Bau de l'Aubesier (Vaucluse), *Bos primigenius, Equus* and *Hemitragus* are the two main species in the lower levels, and associated with Levallois and discoid debitage (OIS 6 à 4). These three species have a different behavior and cannot be hunted in the same environment. Only seasonal occupations could explain the fauna assemblages. Animals were probably pushed from the cliffs or hunted near the Nesque gorges (Fernandes et al. 1998; Fernandes 2001). In the Baume des Peyrards (Vaucluse), the lower levels yield *Ibex, Cervus elaphus* and Aurochs remains. In the upper levels, *Cervus elaphus* becomes the main species, replaced at the top of the sequence by horses, *Ibex* and marmots, indices of a cold climate. Following the authors, while the Levallois debitage is the main method used in the Vaucluse area, and the raw material collection is still local, the technical variety observed among assemblages can be related to site functions, in various climatic contexts. At present, the same conclusions cannot be drawn in the Middle Rhône Valley area.

Abri Des Pêcheurs: Short Occupations with Ibex in a Cave-Hole in the Chassezac Valley?

The lower levels of the Abri des Pêcheurs have yielded poor lithic assemblages (Lhomme 1984). Studies on remains of *Ibex* and carnivores indicate that humans found a refuge inside a hole where herbivores naturally fall (Prucca 2001; Moncel and Lhomme 2007; Moncel et al. 2008c). The artifacts are complete pebbles of metamorphic stones and unretouched flakes from a discoid debitage on local quartz pebbles. Some flint Levallois flakes were introduced from various and certainly great distances (Fig. 22.11). Flint outcrops are rare in the surroundings of the cave. Assemblages, dated from the end of OIS 5 and the beginning of OIS 4, could indicate short and opportunistic human occupations, closely resembling the situation in the Hortus cave in southeastern France (de Lumley 1972).

The Quina Assemblages

Quina assemblages were described by Bordes in the 1950s from assemblages in south-western France (Bordes 1953). They are characterized by the high frequency of thick and asymmetric flakes with an invasive retouch, on local stones. Different kinds of debitage methods were described: *tranches de saucisson* (Turq 1992; Turq et al. 1990, 1999), alternate debitage (Bourguignon 1997; Moncel 1996a, 1996b, 1998a), discoid and laminar debitage (Moncel 1998a; Moncel 2001c; Slimak 1999; Jaubert 2001). In south-eastern France, especially in the Middle Rhône Valley, the few Quina assemblages are considered as original. A "rhodanian facies" has been proposed to explain the high frequency of elongated flakes, the low frequency of Quina scrapers, of backed flakes, and the use of the discoid method (Combier 1967; Meignen 1976, 1981; Boëda et al. 1990; Turq 1992; Turq et al. 1990; Defleur et al. 1994; Geneste et al. 1997; Moncel 1998a, b; Giraud et al. 1998). In south-western France, the more frequent Quina sites were settlements during cold periods, especially OIS 6 or OIS 4, with a large proportion of *Rangifer tarandus* or large herbivore remains (bovids). These assemblages have consequently been related to butchery activities with specialized and numerous tools (Turq et al. 1999).

To obtain the Quina retouch, a large cutting edge is produced by a series of notches and retouches. This does not mean a lack of raw material or a different way of life (Lenoir 1973, 1986). The angle of the cutting edge was efficient to work skin, ochre or wood (Rigaud 1988; Beyries and Walter 1996; Bourguignon 1997; Lemorini 2000).

