Chapter 5
Lithic Variability and Cultures in the East African Middle Stone Age

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Abstract Lithics are the most abundant archaeological evidence from the remote past, however the way they are used to reconstruct past human groups is often biased. The Middle Stone Age (MSA) is the lithic techno-complex linked to the emergence of *Homo sapiens* in Africa. However, there is no consensus in the scientific community about the significance of this lithic culture in terms of connections with particular human social groups nor its evolution. This paper focuses on the relation between lithic variability in the East African MSA and its meaning in terms of the structure of human groups, critical for interpreting the behavioral and evolutionary processes that led to *Homo sapiens* expansion within and out of Africa. Here I examine current knowledge and hypotheses and suggest some methodological advances to overcome the present difficulties.

Keywords Lithic technology • Middle Paleolithic • Africa • Paleolithic culture

Introduction

The Middle Stone Age (hereafter, MSA) has been central in debates in human evolutionary studies in recent decades, because of its connection with the emergence and spread of our species in Africa (White et al. 2003; Shea et al. 2007; Groucutt et al. 2015; Hublin et al. 2017; Stringer and Galway-Witham 2017; Brooks et al. 2018; Deino et al. 2018; Scerri et al. 2018). In fact, until now, all the fossils of early *Homo sapiens* are associated with MSA lithic industries, whose most ancient manifestation is approximately the same age as the oldest *Homo sapiens* fossils (Hublin et al. 2017; Brooks et al. 2018).

The MSA is a lithic industry spanning roughly from ~300 to ~30 thousand years ago (ka), initially conceived of as the counterpart, and sometimes used synonymously with the Middle Paleolithic (MP) of Eurasia, indicating initially, in chrono-stratigraphic terms, something following the Early Stone Age (ESA) and preceding the Later Stone Age (LSA) (Goodwin and van Riet Lowe 1929). The cultural and chronological definitions of the MSA have been the subject of much debate (for a complete review, see Douze 2011). The beginning of the MSA is generally identified by the progressive abandonment of bifaces (handaxes and cleavers) and the presence or the enhancement of the hierarchical core reduction strategies, the so-called Prepared Core Technologies (PCT, e.g. the Levallois method(s) for flake production) (Clark 1988).

It is still unclear, if the MSA is a single techno-complex or if it is the result of multiple technological traditions. As Clark (1988) noticed, in the MSA there are almost as many exceptions as conformities to the rules. Despite its importance in evolutionary terms, in fact, the study of the MSA presents serious ambiguities linked to: (i) the poor technological resolution of most studies; (ii) the large geographical and chronological span; (iii) the scarcity of well dated stratified contexts.

This general uncertainty about one of the main archaeological phases critical to our recent past, has a number of consequences affecting the quality of the models proposed to explain population dynamics (contraction, expansions, drift) in both biological and cultural terms, in this key period. Particularly, this paper focus on the relation between lithic variability in the East African MSA and its meaning in terms of human social groups, critical for interpreting the behavioral and evolutionary processes that led to *Homo sapiens* expansions within and out of Africa. In particular I analyze how and if the current knowledge of the archaeological record is able to detect meaningful social boundaries and

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specific human groups. In fact, it has been proposed that the MSA may correspond with the origin of regional differentiation, linked to a complex process of small-scale population fragmentation (Tryon et al. 2005). The development of regional identity is a fundamental part of the model about the MSA since the famous paper by Clark (1988), however the research about this diversity and the meaning of this identity is still lacking theoretical clarity.

One of the key open questions is whether the variability of the East African MSA is the result of different populations (defined by boundaries), or of the nature of archaeological investigation and its biases. To analyze this problem, we still have to question the anthropological meaning of the archaeologically defined "Paleolithic cultures" and test their significance in terms of human groups.

Lithics and Paleolithic Cultures

Particularly for the most ancient periods, lithics are often the only preserved data from a broader social system that produced them. One of the first questions to be addressed here is if and how lithics are expression of Paleolithic cultures.

Traditionally, archaeologists working with the Paleolithic archaeological record have relied on lithics (1) to define past "cultures", in a culture-historical perspective (i.e. Bordes 1961), and (2) to identify evolutionary trends (Foley and Lahr 1997). However, wherever ethnographic studies have been conducted on recent hunter-gatherers (e.g. Hayden 1979), they indicate that stone tools represent only a minimum portion of the technology used by the groups, and they do not necessarily reflect the complex suite of behaviors and social rules that characterize a past cultural adaption (d'Errico and Banks 2012), despite their utilization for cultural markers in the traditional culture-historical approach (Table 5.1).

Franz Boas (1938) defines culture as the totality of the relations and the activities characterizing the behavior of individuals composing a specific social group, including the products of these activities and the role they play in the life of different groups.

Archaeology relies on material culture, and material culture is an expression of a society. However, if the attribution to a group affiliation is possible for contemporaneous societies, through individual self-ascription to a group affiliation (Barth 1969), it is beyond the resolution of prehistoric archaeology (Tostevin 2012).

In general, in prehistory, we define cultural factors as elements that cannot be straightforwardly explained by practical factors, such as quantity, quality and availability of raw materials (see Tryon and Ranhorn 2020), site function, or mobility strategies. This sometimes goes under the name of "style" (Binford 1962; Binford and Binford 1968; Dunnell 1978), which includes the artefact variability not accounted for by other functional constraints (Tostevin 2012). Here, cultural traits, represent learned and shared behavior, which are acknowledged to be the landmark of a "culture".

In fact, hominins are 'culture-bearing organisms' (Foley 1985). Two factors are inherent in the "culture" concept: the capacity to transmit and receive information; and the associated aptitude to initiate, develop and change behavioral strategies, on a scale unknown in other species (Foley 1985), even if this gap between our species and the others is progressively decreasing (i.e. Whiten et al. 1999).

But how can we assess the meaning and the existence of "Paleolithic cultures"? One of the questions to be addressed is "Are we tracking cultures using the right theoretical tools?".

One of the tools we can use to build models is the capability of culture to define boundaries between one ethnic group and another (McElreath et al. 2003). Ethnic identities are given by the setting of social processes that resist a homogenizing effect, in a frame of a specific spatial structure.

