Variability in the Middle Stone Age of Eastern Africa
Author(s): Christian A. Tryon and J. Tyler Faith
Source: *Current Anthropology*, Vol. 54, No. S8, Alternative Pathways to Complexity: Evolutionary Trajectories in the Middle Paleolithic and Middle Stone Age (December 2013), pp. S234-S254
Published by: The University of Chicago Press on behalf of Wenner-Gren Foundation for Anthropological Research
Stable URL: http://www.jstor.org/stable/10.1086/673752
Accessed: 11/10/2015 19:00

Variability in the Middle Stone Age of Eastern Africa

by Christian A. Tryon and J. Tyler Faith

CA+ Online-Only Material: Supplement A

Eastern Africa is an important area to study early populations of *Homo sapiens* because subsets of those populations likely dispersed to Eurasia and subsequently throughout the globe during the Upper Pleistocene. The Middle Stone Age (MSA) archaeology of this region, particularly aspects of stone-tool technology and typology, is highly variable with only rare cases of geographic and temporal patterning. Although there are differences in timing and perhaps frequency of occurrence, those elements that make up the MSA lithic tool kit are also found at contemporaneous sites elsewhere in Africa and Eurasia, making it difficult to identify a unique archaeological signal for hominin dispersals out of eastern Africa. Rather, regional variation appears to be the outcome of possibly long-term interactions between particular physical and social environments experienced by hominin populations.

The archaeological record of eastern Africa has the potential to play a central role in our understanding of the behavioral evolution of modern human populations. The fossil record from this region includes the earliest specimens attributed to *Homo sapiens* ~195–154 ka (Clark et al. 2003; McDougall, Brown, and Fleagle 2005; White et al. 2003). Both fossil and genetic evidence are consistent with this region providing the source population(s) for subsequent dispersals out of Africa and feature prominently in models favoring the "southern route" from Africa to Arabia (reviewed in Beyin 2011), with each dispersing group sampling a portion of the biological and behavioral variability present in the parent population (Gunz et al. 2009; Prugnolle, Manica, and Balloux 2005; cf. Lycett and von Cramon-Taubadel 2008). Whereas the fossil and genetic data provide the best insights into past biological variation, it is the archaeological record that provides the richest source of information on the behavioral variability of fossil hominins.

All of the early fossils of *H. sapiens* from eastern Africa are associated with Middle Stone Age (MSA) artifacts. These include those from the Kibish Formation (Brown and Fuller 2008; McDougall, Brown, and Fleagle 2005; Shea 2008), the Herto Member of the Bouri Formation (Clark et al. 2003; White et al. 2003), Aduma (Haile-Selassie, Asfaw, and White 2004; Yellen et al. 2005), and Porc Epic (Assefa 2006; Clark et al. 1984; Pleurdeau 2004; Vallois 1951) in Ethiopia and from the Upper Ngaloba Beds at Laetoli (Day, Leakey, and Magori 1980), Mumba Rockshelter (Bräuer and Mehlman 1988; Mehlman 1989), and perhaps the Lake Eyasi Beds (cf. Domínguez-Rodrigo et al. 2007, 2008; Mehlman 1987) in Tanzania. We use the MSA archaeological record of eastern Africa to characterize the behaviors of hominin populations that included *H. sapiens* in addition to other archaic forms. This allows comparison with neighboring regions to better understand the pattern and timing of archaeological diversity and innovation during the Middle and Upper Pleistocene. Put simply, is the archaeological record of eastern Africa consistent with the biological evidence that this region is the source area for *H. sapiens*?

A few points of terminology require clarification. Following the International Commission on Stratigraphy, we refer to the time interval bounded by the Brunhes-Matuyama paleomagnetic reversal dated to ~781 ka and the onset of the Last Interglacial at ~126 ka as the Middle Pleistocene. The Upper Pleistocene lasts from the Last Interglacial until the Holocene at ~11.7 ka. By the MSA, we follow the common usage (e.g., Clark 1988; Goodwin and Van Riet Lowe 1929; McBrearty and Brooks 2000) to refer to sites with lithic assemblages that are characterized by stone or bone points and the frequent use of Levallois methods for flake production. MSA sites lack the large cutting tools such as cleavers and handaxes found in Acheulian (Early Stone Age [ESA]) sites. Backed pieces may be present but are less common than at Later Stone Age

Christian A. Tryon is Assistant Professor in the Department of Anthropology at Harvard University (Peabody Museum of Archaeology and Ethnology, 11 Divinity Avenue, Cambridge, Massachusetts 02138, U.S.A. [christiantryon@fas.harvard.edu]). **J. Tyler Faith** is Postdoctoral Fellow in the Archaeology Program at the School of Social Science of the University of Queensland (Brisbane, Queensland 4072, Australia [j.faith@uq.edu.au]). This paper was submitted 3 VII 13, accepted 20 VIII 13, and electronically published 13 XII 13.

 0011-3204/2013/54S8-0007$10.00. DOI: 10.1086/673752

(LSA) sites. Following McBrearty and Tryon (2006), the term "early" MSA (EMSA) refers to sites that predate the Last Interglacial. "Later" MSA (LMSA) sites date to within or after the Last Interglacial. Finally, "eastern Africa" refers to the modern-day countries of Tanzania, Kenya, Uganda, Ethiopia, Somalia, Djibouti, and Eritrea. Geographically, this region is bounded by the Indian Ocean, the Red Sea and a low elevation coastal plain to the east, central highlands (>1,000 m asl) dissected by the eastern arm of the Rift Valley, and the western arm of the Rift to the west, with vegetation ranging from desert scrub to Afro-alpine forest. The area encompasses ~3.6 million km^2; for comparison this is similar in size to western Europe or India and is a third the size of the Sahara desert or the United States.

Eastern Africa as used here is defined by modern political boundaries as a matter of convenience, but as shown in figure 1 and discussed below, most sites discussed in this paper also share a common environmental context, occurring within or near the boundaries of White's (1983) Somali-Masai center of regional endemism. We recognize that eastern Africa thus provides a useful but imperfect geographic unit. Alternative approaches could emphasize different boundaries, for example, comparing Red Sea coastal sites such as Abdur in Eritrea (Walter et al. 2000) with sites farther north and not included in this review such as Sodmein Cave in Egypt (Mercier et al. 1999; Vermeersch et al. 1994).