As in Saint-Marcel, the assemblage of the lower level of Le Figuier is composed by a large proportion of *Rangifer tarandus* associated with a discoid or centripetal flaking method on flake-cores. Part of the flake-cores were probably brought inside the cave, as in Riencourt-les-Bapaume, Beauvais, Bettencourt, Gentelles, or Abri Romani (Tuffreau Ed. 1993; Vaquero et al. 1998; Tuffreau 2001b; Locht Ed. 2002). At Saint-Marcel, the retouch is marginal, but not at Le Figuier (Moncel 2001). At Le Figuier, three kinds of artifacts were desired: thick Quina scrapers, thin scrapers and points. *Rangifer tarandus*, horses and large bovines were hunted in the valley, *Ibex* on the cliffs around the cave, *Cervus elaphus* on forested areas of the plateau or the valley. Protected against cold winds, the cave was a perfect stop to hunt *Rangifer tarandus*. We cannot attribute Quina assemblages to a specific tradition, whatever the area. According to fauna remains, these assemblages are related to hunting of one species, as *Rangifer tarandus* (Baume Néron, Le Figuier). Occupations took place during a cold and dry phase of the last glacial period, as in the Abri du Maras which yields, however, Levallois flaking products.

The Question of Large Tools from OIS 9 to OIS 4

Bifacial Tools: A Marginal Phenomenon in South-Eastern France

While bifaces were produced from 600 ka in southern France, this type of tool is never abundant in OIS 9 to 6 assemblages (Moncel 2001): it occurs in Baume Bonne (layers II and III, Alpes de Haute-Provence), Payre (Ardèche) and Lazaret (layers C2 and C3, Alpes-Maritimes) (Darlas 1994; Gagnepain and Gaillard 2005). Bifaces disappear from assemblages during more recent periods (OIS 4), except for some isolated instances (Ranc Pointu n°2, Ardèche). Some assemblages did not contain bifaces during OIS 7 and 6: les Cèdres (Var), Payre (Ardèche), Rigabe (Provence) (de Lumley 1969; Defleur and Crégut-Bonnoure 1995; Moncel 1998a, b). No Mousterian of Acheulean tradition seems to have existed in this area. Bifaces, as the bifacial shaping of flake tools, become a marginal occurrence from OIS 9 on.

Blanks for bifaces are various, above all in flint. Some blanks are large flakes, and others flat and elongated pebbles or thin plate fragments. In Orgnac 3, assemblages of biface production flakes suggest a partial shaping inside the site, and certainly a mobility of these tools. No refittings between flakes and tools were possible. In most cases, the bifacial shaping is limited to the two lateral edges and the end (Fig. 22.4). A natural back remains on more than half of the tools, or is created by a break. The blank size is various and its shape often explains the location of the removals. The shaping proceeded face by face and produced plano-convex tools. This method is certainly intentional as the unsymmetric cutting edges were finally worked by a unifacial and unilateral retouch. From OIS 9, in Orgnac 3, bifaces are mostly bifacial tools rather than real bifaces: shapes are various, points are sometimes broken, final retouches are observed on the edges and a back or cortical patches exist at the base. All these observations suggest multifunctional tools, which function can be changed (Hayden 1979; Singer et al. 1993; Moncel 1998a; Moncel 1999, 2001b; Boëda et al. 1990; Boëda 2001; Moncel Ed. 2008).

Pebble Tools

Pebble tools are not a secondary toolkit, though few in assemblages, except in Payre or in the Abri des Pêcheurs (Moncel 2003). When the pebble river beds were far from the site, humans seems to have collected pebbles in various outcrops. The distance from the rivers also explains the size of the collected pebbles, and why some large flakes were brought inside the sites. The tool cutting edge is simply worked, and unifacial. Some other tool types such as discs, pics, pseudo-cleavers etc. can be observed in assemblages. The largest diversity of tool types is found in Payre and Orgnac 3 assemblages, perhaps due to the age of the sequences or the activities. Some entire and broken pebbles show percussion marks and could be hammers. They were manufactured of different raw materials than the pebble tools (Moncel 2003).