Table 5.1 Short definition of the main terms used in the text

Cultural	Transmitted through social learning.
Culture	Ensemble of behaviors and ideas transmitted through social learning, identifying a social or ethnic group.
Ethnic Group	People who belong to the same social or human group and/or identify themselves as belonging to the same culture. It includes one or many social groups.
Human Group	Social or ethnic group from the past. Used here to keep it neutral with regard to ethnicity.
Social Group	Two or more people related by kinship (social bond based on common ancestry, marriage, or adoption) and/or other form of social cohesion.
Significant technological unit (STU)	Technological behavior that is culturally coded, here applied to lithics.
Techno-complex	Lithic industry belonging to a specific cultural tradition.
Tradition	Cultural phenomena transmitted within a social or ethnic group.

Wobst (1974) first assessed how style in material culture would show socially meaningful information, such as group affiliation or membership. Later, the active role of style has been questioned by Sackett (1982): he proposed an "*isochrestic*" (equivalent in use) model where the artisan's choices, conscious or not, regarding non-functional aspects of the artefacts, are dictated by the traditions pertaining to the social group, so the social group itself is socially bounded and consequently diagnostic of ethnicity. Wiessner (1983) has shown in ethnographic contexts that the use of a certain style is often ethic but not emic, thus unconscious: although most San artisans were not aware of making arrows whose style was indicative of their group, nevertheless they could definitely recognize their arrow among a group of arrows.

A further aspect concerns not only the meaning of the shape/morphology of the tool, but the way in which this was produced, going broadly under the term "technology" (sensu Leroi-Gourhan 1964). Technology is defined as the sequence of behaviors in the manufacture of artefacts, and it results in stylistic variation useful for culture-historical reconstruction. Technology is culturally oriented, thus two objects having the same style and the same functional properties could have been made using a different technology. The *chaîne opératoire* method allows one to regroup sets of specific gestures and relation of them to a specific "tradition", meaning by tradition a learned and established aspect of the culture (Mauss 1936; see also Maher and Macdonald 2020). In the view of *chaîne opératoire* theory, the social information of a specific society includes the knowledge necessary to perform the sequence of gestures necessary to execute a technical action. Thus, technology is the material manifestation of the society's cultural information. The gesture identified through the *chaîne opératoire* is directly connected to human social behavior. Consequently, the technology is significant as a phenomenon embedded in social action (Dobres and Hoffman 1994). The technology could fit as well in the definition of *habitus* by Bourdieu (1977), because it generates regular practices that, while not strictly determined by rules, are at the same time collectively structured. So, a different technological system could be related to a different cultural system, because the first is embedded in the second.

Finally, it has been observed that the more visible the attribute on the final artefact, the larger the inventory of possible social processes that could contribute to its variability (Tostevin 2012). This approach is often combined with the study of the "life history" of the tool (Bleed 1986, 2001; Shott 1996), connected with the "behavioral archaeology" (*sensu* Schiffer 1976), and to the "Organization of technology approach" (*sensu* Nelson 1991). Both these approaches are useful tools to detect the stylistic/cultural vs functional meaning of lithic attributes, and to investigate the characteristics of the tools that are inherent to their use and discard. Particularly important are the studies on reduction, reuse and recycling, showing that the shape in which a tool enters the archaeological record seldom reflects the shape of the same tool at the time it was made by the artisan.

In conclusion, a tool (e.g. a Gravettian point) should in general be representative of its time and place (Tostevin 2012). However, it is clear that most lithic tools that could correspond to a stylistic choice have both a chronological and geographical distribution that goes beyond any association with a specific hunter-gatherer group (e.g. Groucutt 2020). For example, the stylistic variation of arrow morphologies in a San language groups, studied by Wiessner (1983, 1984), identified groups of 1,500–2,000 persons, definitely larger than the assumed foraging band of 475 persons postulated by Wobst (1974). It must be noted, however, that the bands are fluid in their composition and their number can vary greatly, never reaching in any case the number expected by Wiessner. In general, without specific ethnographic referencing, the lithic distribution of a single tool often covers areas that are thousands of kilometers wide, impossible to superpose on the home range of any band-dimension society: tool adoption does not fit ethnic boundaries. Here a problem of time averaging also occurs because, since we cannot assert with certainty the distribution of a specific tool in a specific moment, but only in a chronological range, it is difficult to relate the geographical distribution within a narrow chronological time frame. This confusion opens the way for a certain number of simplifications that affect models for culture change and tradition in Paleolithic studies.

Lithics are then an indicative set of technical skills, knowledge and mental templates directly linked to the system that produced them, a system including social practice, symbolism and so on. We can then recognize traditions by the lithic record, and it is in tracking those specifically that maybe we can address some models for human populations.

One attempt to overcome the difficulties is to try to identify which technological and typological attributes, or set of attributes linked to specific technical behaviors, are socially meaningful. The first to relate attributes of lithics to social meaning was Carr, drawing from ethnographic data (Carr 1995). More recently, a unified (middle range) theory of artefact design was proposed by Tostevin, with the purpose to assign potential etic meanings to specific attributes of a specific class of artefacts (Tostevin 2012). The attributes should be linked with potential meanings, and with sub-attributes that are most likely to be relevant for the analyzed processes and social units.

Despite the fact that lithics are socially meaningful, however, prehistoric cultures as they are described and analyzed in the current studies, are not the expression of a single ethnic group. However, different groups of archaeological assemblages share cultural traits, and when they are not explicable by convergent evolution, are thus meaningful under the plan of culture boundaries.

Carla Sinopoli made an archaeological study of ethnographic arrows from Numic speaking groups in the American Southwest (1991): the study of 172 arrows from three different bands showed that the variables on the arrows were most distinctive between the geographically and linguistically closer groups. Eleanor Scerri and colleagues (2014), were able to combine attribute analysis on stone tools with paleoenvironmental data, showing that different population of tools were geographically connected and structured. Katja Douze (2014) positively identified the "tranchet blow" process as a meaningful chronological and cultural marker relative to the Early MSA at Gademotta.

It is only by combining the significant data from lithic attribute analysis, technological analyses, chronological data, spatial analysis and paleoenvironmental data, that it will be possible to identify meaningful social boundaries within the Paleolithic record. I will propose here to use notion of Significant Technological Units (STUs) to identify technological behaviors that can be isolated and tracked in order to relate them to specific cultural traditions.

Mechanisms of Culture Change

Traditionally, the mechanisms of culture change are identified in two main processes: "branching" and "blending" (Collard et al. 2006), or in other terms whether cultures develop by a tree-like splitting process (*phylogenesis*) or by admixture (*ethnogenesis*) (Nunn et al. 2010).

The **branching hypothesis** (phylogenesis) states that the general similarities in material culture between populations are primarily the result of within group transmission and population fissioning, in a (vertical) schema reproducing a phylogenetic tree. It has also been suggested that there are mechanisms of isolation that impede the transmission of cultural elements among contemporaneous communities by Transmission Isolating Mechanisms or TRIMS (Durham 1992).