Sites are irregularly distributed throughout eastern Africa, largely concentrated within the East African Rift Valley system (fig. 1), as a result of geological exposure. We do not attempt to comprehensively review every known eastern African MSA archaeological assemblage, but we emphasize those sites that are sufficiently well published to determine the presence and absence of archaeological attributes and have some degree of chronological or stratigraphic control (see also Basell 2008). Summaries of these sites and their age estimates are provided in table 1, with their locations shown in figure 1. Stratigraphic and chronological control is particularly important because overall site density is very low, with a complete lack of coverage for many areas; radiometric dates are few, and there is a rarity of caves or other deeply stratified sequences that allow ready observation of change through time. In this, eastern Africa is different from western Europe, China, the Levant, or southern and northern Africa, and it relates largely to bedrock geology (i.e., abundant lavas and few limestone or quartzite deposits). As a result, much of the eastern African record consists of open-air sites used as living sites, hunting localities, areas for obtaining stone raw material, and other functions (see, e.g., Tryon et al., forthcoming). Our inability to demonstrate contemporaneity among these sites in most cases diminishes our ability to distinguish variation due to age as opposed to site function or environmental setting.

The irregular distribution of eastern African MSA sites is also reflected in the discontinuous nature of their investigation (Gabel 1984; Robertshaw 1990). There have been few long-term projects in the region since the seminal work conducted in Uganda and Kenya in the 1920s and 1930s (e.g., Leakey 1931, 1936; O'Brien 1939; Wayland 1934; Wayland and Burkitt 1932). The Central Rift Valley of Kenya is an important exception, where multiple MSA sites have been the focus of long-term study by Leakey (1931, 1936) and Isaac and his students (Isaac, Merrick, and Nelson 1972; Merrick 1975), including Ambrose (1986, 2001, 2010) and others (e.g., Anthony 1972; Waweru 2007). Surprisingly, despite investigation since the 1930s and the presence of relevant archaeological material (Leakey et al. 1972; Mabulla 1990), Olduvai Gorge in Tanzania has played little role in our understanding of MSA sites in eastern Africa largely because of apathy on the part of Mary Leakey (1984:213), the principal excavator: "In Africa, the hand axe culture did eventually give place to a surprisingly uninspiring group of industries lumped together under the term Middle Stone Age; a stage in prehistoric archaeology for which I have never been able to feel any enthusiasm." We hope that our paper, together with the others reported in this volume, will serve to inspire new ideas and stimulate discussion concerning a time period that we believe is both interesting and important to understanding our evolutionary past.

Fossil Associations: The MSA Is Not Exclusive to *Homo sapiens*

Although all of the early fossils of *Homo sapiens* are found with MSA artifacts, it is unlikely that our species was the exclusive author of MSA lithic technology. On present evidence, the oldest MSA sites in eastern Africa, at >276 ka (Morgan and Renne 2008), are at least 70 kyr older than the oldest known *H. sapiens* fossil. The early fossils of *H. sapiens* and the populations they represent are highly variable, and there is as yet no consensus on how to partition this variability (Gunz et al. 2009; Pearson 2008; Trinkaus 2005). Given the possible presence of ancestral and sister taxa in the region (e.g., Hammer et al. 2011; Lachance et al. 2012), a more cautious reading of the available evidence would be that the variability among MSA sites likely encapsulates the behavioral outcomes of multiple hominin populations of varying taxonomic affinities. Direct linkage between particular hominins and specific archaeological entities is beyond the resolution of our data, a problem that arises in other regions such as the Levant (cf. Hovers 2009; Shea 2006*a*) and western Europe (cf. Slimak et al. 2011, 2012; Zwyns et al. 2012).

The MSA: Origins and Endings

The appearance and disappearance of MSA technologies can both be defined as processes rather than events, typified by gradual, intermittent, and often complex patterns of change with the loss of diagnostic ESA (Acheulian) or the addition of LSA elements over time. As reviewed below, this pattern is consistent with technological change from existing, local