Territories and Mobility of Human Groups in the Middle Rhône Valley

Raw Material Gathering

The main raw materials used by humans were local stones, especially flint in plate fragments, nodules and pebbles. The gathering took place in a local or semi-local perimeter of 20–35 km size (Moncel 2002, 2003). Although several outcrops were used during the various occupations, only one was

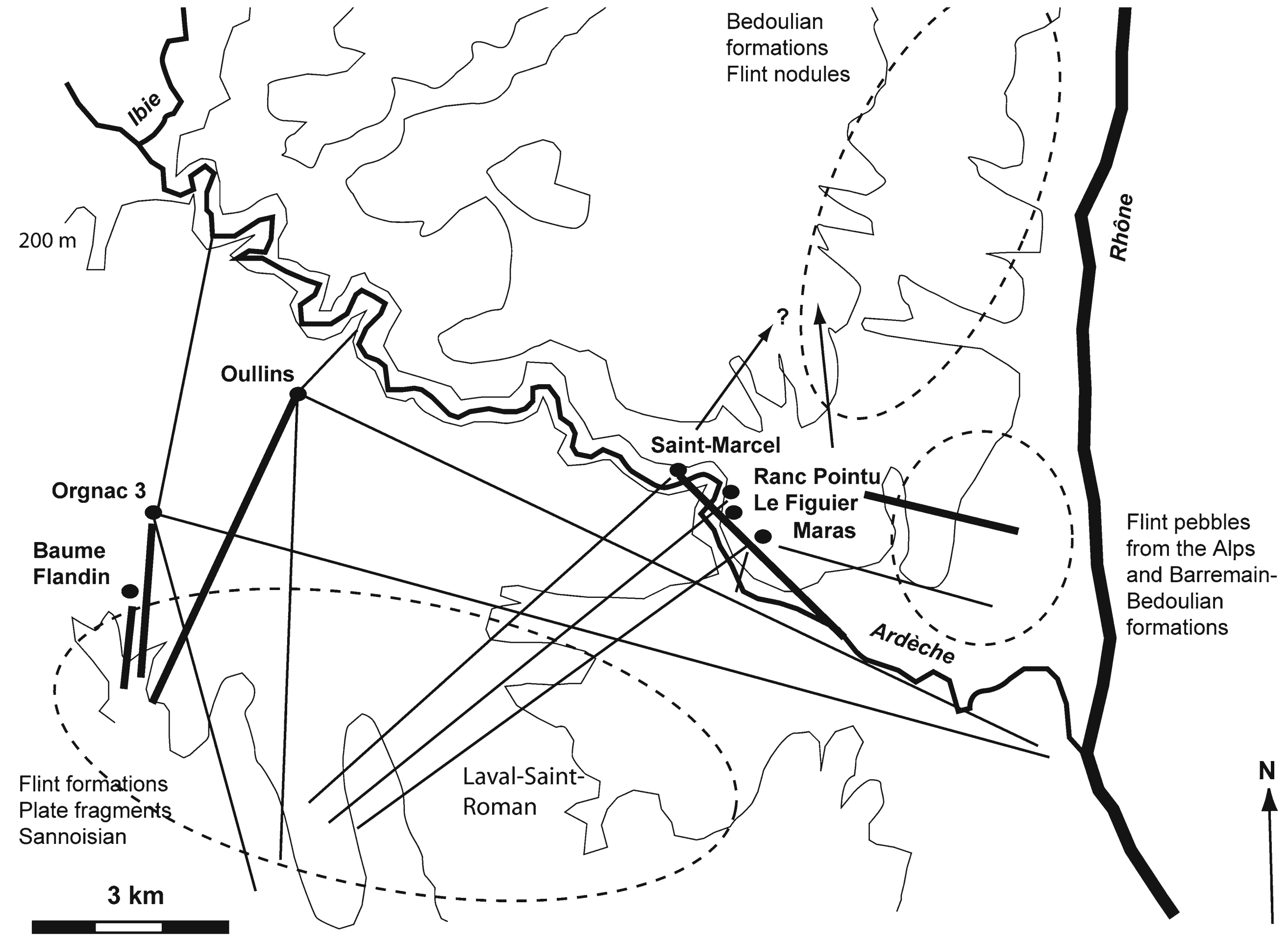

Fig. 22.12 Raw material collecting for Middle Paleolithic sites in the surroundings of the Ardèche valley, according to macroscopic analysis: three main geological areas. *Thick line*: main flint source; *thin line*: secondary flint sources and other stone sources (along rivers)