The branching hypothesis has strong association with biological patterns, aiming to build a phylogenetic tree of related cultures: according to this hypothesis, the history of the diversity of human cultures will also be the history of human populations (Foley and Lahr 2011).

In a branching perspective, the mechanisms of culture change are described as: (1) Local adaptation; (2) Diffusion; (3) Replacement; (4) Migration; (5) Assimilation (Foley and Lahr 1997). Local adaptation can be either the result of drift or innovation.

The **blending hypothesis** (ethnogenesis) (Shennan and Collard 2005) refers to traditional "cultural diffusion" (as in Kroeber, i.e. 1949). Here cultural evolution occurs as a consequence of the borrowing of ideas and habits from contemporary societies, in a scheme of horizontal transmission. Since the beginning of the discipline, anthropology has used the concept of contact between cultures as an explanation of the cultural variation through time and space (Trigger 1996). The basis of this hypothesis is that there has always been a constant flow of ideas, goods, and cultural practices between one community to another, as much as with genes (Collard et al. 2006). This hypothesis correlates the frequency of the contact with the similar cultural patterns. Thus, different scholars state that blending is more significant than branching in human evolution (e.g. Dewar 1995; Moore 2001).

However, if this were the case, the difference within culture would be erased through time and at the present time there could be only one world culture. This is actually not the case, because the building and keeping of boundaries contributes to the big cultural diversity in *Homo sapiens*, that sharply contrasts with a relative biological uniformity, leading to the paradox of low biological diversity and high cultural diversity in modern humans (Foley and Lahr 2011).

The archaeological record itself is the proof of long enduring cultural traditions with recognizable cultural patterns lasting in space and time: the persistence of boundaries attests to social mechanisms that resist to homogenization (McElreath et al. 2003).

Furthermore, where the branching vs. blending hypotheses were tested, it was shown that the branching model is prevailing in cultural transmission (Guglielmino et al. 1995; Hewlett et al. 2002), where the blending effects are limited to trade and exchange. Archaeological inferences concerning mechanisms of cultural transmission should take into account how isolation by distance affects cultural diversity (Premo and Scholnick 2011; Scerri et al. 2014).

The greater the geographical proximity or connection of two populations the more similar two cultures are (Foley and Lahr 2011; Scerri et al. 2014) and this is likely the result of a combination of branching (direct cultural transmission) and blending (acculturation, contact, exchanges of goods and people): the way this happens is operationalized in "cultural transmission theory". Of course, neither branching nor blending alone can explain the immense variability of human cultures, and the phenomenon of convergent evolution also has to be taken into account.

Cultural Transmission Theory

Cultural transmission theory is useful for understanding the processes of transmission, modification, preservation and loss of learned behaviors, including the technical choices of artefact makers, in an evolutionary perspective (Premo and Hublin 2009; Premo and Kuhn 2010).

In cultural transmission theory, culture is defined as "information acquired by individuals from other conspecifics by teaching or imitation" (Boyd and Richerson 1988). Cultural transmission is assimilated both by mates and by people not genetically related, where the teacher is often a high-status individual. This transmission of information can thus be vertical (coming from parents), oblique (coming from other individuals in an older generation), or horizontal, from conspecifics of the same generation (Cavalli-Sforza and Feldman 1981). This generates non-adaptive cultural variants (Premo and Scholnick 2011) by innovation that can be socially fixed (i.e. transmitted), eventually by drift.

Cultural traditions are therefore the outcome of the way in which human groups reproduce themselves over generations (Foley and Lahr 2011), through social learning, defined as the transmission of all the non-genetic information from one individual to another (Galef and Laland 2005; Mesoudi 2016). Differently from genetic traits, cultural traits can be distinguished in many different ways, including their abandonment in favor of others (Foley and Lahr 2011).

Culture as a Biological Adaptation

The idea, then, that culture is a biological adaptation descends from the branching hypothesis, that has been shown to be the most effective explanation of the variation of cultural evolution and of actual human variability. Blending surely plays a role as a consequence of contacts and exchanges, but its impact over the long-term pattern of cultural evolution is limited.

In fact, there is a human selection of different cultural options, leading to cumulative cultural evolution, defined as the accumulation of beneficial modifications over successive generations (Dean et al. 2014; Mesoudi 2016); this is influenced by ecological factors, and its result is the creation and maintenance of boundaries between different communities.

To study the diversity of human cultures, over space and time, is also necessary to analyze *Homo sapiens* adaptations to different environments: in fact, our species peopled the totality of the Earth and multiplied the ways in which they adapted to environments, and the different levels of social complexity (Foley and Lahr 2011). In reconstructing past adaptations from the archaeological record, we are faced with the goal of tracking the implication of the adaptations over the material culture, thus in the archaeological record.

Particularly, when it comes to Paleolithic "cultures" we aim to understand what behavioral signatures are meaningful in terms of biological evolution:

> "*The history of the diversity of human cultures will also be the history of human populations as they have formed, moved and died out, and there will be a relationship between biological and cultural phenotypes*" (Foley and Lahr 2011).

How are biological and cultural traits connected? In Paleolithic archaeology, we have to start thinking about possible biological boundaries (i.e. different human species at the same time) associated with cultural ones, as well as significant ethnic boundaries, within *Homo sapiens*, recognizable from Paleolithic material culture.

Why is there no consistency between the biological and the archaeological records? Human populations responded to variable conditions both demographically and adaptively, engendering a complex series of changes (Lahr and Foley 2016). Different ecological circumstances promote different adaptive strategies, whether biological or cultural (Mirazon Lahr 2016). The behavioral signatures usually precede biological ones (Bateson 1988), and biological changes can be the consequences of behavioral changes (Mirazon Lahr and Foley 2001), as well as the biological changes also potentially creating behavioural change.

Transitions often are the result of the interaction between biological and cultural variation during population collapse and the subsequent loss of variation due to partial population extinction or assimilation (Mirazon Lahr 2016). Is culture merely tracking biological diversity, then?

There is another element to be taken into account, equally likely to occur in biological and cultural evolution: convergence/homoplasy. The issue of convergence is linked to independent change leading to a similar result, such as homoplasy in phylogeny; this is culturally linked to (re)invention. Convergence in cultural choices represents a common solution to limited problems, and could possibly be linked to innate mechanisms connected to brain functioning, related to the evolutionary significance of certain traits. In any case, the possibility to choose between different culturally oriented options is dominated by the primary brain functions and capabilities that are inherent to every human species, thus it has a biological signature.