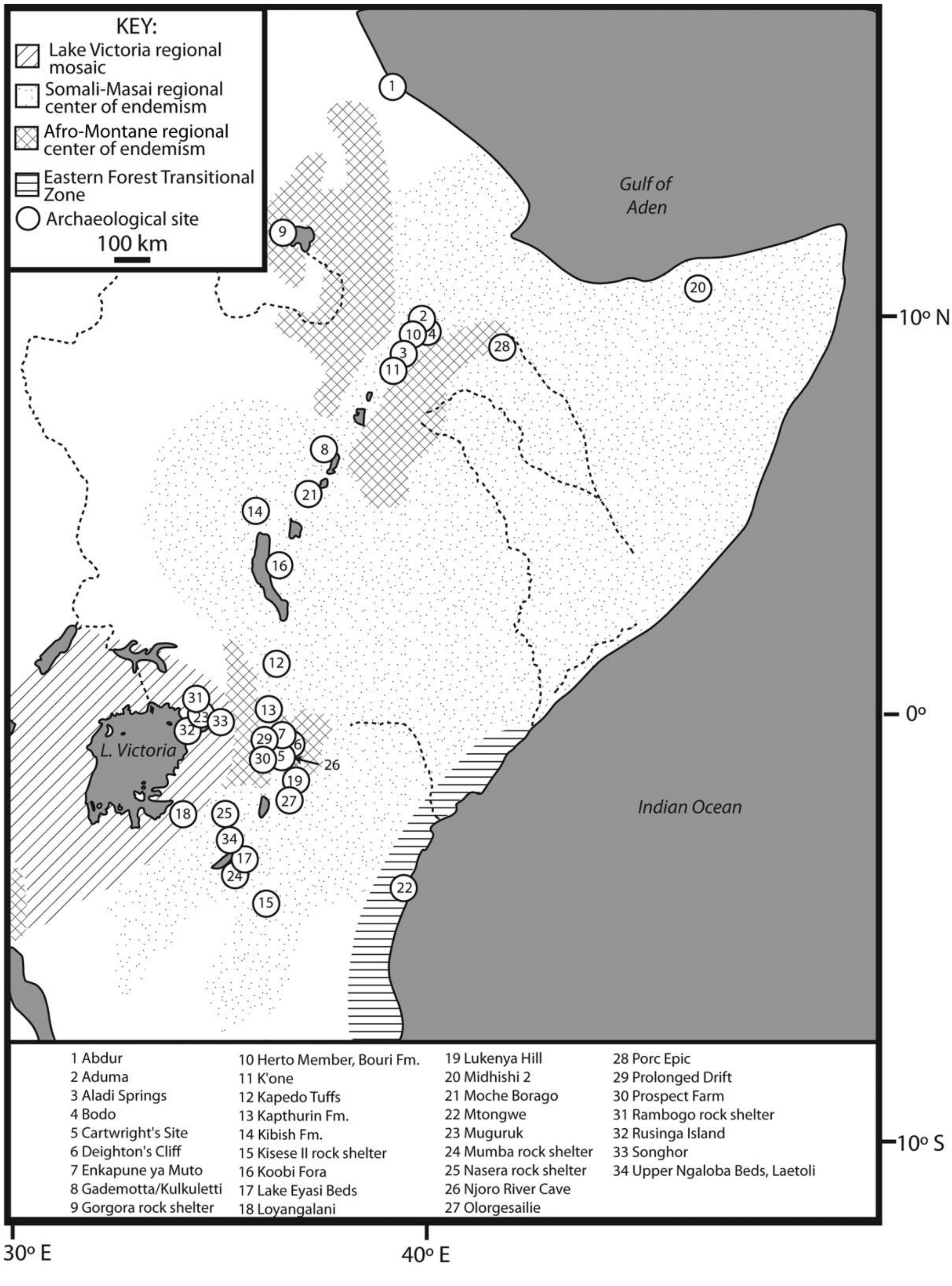

Figure 1. Sketch map showing eastern African Middle Stone Age sites discussed in the text and major biogeographic zones of White (1983).

antecedents and is in many ways comparable with the pattern seen in western Europe. There, late Acheulian sites contain Levallois technology with the number of handaxes declining over time (Monnier 2006), and some Upper Pleistocene industries may show the complex, perhaps nonlinear appearance of backed elements (Bordes and Teyssandier 2012) or retouched points (Slimak 2008).

The MSA Developed from Local Acheulian Antecedents

The overlap between age estimates for the earliest MSA and the latest Acheulian sites supports the hypothesis of a prolonged shift to MSA technologies. Gademotta, Ethiopia, is the oldest securely dated MSA site at >276 ka (Morgan and Renne 2008; Wendorf and Schild 1974). The youngest reported Acheulian artifacts are surface collected from the Herto Member of the Bouri Formation of Ethiopia, dated to ∼154–160 ka (Clark et al. 2003), and in situ material perhaps as recent as ∼125 ka from Abdur, Eritrea (Bruggeman et al. 2004; Walter et al. 2000). These young Acheulian sites are not without their problems. There remains the possibility that the Acheulian artifacts from the Herto Member are older than the dated sediments by an unknown but possibly large interval. The Acheulian attribution of the material from Abdur is unfortunately not supported by detailed artifact descriptions or illustrations. However, if accurate, these results suggest a ∼100–150 kyr overlap between Acheulian and MSA technologies in eastern Africa.

The Kapthurin Formation, Kenya, currently provides the best stratigraphic sequence showing the nature of the appearance of MSA technologies within a single depositional basin (McBrearty and Tryon 2006; Tryon 2006; Tryon and McBrearty 2006; Tryon, McBrearty, and Texier 2005) complemented by recent and ongoing work at Olorgesailie, Kenya (A. S. Brooks and J. E. Yellen, personal communication). In the Kapthurin Formation, sites with points and small Levallois cores are interstratified with those with cleavers, suggesting that Acheulian and MSA technologies overlapped temporally within the same geographic region (∼150 km^2). Further, several elements of lithic technology found at MSA sites find their first expression in the Acheulian. These include the production of blades from cylindrical cores and particularly Levallois methods of flake production from assemblages with handaxes and cleavers (Johnson and McBrearty 2010; Leakey et al. 1969; McBrearty 1999; Tryon 2006). In the Kapthurin Formation and elsewhere in eastern Africa (reviewed in Sharon 2007; Tryon, McBrearty, and Texier 2005), Levallois technology formed one of several methods of producing Acheulian large flake blanks that could be transformed into other tools. In each case, large (>10 cm) Levallois flakes, often with laterally retouched edges, were produced using the preferential method from centripetally prepared cores (fig. 2*a*). Levallois cores and flakes at younger sites in the Kapthurin Formation are smaller and show a greater diversity of Levallois approaches (detailed below), perhaps linked to size reduction of the desired Levallois flake blanks (Tryon, McBrearty, and Texier 2005). Finally, there is an apparent size gradient between small (Acheulian) handaxes and large (MSA) points (McBrearty and Tryon 2006), consistent with a gradual shift in artifact types (and perhaps functions) over time. Whether this size gradient masks different methods of production remains uninvestigated.

The End of the MSA

The end of the MSA was apparently a gradual but complex process rather than an event, with the emergence of the subsequent LSA developing from local MSA roots. At Enkapune ya Muto, Kenya, the sequence from ∼40 to 55 ka shows a basal MSA horizon with Levallois and discoidal methods of flake production and rare backed pieces. It is overlain by an industry attributed to the LSA dominated by the production of large (∼7 cm) backed blades and microliths, which is in turn overlain by an industry with abundant microliths (∼2–5 cm), MSA-like core reduction strategies, and ostrich eggshell beads (Ambrose 1998).

In contrast, at Mumba Rockshelter, Tanzania, the stratigraphic sequence suggests a gradual change in the frequency of typological and technologically important artifacts. Backed elements persist in low numbers across multiple strata, coincident with a reduction in the frequency of Levallois cores and points and an increased use of bipolar percussion for flake production from ∼30 to 68 ka (Eren, Diez-Martin, and Domínguez-Rodrigo 2013; Gliganic et al. 2011; Marks and Conard 2008; Mehlman 1989, 1991). The nature of the change is such that the MSA or LSA attribution of a number of industries at Mumba is uncertain (Diez-Martín et al. 2009). Similar combinations of typically MSA (e.g., points) and LSA (e.g., backed pieces) artifacts are found at the Mochena Borago sequence from Ethiopia (Brandt et al. 2012). As these sites show, the apparent continuity of backed pieces among strata attributed to the MSA and LSA from eastern Africa sites is distinct from the discontinuous appearance of backed pieces in southern Africa (cf. Howiesons Poort and Wilton assemblages) or the late appearance of backed pieces in northern Africa (e.g., Close 2002; Deacon and Deacon 1999; Villa et al. 2010; Wurz 2013).