used intensely. Microscopic studies on flint in the area are still rare, but new results on the Gb level at Payre confirm the local and semi-local gathering on southern plateau during other subsistence activities. Some stones from a long distance away have also been observed (up to 60 km from the south) (Fernandes et al. 2006, 2008). The good quality of flint does not seem to be the main reason for the choice. The outcrop diversity results from the undulating landscape and the geological context. As flint is abundant in the Barremain and Bedoulian formations on Rochemaure-Meysse plateau, many nodules were collected by humans in this area (Aspinall et al. 1979). Some flint pebbles were also gathered all along the Rhône River or, in few quantities, along Rhône tributaries (Saint-Marcel, Maras, Figuier, and Mandrin) (Fig. 22.12). Rivers were never obstacles and the plateaus were easily accessible (Moncel 1996b, 1998a; Moncel 2001c). In most cases flint was worked inside the sites. The only exceptions are some bifacial tools and large or small unretouched/retouched flakes which were brought from outside. They attest an interruption in some flint debitage processing systems.

Basalt, quartz, limestone and quartzite pebbles were collected in local rivers or from old colluvial sediments nearby the sites. The complete pebbles were brought into the site, sometimes as large flakes from huge pebbles. Fragments of cave limestone were collected at Payre but this behavior is not attested elsewhere. When these types of stones are abundant in assemblages, the gathering took place in various outcrops (Orgnac 3, Payre) (Moncel 1999, 2003; Moncel Ed. 2008b). The kind of shaping depended upon the stones and their shapes. Abri des Pêcheurs is the only exception with a high frequency of metamorphic stone and quartz pebbles, collected at the foot of the site, quartz being used for debitage production.

Since the local and semi-local raw material was collected first, it suggests micro-territories, and an exploitation of the surroundings of the sites including plateaus and valleys. New results in Payre (Gb level) would be the first evidence of high mobility of human groups in the area. Territories were more towards the Rhône Valley and the southern areas rich in flint. The groups collected the best local stones in relation to their subsistence and technical needs. The frequency and quality of the different worked stones would reflect various human activities, whatever the technical tradition. Sites such as the Abri des Pêcheurs would be specific settlements, a human refuge in a cave-hole with trapped *Ibex* corpses (Prucca 2001). The recent patterns do not provide sufficient information on the eastern human movements. We do not know if human groups moved from the Rhône Valley to the Massif Central middle mountain. Assemblages of Sainte-Anne 1 and Baume Vallée indicate the use of various stones, including flint which came from a larger perimeter. Hydrographic basins from Ardèche, Loire and Allier Rivers are located close together. There is no obstacle to human circulation between the Rhône corridor and the small interior basins inside the Massif Central (Raynal et al. 2005).

Site Types

Along some valleys such as Chassezac and Ardèche, most of the archeological evidence was found in caves or shelters in karstic areas. For the Ardèche Valley, the settlements were linked to caves which are located on the level of the 45–70 m terrasse, close to the river during the occupation (Belleville 1985; Debard 1988; Nicod 1997). Orgnac 3 is an example of human mobility involving plateaus far from river beds. Sites are located close to the nearest water sources, or near raw material outcrops, always close to a plateau and in favorable topographic contexts. The cave entrances are oriented towards the south-east or west.