Convergence is one of the big puzzling questions in the analysis of Paleolithic artefacts, and, together with branching and blending, it is one of the three hypotheses to be tested to assess similarities, contacts and descent within human groups in the Pleistocene.

Lithics and Cultures in East Africa

The multiple facets of MSA technology are currently the subject of intense investigation, and it is more and more clear that they are connected to ancestral populations likely more diverse than previously expected. First, the variability within the MSA likely includes the behavioral outcomes of multiple hominin populations and perhaps even species (Tryon and Faith 2013). The model of 'African Multiregionalism' (*sensu* Scerri 2018) helps depict a scenario that is much more complex than formerly thought, where the MSA is the result of multiple populations showing genetic and morphological differences. This model would fit with a multiple (ragged) origin of MSA, resulting in strong regional differences and a large variability overall.

Yet, most of the distinctive traits of MSA technology, such as the reliance on prepared core technology, originating as far as ~500 kya BP, are shared all over Africa. In this case, we could imagine one ancestral single population dating back to the lineage splitting from *Homo heidelbergensis* or which hominin species turns out to be ancestral to our own, leading to multiple facets and adaptations that finally were expressed into MSA.

Does the archaeological record then reflect this varied population history? Does the spatial distribution of artefacts types reflect the geographical range of specific populations? In fact, cultural change cannot be separated from its geographical and chronological dimensions (Mirazon Lahr 2016). Can we isolate human groups, in terms of populations or groups of populations, that are socially and biologically meaningful, on the basis of lithic technology?

It has been proposed that among early *Homo sapiens* populations significant behavioral novelties were associated with cognitive shifts, and thus biological evolution (Foley and Lahr 2011). The MSA origin may parallel the origin of regional differentiation, in a complex process of small-scale population fragmentation, isolation, expansion and replacement (Tryon et al. 2005; Scerri et al. 2018).

Foley and Lahr (2011) propose a model centered on East Africa, and emphasize five stages of the evolution of cultures from early *Homo sapiens* (*sensu* Bräuer 2008): (1) anatomical modernity and cultural continuity within the MSA; (2) African MSA regionalism; (3) diversification of human populations; (4) fragmentation linked to climate and environment; (5) post-Pleistocene complexity.

For the sake of this paper, I take into account the MSA context in East Africa in particular (Fig. 5.1), considering it as a chrono–cultural entity, in its original definition (Goodwin van Riet Lowe 1929; see Douze 2011 for a review), following the Acheulean and preceding the LSA. East Africa includes: South Sudan, Eritrea, Ethiopia, Djibouti, Somalia, Kenya, Uganda, Rwanda, Burundi, Tanzania.

The generalized neutral hypothesis concerning East Africa, implies that by ~200 kya BP, early *Homo sapiens* were the sole occupants of the region. This is the dominant model, mostly the outcome of current fossil and genetic evidence. However, the presence in the African continent of multiple human species at that time, should imply caution about this assumption.

The research questions regarding the MSA in East Africa involve: (i) the technological innovation developing in the archaeological record (e.g. prepared core technology, point production); (ii) the cognitive shift from the early/archaic *Homo sapiens* population to fully modern *Homo sapiens*; (iii) the expansion of the *Homo sapiens* population to eventually reach the rest of the continent and beyond.

MSA patterns can be interpreted as the gradual evolution of a variety of cultural adaptations in response to shifting regional, environmental and fluctuating demographic conditions (Kuhn 2013).

The beginning of the MSA is characterized by a number of technical innovations that follow the ESA in the archaeological sequences: (1) the (sometimes progressive, sometimes abrupt) abandonment of large cutting tools (LCT), (2) the enhanced reliance on prepared core technology (PCT), (3) blade/bladelet production; (4) the intense production and use of convergent tools. As we can see, the MSA innovations involve systems of both production (PCT, blade etc.) and use (convergent tools, microliths, etc., abandonment of handaxes) that have to be linked to a complex set of subsistence behavior. However, while those traits are incredibly stable over the early MSA, in sites often separated by thousands of kilometers and thousands of years, the modalities in which those innovations are managed and the rate of innovation and maintenance of ESA tradition change site by site. Furthermore, those innovations are not synchronous.

The differences between Eurasian MP and African MSA have been object of debate, however there are few comparative studies. Is the biological difference between *Homo sapiens* and *Homo neanderthalensis* uninfluential with regard to lithic production? Or, on the contrary are the MSA and MP more diverse then expected? After Kuhn (2013) the overall limited variability of the Middle Paleolithic is linked to the low necessity to signal identity and it is structurally different in the Eurasian MP and the African MSA. While in Europe this may be the indication of very small and dispersed groups, in the African MSA it could be the result of cumulative cultural evolution, more similar to the European Upper Paleolithic. Could this model be valuable also for the early MSA of East Africa?

It appears that in East Africa there is a persistence of some technological traits over space and time, showing no definite trend, until the explosion of what has been called the "beginning of social identity" (e.g. Wadley 2005; Scerri et al. 2014) with the large MSA variability, around MIS 4 but with different timing in the whole continent.

On another side, those peculiar traits could be stable because of an independent evolution from the ESA, leading to convergence. The phenomenon of drift and loss of peculiar technological innovation could be linked to the sparsity of populations (Kuhn 2013), and it has been