MSA Lithic Technological Variability

Stone tools and their manufacturing debris make up the bulk of our evidence for studying hominin behavioral variability. Table 1 summarizes this variability for a number of key dated sites in the region. As detailed below and recently emphasized by Shea (2011*b*), the MSA record of lithic technology is highly variable from its first appearance. We first examine the variation within each of the major artifact classes summarized in table 1. Moving from particular artifact types to artifact aggregates, we then conduct more formal analyses of interassemblage variation to more rigorously test hypotheses of

Table 1. Artifact variability at eastern African Middle Stone Age sites

Site/evidence	LMSA/EMSA	Lat.	Long.	Age (ka)	Ochre	Beads	Anvil	Grindstone	Platform core	Discoidal core	Levallois preferential core	Levallois recurrent core	Levallois point/core	Bipolar core	Blades	Backed pieces	Retouched point	Other large biface	Heavy-duty tool	Misc. retouched	% retouched pieces
Mumba Bed III lower (Nasera Industry)[a]	LMSA	−3.53	35.32	30–40	+	+	+	+	+	+	+	?	?	+	+	+	+	−	+	+	5.5
Mumba Bed V (Mumba Industry)	LMSA	−3.53	35.32	50–60	+	+	+	+	+	+	+	?	?	+	+	+	+	−	−	+	4.9
Mumba Bed VI-A (Kisele Industry)[a]	LMSA	−3.53	35.32	60–68	+	−	+	−	+	+	+	?	+	+	+	+	+	−	+	+	13.8
Mumba Bed VI-B (Sanzako Industry)[a]	LMSA	−3.53	35.32	>68	+	−	−	−	+	+	+	?	−	+	?	−	+	+	+	+	10.5
Eyasi Beds	EMSA?	−3.52	35.17	≥88–132	−	−	−	−	+	+	+	?	−	−	−	−	−	−	+	+	4.7
Nasera levels 6–7 (Nasera Industry)	LMSA	−2.74	35.36	>18–26[a]	−	−	+	+	+	+	+	?	?	+	+	+	+	−	+	+	3.5
Nasera levels 8/9–11 (Mumba Industry)	LMSA	−2.74	35.36	>18–26[a]	−	−	+	−	+	+	+	?	?	−	+	+	+	−	−	+	10
Nasera levels 12−25 (Kisele Industry)	LMSA	−2.74	35.36	>26–55[a]	−	−	+	−	+	+	+	+	+	+	+	+	+	−	+	+	5.6
Wasirya Beds, Rusinga Island	LMSA	−0.42	34.17	38−100	−	−	−	−	+	+	+	+	+	−	+	−	+	−	−	+	4.1
Mochena Borago S-group	LMSA	6.90	37.76	43	+	−	−	?	+	−	+	−	+	+	+	+	+	−	−	+	2.1
Mochena Borago Upper T-group	LMSA	6.90	37.76	43–45	+	−	−	?	+	+	+	−	+	−	+	+	+	−	−	+	2.7
Mochena Borago Lower T-group	LMSA	6.90	37.76	45–53	+	−	−	?	+	+	+	?	−	−	+	−	+	−	−	+	2.0
Midhishi 2 LSU III	LMSA	10.95	47.37	19–>40	?	?	−	−	+	+	+	?	+	−	+	+	+	+	+	+	7.3
Midhishi 2 LSU IV	LMSA	10.95	47.37	40–90	?	?	−	−	+	−	+	?	+	−	?	−	+	+	+	+	6.2
Midhishi 2 LSU V	LMSA	10.95	47.37	40–90	?	?	−	−	+	−	−	?	+	−	?	−	+	+	+	+	3
Midhishi 2 LSU VI	LMSA	10.95	47.37	40–90	?	?	−	−	+	+	+	?	+	−	?	+	+	+	+	+	7.8
Porc Epic	LMSA	9.63	41.87	33–79	+	+	−	+	−	+	+	+	+	−	+	+	+	−	−	+	8
Prolonged Drift (GrJi11)	LMSA	−0.48	36.1	30–72	−	−	−	−	+	−	?	−	?	−	−	−	+	−	−	+	6.1
Muguruk Formation, Member 4, Pundo Makwar Industry	LMSA?	0.08	34.63	>10–170	−	−	+	−	+	+	+	?	+	−	−	−	+	−	+	+	1
Muguruk Formation, Member 6, Pundo Makwar Industry	LMSA?	0.08	34.63	>10–170	−	−	+	−	+	+	+	+	+	−		−	?	−	+	+	2.4
Muguruk Formation, Member 2, Ojalla Industry	EMSA?	0.08	34.63	>10–170	−	−	+	−	+	+	+	?	+	−	−	−	+	+	+	+	2.2
Mtongwe, Locality KY-55 East, Upper Group	LMSA?	−4.08	39.13	<125?	−	−	−	−	+	+	?	−	−	−	+	+	−	−	−	+	7.3

Mtongwe, Locality KY-55 East, Middle Group	LMSA?	−4.08	39.13	<125?	−	−	−	−	+	+	?	?	−	+	+	+	−	−	−	+	3.4
Mtongwe, Locality KY-55 East, Lower Group	LMSA?	−4.08	39.13	<125?	−	−	−	−	+	+	+	+	−	−	?	+	−	−	+	+	4.1
Ardu Beds B/C contact, Aduma site A5	LMSA	10.42	40.52	80–100	−	−	?	+	+	+	+	?	+	−	+	−	+	+	−	+	1
Ardu Beds B, Aduma sites A4, A8, A8A, VP 1/1, VP 1/3	LMSA	10.42	40.52	80–100	−	−	−	+	+	+	+	?	+	−	−	−	+	+	−	+	2
Ardu Beds B (base), Aduma site A1	LMSA	10.42	40.52	80–100	−	−	−	−	−	+	+	?	−	−	+	−	+	+	−	+	1.8
Kibish Formation, Member II/III, site BNS	LMSA	5.41	35.9	98–123	−	−	−	−	+	+	+	+	+	?	−	?	+	−	−	+	1.6
Kibish Formation, Member I, site AHS	EMSA	5.41	35.9	195–204	?	−	−	−	−	+	+	?	+	−	−	−	+	+	−	+	1
Kibish Formation, Member I, site KHS	EMSA	5.41	35.9	195–204	−	−	−	−	+	+	+	?	+	−	−	−	+	+	−	+	5.8
Kapthurin Formation, site Koimilot Locus 2	EMSA	0.52	35.9	200–250	+	−	−	−	+	+	+	+	+	−	+	−	−	−	−	−	0
Kapthurin Formation, site Koimilot Locus 1	EMSA	0.52	35.9	200–250	−	−	−	−	+	+	+	+	−	−	−	−	−	−	+	−	0
Gademotta Formation (ETH72-5)	EMSA	7.94	38.6	<183	−	−	−	−	+	+	+	?	−	−	+	−	+	−	−	+	2.2
Gademotta Formation (ETH72-6, ETH72-9)	EMSA	7.94	38.6	<183	−	−	−	−	+	−	+	+	−	−	+	?	+	−	−	+	1.8
Gademotta Formation (ETH72-7B, ETH72-1)	EMSA	7.94	38.6	~183	−	−	−	−	+	−	+	+	+	−	+	−	+	+	−	+	1.6
Gademotta Formation (ETH72-8B)	EMSA	7.94	38.6	>276	−	−	−	−	+	+	+	?	−	−	+	−	+	−	−	+	3.8
Kapedo Tuffs	EMSA?	1.07	36.08	123–135	−	−	−	−	−	+	+	+	−	−	+	−	−	−	+	+	3.1