Site Function

The environmental context and faunal remains of all human occupations of the sites discussed are different, depending on the season and climatic period. The animal remains give an indication of the species present around the site, or of the human choices involved. The state of knowledge on subsistence behavior of occupations of the Rhône Valley, plateaus and valleys is thus based on limited information. Exploitation of the surroundings characterizes all the archeological sequences from most of the caves. The cave location, near rivers or in small protected valleys, explains perhaps some kinds of activities. River sides and plateaus are favorable for large herbivore herds. Some caves were regularly inhabited (long sequence), indicating that the site was known for a long time. The reasons for selecting a type of debitage production or types of tools during settlement are unknown. Moreover, perceptions can be disturbed by the type of record. Data on subsistence behavior are from cave occupations only as few open air sites have been found. Through all of the sequences, the technical and subsistence behavior remain similar, while this behavior is highly variable between the sites of the area: is the continuity of behavior in sequences due to quick sedimentation, similar environments, or stability of human behavior over time? Can the variability among sites is concerned, by different traditions or specific activities in relation to the sites? The functional variability of toolkits and the shape and angles of the cutting edges could be a key for a better understanding of the assemblage compositions. Neanderthal toolkit from the area (scrapers, points and sometimes some pebble tools) seems to have been limited.

Discussion and Conclusion

Data from the Middle Rhône Valley sites indicate similarities but also differences between the behavior of Neanderthal communities from other geographical areas. The question of the specificity of the behavior from this southern area has to be further investigated. It is necessary to obtain more information on the chronological and biostratigraphic framework. Humans inhabited this area continuously since OIS 9. Most of the sites date to OIS 4 and the beginning of OIS 3. As over all of Europe, extensive Neanderthal occupation with its classical features is attested from OIS 5. A clear division between OIS 5 and OIS 4 (early and recent Middle Paleolithic) exists in the area, in terms of the higher number of sites associated with OIS 5. The Levallois method was practiced in Orgnac 3 before the end of OIS 9, as in southern Europe (Atapuerca, Spain) and northern Europe (sites on Somme terrasses, France) (Moncel 1999; Carbonell et al. 2001; Tuffreau 2001a, b; Antoine et al. 2003). In south-western France, in Vaufrey cave (Rigaud 1988), and la Chaise (Delagnes 1992) or in Biache-Saint-Vaast in northern France (Tuffreau and Somme Ed. 1988), the Levallois centripetal method was not employed before OIS 5, while it was in Orgnac 3 at OIS 9 (Revillion and Tuffreau 1994; Geneste et al. 1997). In the Middle Rhône Valley, unipolar and bipolar methods are more related to earliest periods than to OIS 5. The types of debitage of OIS 9 to 7 persisted in earlier periods. The exception is the debitage of elongated flakes (blades or points) by a Levallois method which is introduced at the beginning of OIS 4. Most of the assemblages consist of flakes, produced mainly by one standardized method. The current state of knowledge indicates that large technical traditions seem to persist along time, regardless of the climatic context. The few bifaces disappear from assemblages during OIS 6. The Rhône Valley show less technical diversity over time than other regions. This does not indicate an oddness of the area. Stratified sequences are rare, and the sites are in all cases caves, never open air sites. Consequently, no comparison can be drawn between different kinds of sites as in other areas. Each technical behavior observed in assemblages is not related to specific climatic contexts but rather to both temperate and cold climates. The rare Quina assemblages seem to be the only exception and may be linked to a colder climate (Le Figuier, Baume Néron) for example in south-western France. There is no indication that forested periods had any impact on the human technical and subsistence behaviors, even if Neanderthals in northern France seemed to have preferred open areas, favourable for the hunting of large herbivores (Roebroeks and Tuffreau 1999; Antoine et al. 2003).