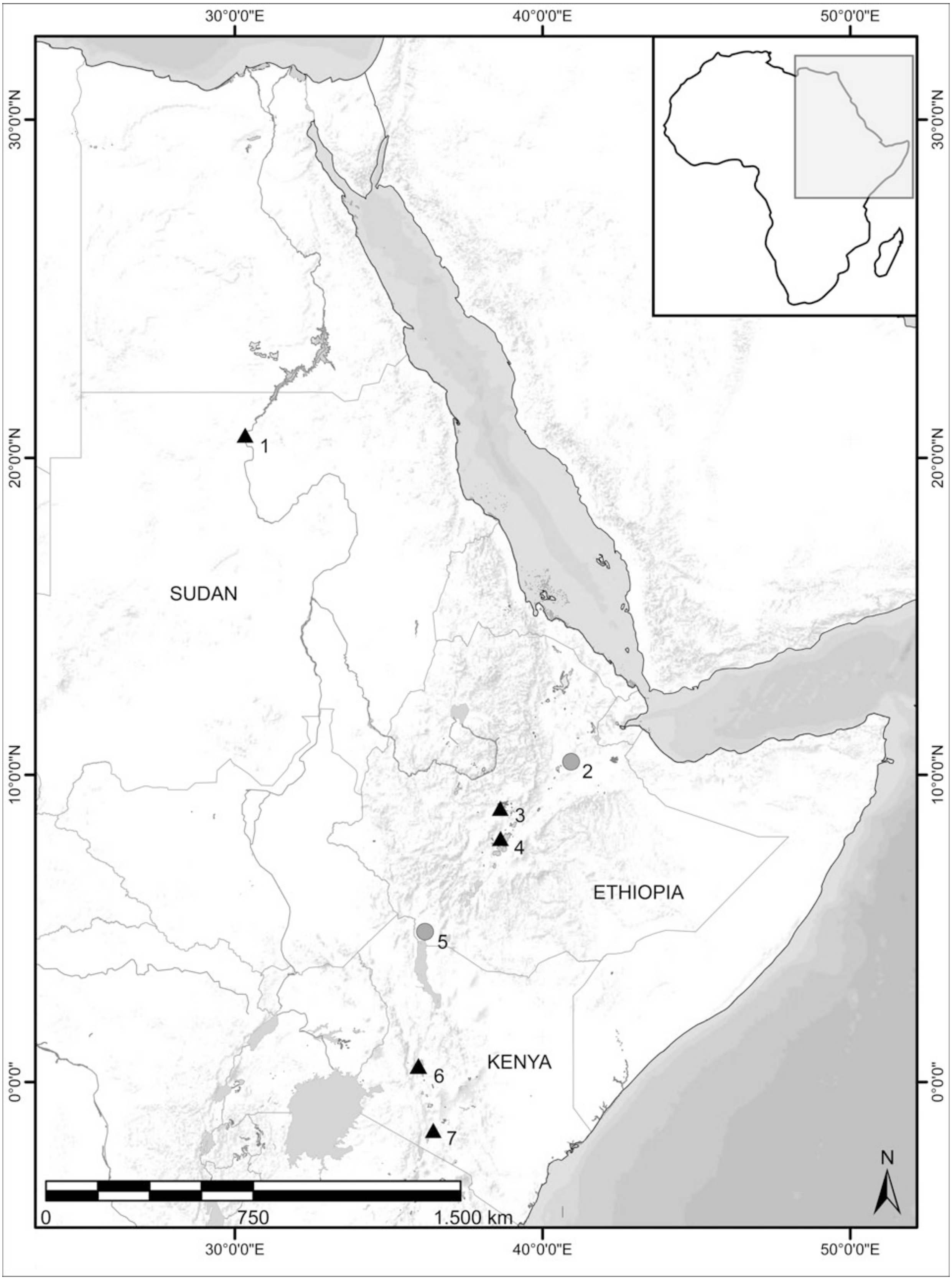

Fig. 5.1 Map of the MSA sites cited in the text. 1. Sai Island, 2. Herto, 3. Melka Kunture, 4. Gademotta, 5. Omo Kibish, 6. Kapthurin, 7. Olorgesailie

assessed that hominin population densities were low during the MSA, after an estimation based upon ethnographical comparisons, primate group sizes, environmental carrying capacities, and density of archaeological sites over time (Basell 2012). Moreover, small populations have low rates of invention, because the rate of novelty is directly linked with the population size (e.g. Kline and Boyd 2010).

From a point of view that combines cultural transmission theory and evolutionary ecology, an attempt can be made to relate lithic cultures in the East African MSA with population dynamics, expansion and isolation, within and outside East Africa. To achieve this goal, it would be necessary to build archaeologically appropriate theories to connect the research questions to the models in the (available) archaeological record (Binford 1977).

Although the MSA is often considered as a "package", the different characteristics are in fact asynchronous. It is thus important to analyze every technological aspect as the expression of a single behavior (single cultural component). It has already been shown that different technological aspects can evolve and stem independently. For example, the observations made in the Kapthurin Formation (Tryon 2006) suggest that two of the aspects considered the hallmarks of the MSA, (i) formal tools such as points (see Douze et al. 2020), and (ii) the means of flake production, including Levallois methods, represent two independent elements of hominin adaptive behavior, each having its own distinct development.

Furthermore, the few sites with long sequences spanning from the ESA to the MSA (Fig. 5.1) such as Sai Island, Gademotta, Kulkuletti, Melka Kunture, Kapthurin (Van Peer et al. 2003; McBrearty and Tryon 2006; Douze 2012; Mussi et al. 2013) in general do not show significant technological change through time and are characterized by a great variability (Clark 1988; Tryon and Faith 2013). In some sites there is a technological continuity (such as in Kapthurin); in others there are unconformities (e.g. Sai Island) that may indicate population replacement (Van Peer 2003; Tryon 2006).

Technological continuity within assemblages may indicate the presence of stable techno-cultural system over time (Douze and Delagnes 2016), while cultural diversity is more accentuated between sites located in geographically separated sites (Shea 2008). This model fits with the hypothesis of separate populations, in which the technological innovation, stemming from a common basis, took a separate course.

One of the questions to be asked is whether those traits are stable over time because they are linked to small populations that kept contacts and/or are phylogenetically connected. This hypothesis would fit with the assumption of small population sizes during the Pleistocene.

Another alternative hypothesis is that those traits are stable because they are originally linked to a single population that then split and occupied larger areas, keeping these technological traits stable. Phylogenetically the question to be asked then is whether those traits were present in the original MSA making population or they were only successively developed.

To disentangle this question, each and every single significant cultural trait shall be treated separately. It has been shown in specific cases that elements considered as the hallmark of MSA, such as methods for flake production (i.e. Levallois) and tools such the points, in reality have a different history of development (Tryon 2006).

I will in this paper introduce the definition of Significant Technological Unit (STU), as a behavioral package of technological traits identifiable in the archaeological record, considered independently of one another. STU is defined here as a technological behavior that is culturally coded, e.g. it needs to be invented, copied and reproduced, and to be archaeologically visible. Each and every STU in a specific archaeological context could be either the result of independent invention (convergent), direct transmission (branching) or cultural assimilation (blending).

I choose to examine here two different STUs, in order to discuss two technological methods: (i) the origin of Levallois technology, (ii) the origin of blade/bladelet technology; and one associated behaviour, (iii) the circulation of raw materials.