Note. Artifact variability at eastern African sites: + = present; − = absent; ? = uncertain. See text for definitions and references. Multiple assemblages from a single site shown in stratigraphic order. Sites are attributed to Early MSA (EMSA) or Later MSA (LMSA) based on radiometric dates; uncertainties arise for undated sites, those that span the ~126 ka boundary between the EMSA/LMSA, or where biostratigraphic data differ from radiometric age estimates. Latitude and longitude expressed as decimal degrees.

[a] Data from 1938 Kohl-Larsen collections rather than those of Mehlman (1989); these are likely overestimates.

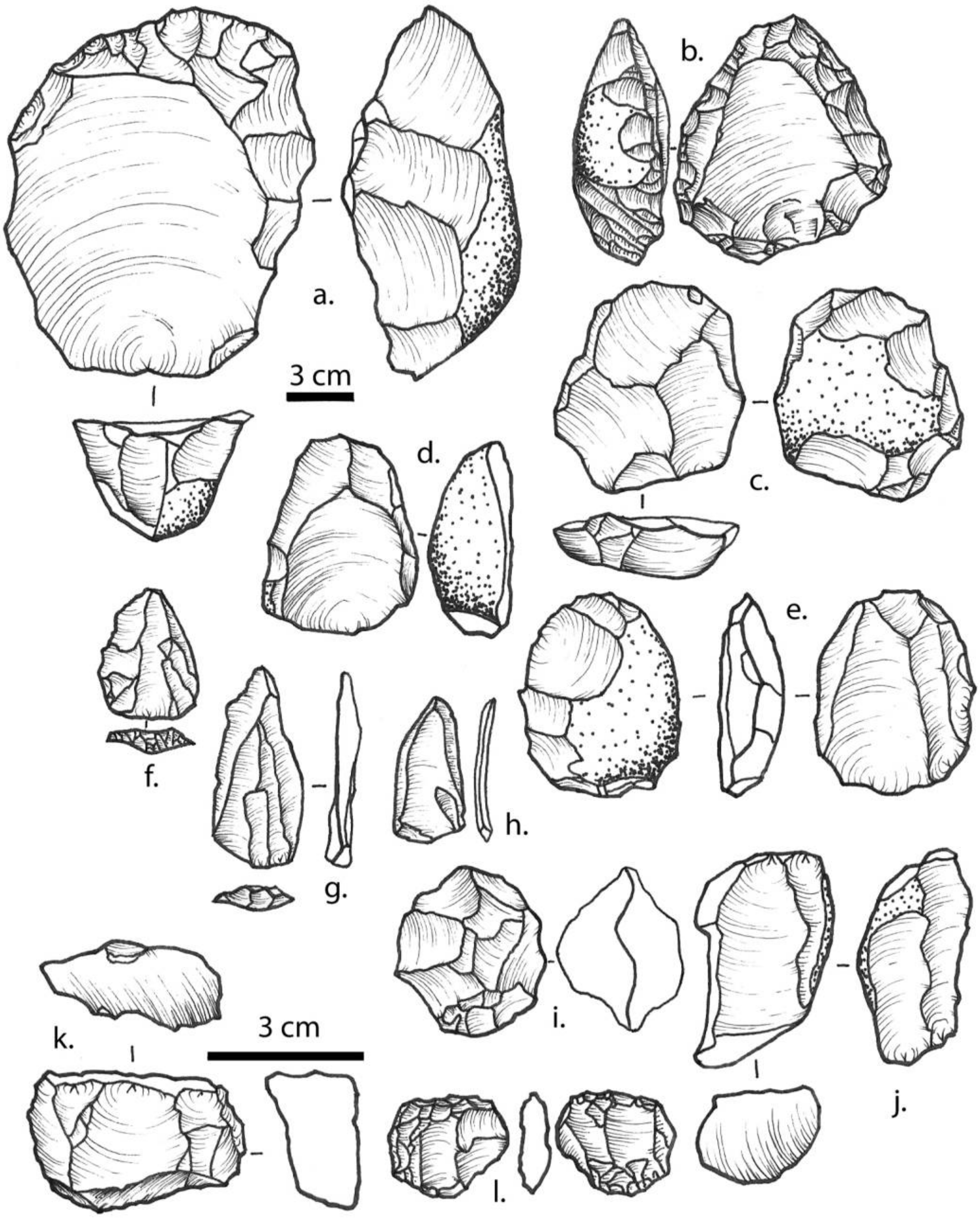

Figure 2. Selected cores and flakes from eastern African Middle Stone Age sites. *a*, Preferential Levallois core from the Acheulian Factory Site, Kapthurin Formation, Kenya. *b*, Preferential Levallois core from Gademotta, Ethiopia. *c*, Recurrent centripetal Levallois core from the Kapedo Tuffs, Kenya. *d*, Nubian core from the Wasiriya Beds, Rusinga Island, Kenya. *e*, Recurrent bipolar Levallois core from Nyogonyek, Kapthurin Formation, Kenya. *f*, Levallois flake from K'one, Ethiopia. *g*, *h*, Levallois points from Koimilot, Kapthurin Formation, Kenya, and Midhishi 2, Somalia. *i*, Discoidal core from the Wasiriya Beds, Rusinga Island, Kenya. *j*, Blade core from the Kapedo Tuffs, Kenya. *k*, Single-platform core from Nasera Rockshelter, Tanzania. *l*, Bipolar core from Nasera Rockshelter, Tanzania. Artifact illustrations after Gresham (1984); Kurashina (1978); Mehlman (1989); Tryon (2003); Tryon, McBrearty, and Texier (2005); Tryon, Roach, and Logan (2008); Tryon et al. (2012); and Wendorf and Schild (1974). Note that *k* and *l* use the lower scale bar; all others use the upper scale bar.

temporal and geographic variation within the eastern African MSA.