The way of collecting raw materials did not change over time and the cost of collecting seems to have been minimal. Flint was abundant in the local perimeter of the sites, and rivers offered various pebbles. Raw materials were collected in a variety of outcrops, perhaps during other subsistence activities. The stone collecting took place more intensively in the Rhône Valley and the plateaus and Rhône tributaries than in the Massif Central Mountains. The influence of the type of raw material on technical choices was limited and lithic variations between sites are more related to activities and traditions. Levallois debitage was rather performed on flint, while quartz was worked by different and other methods, for example the discoid method. The toolkit (scrapers, points) is poorly diversified, is especially in flint, but some quartz and limestone artifacts also occur. The unretouched artifacts were diversified enough to have worked a large variety of material.

From the archeological patterns observed, it can be deduced that the exploited territories were small (Daujeard and Moncel, 2010). Human groups were certainly mobile, probably moving seasonally. Similar to the Rhône River Valley, highly mobile Neanderthal groups occurred probably all over Europe. The study of raw material collection has shown that this region was integrated into territories which covered also plateaus and lateral valleys. Neither the size of this territory, nor the kind of mobility (Kuhn 1995) can be estimated based on the current state of knowledge. Evidences of stones collected from long distance areas are few. The Gb level of Payre yields the first clues of mobility or exchange in human population on a large scale (evidence of stones from a distance of 60 km by a microscopic study) (Fernandes et al. 2008). Ethnographic analyses have shown that the territory size depends upon the climatic conditions, type of environment and topography. In the Middle Rhône Valley, sites cover a long period of time, and comparing sites and raw material collection in diversified climatic contexts is not easy. The periods during which forest was well developed may have favoured territories of small size, and steppic environments larger ones.

Ethnographic examples show that high mobility is associated with a low number of individuals in a group (or small group size) (Binford 1978, 1983, 1987). Can we find indices of an original geographical organisation of Neanderthal groups? Human groups of small size should have been in contact and genetic flows occurred at a regional scale for human survival (Bocquet-Appel 1985). The density of isolated human groups needs not to have been high to ensure demographic survival. Consequently, genetic contact could have favoured cultural exchanges between groups belonging to large cultural units covering regional areas, such as the Rhône Valley. The technical variability observed in the lithic assemblages of the Rhône area could reflect regional traditions, in large areas covering perhaps more southern parts of France, such as Drôme, Gard and Vaucluse, from OIS 9 to 3 (de Lumley 1969; Meignen 1976, 1981; Buisoon-Catil 1994; Texier and Francisco-Ortega 1995; Texier et al. 1996; Bourguignon 1997; Giraud et al. 1998). The western areas of the Massif Central Mountains cannot yet be related to the sites of the Middle Rhône Valley, such as Saint-Anne I, dated to OIS 6 which attests a human occupation at an altitude of 790 m. At this site, the flaking methods were Levallois, Quina and discoid, and the rocks gathered consist of metamorphic and volcanic stones, and secondary flint (Raynal et al. 2005).

The Middle Rhône Valley belongs to southern Europe, characterized by small basins, valleys and plateaus, in size and relief quite different from the wide northern plain. The topographic framework has certainly influenced the types of subsistence behavior and mobility of human groups. While in northern France human occupation seems to have been discontinuous during the coldest periods, the Rhône Valley was occupied continuously from OIS 9 (Tuffreau 2001a; Antoine et al. 2003). This may explain the technical variability between the two regions. Evidence of ancient practice of laminar debitage exists only in northern Europe (Tuffreau Ed. 1993; Revillion and Tuffreau 1994). It appeared in the south during OIS 4 (Moncel 2001a, 2005). This cannot be explained by different raw materials, even if large flint nodules, suitable for the manufacture of elongated products, were common in northern Europe. The Middle Rhône Valley sites differ sometimes also from other sites of south-western France, which cannot be explained at present (Dibble 1988). The Massif Central Mountains could have been a barrier, and the south-western area a refuge. In conclusion, the data obtained from the Middle Rhône Valley falls into the pattern of variability for Neanderthal behavior (Dibble and McPherron 2006). The differences observed may be related to cultural traditions separated in time and space, but they do not exceed those found between sites from south-western and northern France.

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