One of the "big questions" about the MSA, the production of points (see Douze et al. 2020), was intentionally left out here, for a number of reasons. Lithic point production is among the most ubiquitous cultural elements that encompass both African geography and the entire time span of the MSA. Points have been associated with MSA research since its inception; however, our knowledge about their production methods, functions and curation is still largely insufficient (Douze and Spinapolice 2016). Points are outside the aim of this paper principally because it is hard to assess how many STUs characterize point production, since sometimes they are obtained through convergent Levallois core reduction method, others from volumetric cores, and in other cases points (convergent tools) are shaped and/or retouched (Perlès 1974; Douze and Delagnes 2016). For example, Levallois point production consists at least in six interconnected steps (Leroi-Gourhan 1964) and can be considered at least a single STU. To disentangle this question would possibly require a separate work.

The STUs considered here, are, on another side, well known technological packages that are the basis for a large part of the lithic production in East African MSA: Levallois and blade technologies.

Origin of Levallois Technology

The development of Levallois methods is an aspect of lithic technological change that may provide clues to local patterns of innovation and replacement during the period of transition between ESA and MSA (Tryon et al. 2005).

The origin of Levallois is believed to be one of the main features of the MSA, as a "prepared core technology" (PCT). PCT is present in the ESA; however, the reliance of human groups on this production method in that period was poor, while in MSA contexts it becomes the most common way to produce blanks and persists all over the Late Pleistocene.

Following the definition of Boëda (1994), the Levallois method is characterized by the organization of two opposed surfaces, hierarchically patterned: the upper, dedicated to flake production, and the lower, to core preparation. The Levallois method variability includes two main forms of production: preferential and recurrent, and different flaking directions (i.e. unidirectional, convergent, centripetal).

The beginning of Levallois flaking is an event of particular importance that goes beyond lithic technology and may be an indication for the emergence of changes in hominin social, behavioral, and cognitive structures (Ambrose 2001), especially in the light of the long stasis that precede it, characterized by multiple faking systems (White and Ashton 2003).

Levallois technology is widespread in the old world, and the question on whether it comes from a single event or from a polycentric origin is a matter of debate (Rolland 1995). Among the first examples of Levallois production in Africa is the production of blanks to make cleavers (Tryon 2006), both in North Africa (Alimen and y Zuber 1978; Dauvois 1981) and in East Africa (Roche and Texier 1995).

However, there are different trajectories in the beginning and development of Levallois production strategies. Rolland (1995) identifies a dichotomy between Europe, where Levallois stems from biface production, and Africa, where it comes from successive variations of prepared cores. However, this interpretation is contradicted by some recent evidence from the European Mousterian (see for example Picin 2018).

The origin of Levallois technology has been also related to a single origin, linked to a population of archaic *Homo sapiens*, that successively spread into Eurasia (Foley and Lahr 1997). However, this single-origin hypothesis has been repeatedly challenged (see Adler et al. 2014 and references therein), and many scholars now believe in a multiple origin of Levallois technology (see Groucutt et al. 2015).

Another hypothesis states that the source of the Levallois method can be linked with handaxe production in Africa, directly evolving from existing Acheulean tradition (Biberson 1961; Dauvois 1976; Clark and Kurashina 1979). An alternative hypothesis claims that in South and East Africa the Levallois methods is possibly derived from the Victoria West cores, also called Protolevallois (Rolland 1995). However, Victoria West cores could as well be related to biface production.

The Levallois method has been classified into different sequences of production, mainly recurrent (continuous production of Levallois products) and preferential (sequence ending with the production of a preferential flake or point, Boëda 1994). It would be interesting to analyze the two methods as a separate STU, in order to identify possible trajectories of tradition and/or reinvention. Actually, there is no chronological or geographical trend in the use of recurrent vs preferential method, and both are commonly used in the same sites, often in the same assemblages, possibly to adapt to the goal of specific flake morphology, and to adapt to the shape and availability and quality of the raw materials.

In my opinion, the origin of the Levallois technology has profound cognitive and adaptive bases and consequences; however, it has to have occurred in the Middle Pleistocene, being already present in the Late Pleistocene in many sites in Africa and Eurasia, and thus has to be biologically correlated roughly with *Homo heidelbergensis* (see following paragraph).

Finally, the multiple facets linked to Levallois technology and the large variability of this method for flake production do not make this technological behavior suitable to delimit single population histories or to trace population directories within the setting of East African Middle Pleistocene. The abandonment of LCT production in favor of PCT indicates a shift in the technological strategies based on a previously acquired technology. It would be more useful, in terms of early *Homo sapiens* adaptation and behavior, to investigate the modalities and the causes for such a choice (e.g. raw material availability, environmental changes etc). The Levallois production method, being one of the hallmarks of the MSA, is therefore not suitable to answer the question: how were hominin populations structured in East Africa in the Late Pleistocene?

Origin of Blade and Bladelet Technology

Among the hierarchical core reduction strategies adopted in the MSA technological repertoire, blade and bladelet production plays an important role (e.g. for a review Bar Yosef and Kuhn 1999), because this production method has been traditionally linked to the European Upper Paleolithic "Revolution" (e.g. Mellars and Stringer 1989; Bar-Yosef 2002) and included in the hallmarks of "modern behavior". However, after the ground-breaking assumption that, from an African point of view, there was no Revolution (McBrearty and Brooks 2000), more and more evidence pushes the adoption of this strategy back in time, and it is clear now that if the systematic standardized production from prismatic cores broadly coincides with the Upper Paleolithic, the production of elongated blanks is part of the

MSA since its very beginning (Wilkins and Chazan 2012), predating the oldest currently known *Homo sapiens* fossils. After Herries (2011), the technology of blade production precedes PCT, and Levallois point production itself and these technological modifications coarsely correlate with the appearance of *Homo heidelbergensis* (Rightmire 2001). In fact, in East Africa, the earliest occurrence of non Levallois blade production is attested in the Kapthurin Formation and dated to 509 ± 9 ka (Johnson and McBrearty 2010).

The laminar technology provides evolutionary fitness, because it promotes the production of long cutting edges with a relative small technological investment (but see Eren et al. 2008). Furthermore, the rhythm of the blade production is continuous, leading to a complete reduction of the core, and the platform cores do not need a re-preparation of the surfaces as happens for Levallois cores. The continuity in the production is a characteristic shared by recurrent Levallois and blade production, while preferential Levallois requires a bigger investment of preparation and/or a discard of the core after the extraction of the preferential flake. An interpretation about the appearance of blade technology is that prior to the Upper Paleolithic, it appeared and disappeared, being linked to local adaptations and raw material availability (Wilkins and Chazan 2012).