Levallois Technology Is Highly Variable

Levallois technology in eastern Africa is as highly variable as it is in other well-studied regions such as western Europe or the Levant (e.g., Delagnes and Meignen 2006; Hovers 2009). Although Levallois cores and flakes have been reported from eastern African sites since at least the 1930s (e.g., Leakey 1936), few sites in the region have been analyzed using the reconfigured understanding of the Levallois concept most strongly associated with the work of Eric Boëda (1994, 1995). Briefly, the Levallois concept is an approach to flake production that targets the preparation and subsequent reduction of a single core surface for the removal of relatively large and thick flake blanks (Eren and Lycett 2012). From this Levallois flake removal surface, a single Levallois flake, blade, or point is removed before repreparation of the convexities of the core (the preferential method), or multiple flakes, blades, or points are removed before repreparation (the recurrent method). The Levallois flake removal surface is shaped by the removal of "preparatory" flakes that alter core convexities. These convexities control the fracture pattern that in part dictates the form of the Levallois flake(s) removed from that surface (Van Peer 1992). Levallois flakes and preparatory flakes may be removed using a number of different patterns, including removals from one direction (unidirectional), from opposite ends (bidirectional), about the circumference of the core (centripetal), or subtle variations on these major themes (e.g., unidirectional convergent flaking).

The combination of the particular Levallois method (preferential or recurrent) and the flake removal patterns (e.g., unidirectional, bidirectional, centripetal) combine to produce substantial variability within the Levallois approach to flake production. Many of these variants are expressed at multiple MSA sites in eastern Africa (fig. 2*b*–2*h*). Importantly, variable approaches to Levallois flake production are present at EMSA sites such as the Kapthurin Formation, Kenya (Tryon 2003, 2006) and Gademotta/Kulkuletti, Ethiopia (Douze 2008; Wendorf and Schild 1974), as well as at LMSA sites, including Aduma (Yellen et al. 2005) and Porc Epic (Pleurdeau 2004) in Ethiopia and Rusinga Island in Kenya (Tryon et al. 2012).

Levallois points (fig. 2*g*, 2*h*) are present at several eastern African sites where they make up from ~8% to 62% of recovered Levallois flakes, such as Koimilot in the Kapthurin Formation, Kenya (Tryon 2006); the Bird's Nest Site (BNS) and Awoke's Hominid Site (AHS) from the Kibish Formation, Ethiopia (Shea 2008); and Midhishi 2 in Somalia (Brandt and Gresham 1989; Gresham 1984). This frequency is within the range of but is often greater than that found at some Levantine sites (cf. Hauck 2011; Hovers 2009:217). The Nubian Type 1 method is a Levallois point variant distinguished by two elongated preparatory flakes removed from the distal end of the core. Nubian Type 1 cores are prevalent to the north in the Nile Valley and to the east in parts of the Arabian Peninsula (see Rose et al. 2011; Van Peer 1992, 1998) and provide some of the strongest archaeological evidence for connections between Africa and Arabia in the Upper Pleistocene. Nubian Type 1 cores are found in eastern Africa at sites at or near the margins of the Nile drainage basin (fig. 2*d*), including K'one and Aduma in Ethiopia (Kurashina 1978; Yellen et al. 2005) and Rusinga Island in Kenya (Tryon et al. 2012), documenting an extensive range for this Levallois variant. Some Levallois approaches, such as that used for blade production at some South African sites (Wurz 2002, 2013), are not found in eastern Africa.

Beyond Levallois: Other Flake Production Methods

Although Levallois technology is a critical part of our understanding of MSA sites, other forms of flake production persist, and additional, non-Levallois methods were introduced (table 1). Discoidal and single- and multiple-platform cores are widespread at MSA sites (fig. 2*i*, 2*k*). Discoidal cores result from the alternate flaking of both sides of the periphery of (typically) an oval cobble, resulting in a bifacially flaked, biconical core. Platform cores (including the "migrating plane cores" of White and Pettitt 1995) result from the use of one or more edges as striking platforms. Discoidal and platform cores are found at ESA (both Oldowan and Acheulian) sites and form a technological substrate for the production of sharp-edged flakes in some LSA assemblages (e.g., Mehlman 1989). Bipolar cores (fig. 2*l*) resulting from the production of small flakes using an anvil are also known from ESA (Oldowan) sites (e.g., de la Torre 2004). Bipolar cores occur irregularly at MSA sites in eastern Africa, including Nasera and Mumba rockshelters in Tanzania (Diez-Martín et al. 2009; Eren, Diez-Martin, and Domínguez-Rodrigo 2013; Mehlman 1989) and Cartwright's site in Kenya (Waweru 2007). Blade or bladelet production (fig. 2*j*) occurs at EMSA assemblages at Gademotta/Kulkuletti (Wendorf and Schild 1974) and LMSA assemblages at Aduma and Porc Epic in Ethiopia (Pleurdeau 2004; Yellen et al. 2005) and elsewhere. As noted previously, blades also occur in ESA (Acheulian) assemblages in eastern Africa. Truncated-facetted pieces used for the production of small flakes are common at some Levantine and European Middle Paleolithic sites (papers in McPherron 2007) and some eastern African LSA sites (e.g., Newcomer and Hivernel-Guerre 1974). Although rare and probably underreported from eastern Africa, truncated-facetted pieces are reported from the MSA at Gademotta/Kulkuletti (Wendorf and Schild 1974:89); K'one Locality 5, Ethiopia (Kurashina 1978); and perhaps Lukenya Hill (Clark 1988) and Prolonged Drift (Merrick 1975), Kenya.

Points: Functional, Spatial, and Temporal Variability

Along with the frequent use of Levallois technology, points are a defining element of the MSA. Point forms at eastern

African sites are highly variable in size and shape (fig. 3*a*–3*d*). "Point" refers to a broad category of artifacts made of stone including unretouched, unifacial, and bifacial implements made on Levallois and other flake blanks. The term is both a morphological description (a pointed artifact) and an ethnographically based functional inference (as the tip of a spear or other hunting implement). Studies of point shape, microwear patterns, and mastic traces from sites in eastern Africa and adjacent areas indicate that many points were hafted and probably used to tip spears, darts, or even arrows (e.g., Brooks et al. 2006; Donahue, Murphy, and Robbins 2002–2004; Shea, 2006*b*; Van Peer, Rots, and Vermeersch 2008; Waweru 2007).