In East Africa, the appearance of bladelets is particularly interesting. It has been proposed that the complex behavior linked to blade technology has to be shifted, in terms of efficiency, to the bladelet production, leading to the production of composite tools, and microliths (e.g. Eren et al. 2008). Bladelets in fact can be used as components of tools of greater complexity, such as composite tools, technologically more articulated than simple hafted tools (Ambrose 2001), involving a different design and an innovative set of strategies of production, use and maintenance (*sensu* Bleed 1986).

One of the most interesting aspects of bladelet technology is its relation with hafting. The evidence for hafted tools in the MSA and MP archaeological record is often discussed as a potential signature of behavioral complexity (so called "modern behavior") (Ambrose 2010; Barham 2013), involving a complex set of actions linking the tool, the joint and the haft. Hafting has also been interpreted as part of constructive memory, linked to specific cognitive abilities (Ambrose 2010; Wadley 2010). While there are some reservations on the importance on hafting in blade technology the use of bladelets and in general, microliths, is strictly linked with hafting methods. In fact, the use of adhesives appears later than the first appearance of blade technology, as in the Howiesons Poort technology in South Africa (Lombard 2006; Wadley 2010; Charrié-Duhaut et al. 2013).

One problem here is the classification of bladelets themselves, that is rather ambiguous. Bladelets are by definition smaller than blades, but their dimensional demarcation often overlaps with blades, and the quantitative definitions of blades versus bladelets differ substantially between researchers (Kaufman 1986). Quantitative descriptions of lengths and width/length ratios of artefacts can minimize the subjectivity; however, a universal definition of this boundary it rather difficult because it depends on raw material size and availability, mechanical properties, morphology of hafts and other factors (Ambrose 2002).

Despite those difficulties, a more detailed analysis of the appearance of bladelets in the archaeological record is noteworthy. Bladelets, unlike blades, appear to be a constant from the onset of the East African MSA, and could be the East African counterpart of the South African backed tools. One of the questions is whether microlithization is a mover and/or a consequence of the development of composite tool technology. Different elements contribute to considering bladelets as part of composite tools (Ambrose 2010): for example, microwear (Beyries 1988; Anderson-Gerfaud 1990), traces of mastic and red ochre (Boëda et al. 1996), and standardization of artefact size and shape (McBrearty and Brooks 2000).

The presence of bladelets (~2–4 cm) and bladelet cores is constant in most of the assemblages from the early MSA in East Africa (contra Ambrose 2002): Gademotta (Douze 2012), Garba III (Spinapolice and Mussi in prep.), Omo Kibish (Shea 2008), Olorgesailie (Brooks et al. 2018). While these bladelets are not as standardized as their LSA/UP counterparts, still they are regular in shape and average dimensions. The question arises whether this invention is independent, thus created by convergence, or is a result of the cultural transmission of the same innovation. Is there any chronological or geographical trend in the adoption of bladelet technology in MSA? In light of recent discoveries, Olorgesailie seems to be one of the most ancient MSA sites so far discovered: the most recent report includes five localities, dating to ~295–320 ka. Here all the characteristics of MSA are present, including prepared core technologies, and here blade and bladelet production seems to increase through time (Brooks et al. 2018). The same chronological trend has been analyzed by the author in Garba III. It is likely that the bladelets of early MSA constitute the first application of composite tools, later becoming the hallmark of the LSA, in East Africa and elsewhere (Leplongeon 2014).

Furthermore, the presence of Micro-Levallois flakes, in many of the same lithic assemblages where bladelets are present (Garba III, Gademotta, Omo Kibish), is another argument in the sense of an intentional microlithization of the assemblage, and this could be true either if the very small flakes (<2.5 cm) were the result of adaptation to raw material, or an independent technological choice (Spinapolice 2014, 2016).

Making a composite tool is a behavioral signature for planning and reliability (*sensu* Bleed 1986). It requires collecting and preparing several kinds of components and the assembling of different raw materials, which may be gathered at different times and in different places (Stout 2002). The final assembly of the functional artefact may occur much later, and some materials may be kept in reserve for maintenance and repair of composite tools. Composite-tool manufacture in the MP and MSA thus marks an increase in technological complexity compared with the single-component tools (Ambrose 2001, 2010).

The technological and cultural continuity of this tradition in East Africa is clear.

Composite-tool manufacture reflects a substantial advance in planning and hierarchical assembly of artefacts (Ambrose 2002). Bladelets have short use lives, and their use shall be coupled with a strategy for maintenance, in a system where possibly the haft is more technologically important than the tool itself. Traditionally, bladelets in UP have been associated with hunting strategies, and their presence fits well with the model of groups having complex social structure and interconnections. However, until functional analyses are applied, it cannot be excluded that bladelet were used also as simple cutting tools, as it happens for backed tools in South Africa (Igreja and Porraz 2013).

For those reasons, I believe that bladelet technology at the onset of East Africa MSA is a Significant Technological Unit that needs further investigation and has the potential to be linked to human evolution. Groucutt and colleagues (2015) argued that Levallois and blade technology evolved convergently and that there was a repeated and independent evolution of microlithic technology. However, until now, there has been no attempt for an evaluation of multiple versus single origins of bladelet technology. Further investigation and multivariate quantitative analyses could allow us to evaluate if this technological invention is suitable to test models about population contact and/or branching.

Raw Materials Transfer and Territories

The transfer of raw material over long distances has long been considered a mark of the "Upper Paleolithic" and later, of *Homo sapiens* behavior (e.g. Binford 1989, but see Spinapolice 2012). Distances from "site-to-source" (Tryon and Faith 2013) for lithic raw material provide one of the material estimates of the size of the social landscapes familiar to early hominin populations and it has long been applied for European Middle and Upper Paleolithic (Gramly 1980; Andresfky 1994; Kuhn 1995; Moncel 2004; Minichillo 2006; Féblot-Augustins 2009). Gamble (1998) considers modern humans to be associated with "extended social landscapes", defined by interaction networks that link diverse groups, occupying different areas.

The link between raw material transfer and cognitive abilities has been maintained until recent times. Ambrose (2010) considers both the passage to composite technologies and the transfer of raw material over long distance, from around 300 kya, a major shift in human cognition. Ambrose (2010), after the review of both European MP and African MSA Pleistocene hominin behavior, suggests that hominins optimize scheduling of land use developing enhanced long-term memories and understanding of seasonal environmental cues: the "culturally constructed niche".

If compared with ESA hominins, the groups making MSA artefacts in general used more frequently finer-grained rocks, particularly obsidian: there was a selection of the best raw material. The best studied lithic material is obsidian itself: from the MSA onward, obsidian is found in frequent use in almost all sites within a 50 km radius of major obsidian sources in the central Rift Valley (Merrick and Brown 1984) as well as in Ethiopia near major sources (Wendorf and Schild 1974; Muir and Hivernel 1976). Outside the immediate vicinity of the major central Rift sources, the frequency of obsidian use falls off (e.g. De Lumley et al. 2004; Tryon et al. 2005; Shea 2008); however, very small quantities of central Rift Valley obsidians are found up to 190 km from their sources (Merrick and Brown 1984; Blegen 2017; Blegen et al. 2018).

Nevertheless, despite the long tradition (Merrick and Brown 1984; Clark 1988) the geochemical characterization of the raw material sources in East Africa still covers very limited areas and focuses almost exclusively on volcanic rocks. MSA hominins regularly transported obsidian cores, flakes and tools over distances exceeding 30 km, such as in Porc Épic (Negash and Shackley 2006; Vogel et al. 2006), and sometimes exceeding 140 km, as in Songhor (McBrearty 1981), and Muguruk (McBrearty 1988) but sometimes the provisioning was mostly local, such as in Melka Kunture (Negash et al. 2006) and Gademotta/Kulkuletti (Shackley and Sahle 2017). As stated for the European MP, the difference in transported elements reflects a complex set of mobility and foraging strategies: provisioning of places vs. provisioning of individuals (sensu Kuhn 1994), or alternatively, a network of trade and exchange of tools and cores among proximity groups.

The evidence coming from recently investigated sites adds to this discussion. Recent data show that possibly the building of more complex social groups is evident since the very beginning of the MSA. Recently, the evidence from Olorgesailie pushed back in time the emergence of this behavior. According to the authors, the long-distance transport (25–50 km) of raw materials at this site suggested the existence of structured social networks among foragers at ~300 Kya. In fact, exotic raw materials can indicate connections between individuals and groups occupying different territories. Raw materials can reach a site through a series of successive phases of reduction, passing hand to hand or travelling as a prepared core or tool in the hand of the same person or group. "*The distances over which exotic raw materials were obtained can be an indicator of human movement on the landscape and of inter-individual and inter-group contacts and social complexity*" (Brooks et al. 2018).

The element of raw material circulation is noteworthy because it has been suggested that the MSA is linked with an expansion into new habitats, an increased foraging range and broadened dietary basis (Tryon 2006).

Long distance raw material transport thus provides the archaeological evidence as far as $\sim$300 Kya BP for the great extent of territories during the Pleistocene. Do these connections also imply the early structuring of *Homo sapiens* populations? The associated selection for fine grained raw material is one of the components of this behavioral package. However, it is hard to test this model. The greatest bias consists in the impossibility to test for home ranges of population territories where the sites are located in the proximity of very good raw materials sources, such as obsidian (e.g. Melka Kunture). While the long-distance raw material transfer is an indicator of large territories or of circulation of people or objects, the reliance on local raw material, especially where abundant and of good quality, is not necessarily a sign of small-scale territories or reduced social complexity. The diversity of the raw material spectrum in East Africa, the vastness of the region and the difference in biomes makes it really hard to assess anything before a specific analysis of local territories and regions. In fact, East Africa is characterized by a great variability in biomes, and it would be interesting to see the relation between the specificities of the different biomes with the different raw material transport distances. Furthermore, the variation in raw material selection and procurement can be analyzed following the changing of raw material availability over time, because climatic and/or catastrophic events can affect the procurement patterns. However, as has happens for the European MP, the analysis of raw material provisioning can add very important data to the discussion about mobility, and thus social structuring, and an attempt to further analyze this aspect in East African MSA would be very important.

Crossing the data from mobility and provisioning with the STU should be one of the goals to achieve in order to assess the structuring of different Late Pleistocene Populations in East Africa.

Towards an Understanding of MSA Human Groups

In conclusion, we can summarize two major partially complementary models for cultural transmission in the East African MSA. First the model of distinct populations/ human groups, keeping traditions stable in certain areas/regions (see interpretation for Gademotta, Douze 2012; Douze and Delagnes 2016) in the early MSA; however, for the Late Pleistocene record, hypotheses of increased interaction on larger scales have been suggested. The same technological continuity is visible in the ESA/MSA transition in Kapthurin, as a process rather than an event (Tryon et al. 2005). The second model imagines the periodic exchange of information and people from one group to another, associated with long period of separation/isolation as Scerri (Scerri 2018; Scerri et al. 2018) suggests within the model of African Multiregionalism.

Arguments against the first hypothesis are that there are not definite chronological and geographical trends linked to technological innovations, partially because at the current state of research we are not able to reconstruct phylogenetically the vast majority of significant technological units (STU). This, however, could be a derivation of the research itself, and this bias could be filled by finding more sites, and by having a more accurate chronology.

The second model seems to fit better the actual evidence, both fossil and archaeological. However, if a major contact of ideas and people occurred intermittently during the final part of the Pleistocene, one could argue that the difference in the archaeological record would be erased in a more accelerated way than we actually see in the records we have nowadays. Nevertheless, there is evidence for a 'mosaic pace' within the first half of the MSA time-scale, since typical Acheulean is still found $\sim$200 ka (e.g. Mieso, see de la Torre et al. 2014). This could also be linked with a biological diversity within those populations. The MSA period is definitely a key period and consequently a complex one, for which convergence is probably more difficult to interpret than divergence.

The presence of specific technological behavior in specific sites, such as the *coup de tranchet* (Douze 2014), shows that a certain amount of local tradition existed and persisted in the East African MSA, as has been shown in the case of tanging/pedunculation in North Africa (Scerri et al. 2014; Scerri 2017). The more and more detailed analysis of lithic assemblages should allow the identification of other Significant Technological Units that will improve our knowledge.

It is agreed that the explosion of the MSA (post MIS 5) is characterized by the flourishing of many regional variations. However, the regions considered here are still very wide and too large to correspond to single social groups of foragers. Moreover, despite the big variability in the MSA, the technological trend is still showing a certain degree of uniformity, if considered in the basis of technological behavior.

It is possible that the whole MSA is rooted in a common lithic tradition, and this makes it difficult to identify small scale regional differences. Furthermore, a common origin could make the invention of the same technological process more likely to be a consequence of simple convergence, where the adaptive conditions in terms of ecological niches are similar.

The aim of this paper has been to enlighten the complexity of the association between lithics and cultures in the MSA, in order to open the debate through articulated models, avoiding simplistic views.

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