We cannot assume that all points were used as armatures or projectiles. Gademotta is the only eastern African MSA site subjected to two independent analyses of artifact function (Douze 2008; Wendorf and Schild 1993). Both analyses found that typologically defined points were used as cutting tools rather than as spear tips, serving as an important reminder about the potential dangers of inferring stone-tool function from artifact form. Villa and Lenoir (2006; see also Villa, Delagnes, and Wadley 2005) have shown almost the opposite for the European Middle Paleolithic record, where some "convergent scrapers" show impact damage consistent with their use as the tips of thrusting spears. Microwear analyses of Levantine Levallois points emphasize the diversity of cutting tasks served by these tools in addition to their possible use as spear tips (Beyries and Plisson 1998).

Whatever their function, for retouched pieces, EMSA average point length (54.25 ± 16.40 mm, $n = 50$) is significantly larger than LMSA points (42.22 ± 14.30 mm, $n = 250$; Mann-Whitney U-test: $z = 5.222$, $P < .001$; table A1 in CA+ online supplement A). These size differences may reflect changes in tool function, including the evolution of complex projectile technology, which may appear at LMSA sites ~40–100 ka (Brooks et al. 2006; Shea 2006*b*). Some stratigraphic sequences such as Aduma and Nasera show a monotonic decrease in point size over time, whereas Mumba, Gademotta/Kulkuletti, and Gorgora rockshelters (Leakey 1943) do not (table A1).

Clark (1993) and McBrearty and Brooks (2000) have emphasized geographic variation among MSA points at the subcontinental scale, although formal definitions or tests of the extent of many of these variants remain to be done. The Lupemban is one of the most distinct MSA regional variants, characterized by large (>10 cm), thin, bifacially flaked lanceolate points (fig. 3*a*). Originally defined from sites in central Africa, Lupemban lanceolates are found as far east as the Lake Victoria region of Kenya. Although poorly dated in eastern Africa, the large size of Lupemban lanceolates suggests attribution to the EMSA, consistent with U-series age estimates of 170–270 ka for Lupemban assemblages in Zambia (Barham 2000) and the >10–170 ka age estimate from sedimentation rates published by McBrearty (1988) for western Kenya. Other points from eastern African MSA sites are smaller but morphologically highly variable and are not attributed to named larger archaeological entities equivalent to the Lupemban. While the small, subtriangular bifacially flaked forms (fig. 3*b*–3*d*) are distinct from lanceolate points or tanged pieces from Lupemban or Aterian sites, similar forms occur as far west as Mali (Soriano et al. 2010) and as far south as Botswana (Coulson, Staurset, and Walker 2011), reducing their utility as a unique regional artifact form.

Other Shaped Tools

Although used to define MSA technology, points and indeed all forms of shaped or retouched tools are rare at MSA sites, typically making up <5%–7% of the flaked artifact total (table 1). This is also true of many southern African MSA sites (e.g., Thackeray 1989), and the rarity of retouch has made it difficult to directly apply typologies such as that of Bordes (1961) that emphasize shaped or modified tools (see discussion in Villa, Delagnes, and Wadley 2005). In some areas, retouch frequency is directly linked to the presence of fine-grained raw materials, with retouch being rare on lava artifacts but more common on those made of chert or similar rocks (Tryon, Roach, and Logan 2008). The Bordes system has been successfully applied to sites in northern Africa where chert is widespread (e.g., Hublin, Tillier, and Tixier 1987) and in eastern Africa to sites such as Gademotta/Kulkuletti, Ethiopia (Wendorf and Schild 1974), where obsidian was used nearly exclusively. Despite the relative rarity of retouched implements, three tool classes are important to understanding MSA lithic technology: heavy-duty tools, scrapers, and backed pieces.

Several MSA sites have "heavy-duty tools" (sensu Clark 2001*b*) such as picks (fig. 3*h*). These tools are also found in Acheulian or other earlier regional industries or industrial complexes such as the Sangoan and are likely a retention of characteristic ESA technologies (table 1). These MSA sites include Koimilot in the Kapthurin Formation (Tryon 2006) and the Kapedo Tuffs of Kenya (Tryon, Roach, and Logan 2008), assemblages from Kibish Formation of Ethiopia (surface collected and not from the localities listed in table 1; Shea 2008), and the >68–130 ka basal Bed VI at Mumba Rockshelter, Tanzania (Gliganic et al. 2011; Mehlman 1989: 194). Similar tools also occur at the undated sites of Muguruk (McBrearty 1988), FxJi 61 near Koobi Fora (Kelly 1996:159), and the basal MSA levels at Mtongwe in Kenya (Omi 1986, 1988).

As a tool class, scrapers have been reported from some of the earliest archaeological sites. However, in a qualitative sense, most scrapers from African Oldowan, Acheulian, and many MSA sites are characterized by rare and irregular retouch. These are very different, for example, from the classic scrapers defined by Bordes. It is only at MSA sites that some scraper forms appear that show continuously retouched edges used to alter the shape of the tool (fig. 3*f*), a difference in form that may result from extending the use-life of hafted

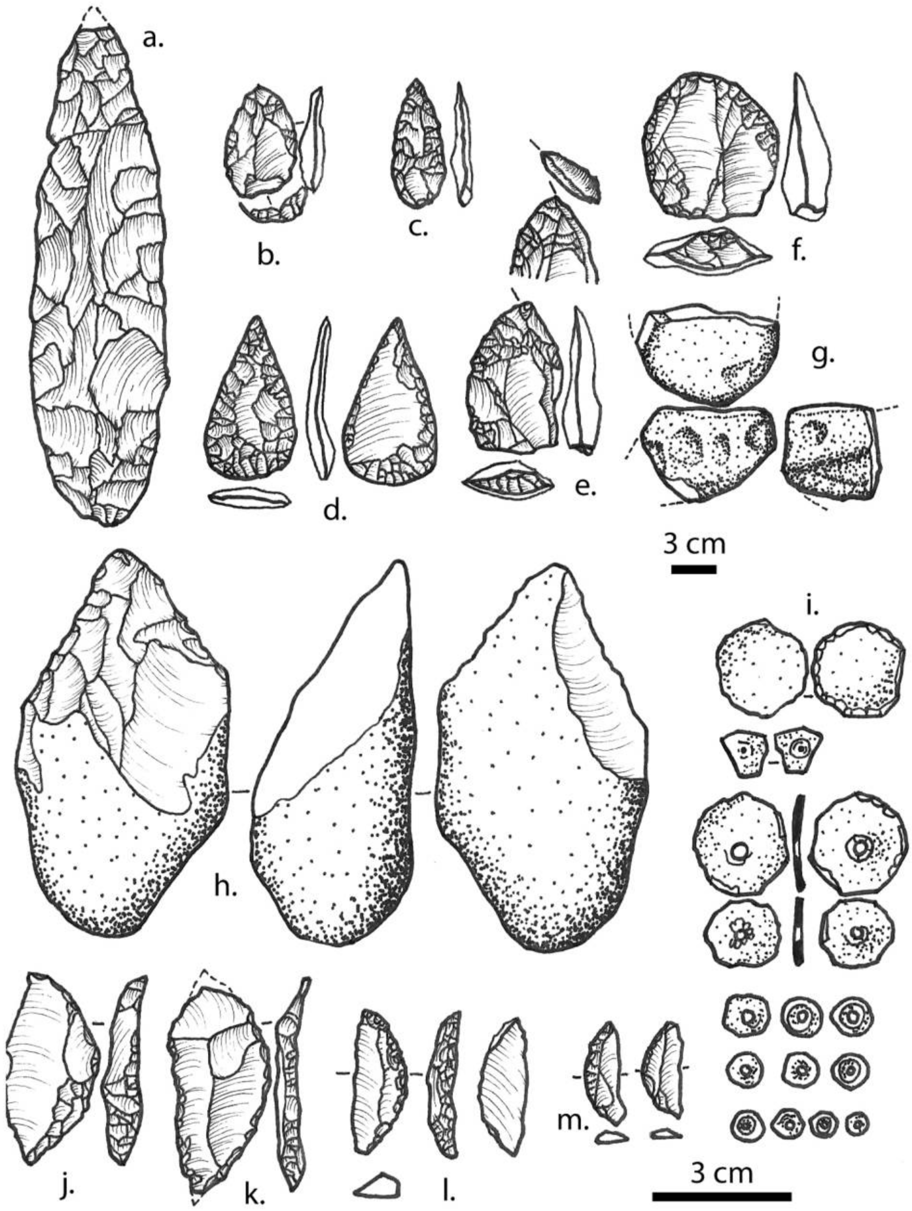

Figure 3. Selected tools and beads from eastern African Middle Stone Age sites. *a*, Lupemban lanceolate point from Muguruk, Kenya. *b*, Point with basal thinning from Nasera Rockshelter, Tanzania. *c*, Point from Porc Epic, Ethiopia. *d*, Point from BNS, Kibish Formation, Ethiopia. *e*, Point with resharpening flake, Gademotta, Ethiopia. *f*, Scraper from Gademotta, Ethiopia. *g*, Grindstone fragment from Mumba Rockshelter, Ethiopia. *h*, Pick from Kapedo Tuffs, Kenya. *i*, Ostrich eggshell beads and production fragments from Mumba Rockshelter, Tanzania. *j–m*, Backed pieces from Mumba Rockshelter, Tanzania (*j*, *k*); Mtongwe, Kenya; and Enkapune ya Muto, Kenya. Artifact illustrations after Ambrose (1998); Clark et al. (1984); McBrearty (1986); Mehlman (1989); Omi (1986); Shea (2008); Wendorf and Schild (1974). Note that *a* through *h* use the upper scale bar; *i* through *m* use the lower scale bar.

implements through resharpening (cf. Keeley 1982), suggested in particular by distinctive resharpening flakes found at Gademotta/Kulkuletti (Wendorf and Schild 1974; fig. 3*e*).

Backed pieces first appear at LMSA sites in eastern Africa. Backed pieces are flakes or blades with one lateral edge made steep or blunted ("backed") by abrasion or direct percussion. Comparisons with historical examples (Clark, Phillips, and Staley 1974), experimental work (Clark and Prince 1978), and rare traces of ochre likely used as mastic (Ambrose 1998) suggest that backing is performed to facilitate hafting into a slotted wooden shaft consistent with findings from sites elsewhere (e.g., Villa and Soriano 2010). In eastern Africa, backed pieces first appear ∼120–130 ka at the site of Deighton's Cliff, Kenya (Ambrose and Deino 2010) but are a more regular feature at LMSA sites ≤80 ka (fig. 3*j*–3*m*; table 1), including Porc Epic (Clark et al. 1984; Pleurdeau 2004), Mochena Borago (Brandt et al. 2012), and Mumba and Nasera rockshelters (Mehlman 1989, 1991). Backed pieces are also present in small quantities from the <55 ka basal layers at Enkapune ya Muto (Ambrose 1998), with undated examples from probable MSA strata at Mtongwe, Kenya (Omi 1984, 1986, 1988), and Kisese II Rockshelter, Tanzania (Inskeep 1962; Mehlman 1989:365), although published details from the latter site are scant.

Ochre and Grindstones

Ochre (or other mineral pigments) and grindstones (fig. 3*g*) are two key elements of MSA lithic technology. These two artifact classes often co-occur (table 1), suggesting a functional association. Ochre staining has been reported from some grindstones, including those from the Kapthurin Formation and Enkapune ya Muto, in Kenya (Ambrose 1998; McBrearty and Brooks 2000). The Kapthurin Formation example (from site GnJh-15) is the earliest reported occurrence of grindstones and ochre from eastern Africa, dated to ∼284–500 ka and associated with a lithic assemblage that cannot be confidently attributed to the Acheulian or MSA. Otherwise, grindstones and ochre are found at the LMSA sites (table 1) of Aduma (Yellen et al. 2005) and Porc Epic (Clark et al. 1984) in Ethiopia; Mumba and Nasera rockshelters in Tanzania (Mehlman 1989); and Enkapune ya Muto in Kenya (Ambrose 1998).

In addition to working ochre, grindstones may have also been used to process seeds or other plant material, an activity with considerably less archaeological visibility. Mercader (2009) reports starch grains from grindstones and other tools from Ngalue, Mozambique, suggesting grass seed processing ∼105 ka. The extent to which these results can be applied to grindstones at eastern African MSA sites is unknown but should be a focus of future research. As emphasized by Kuhn and Stiner (2001), the appearance of grindstones for seed processing in MSA sites implies a shift toward lower-return foodstuffs that require substantial energy investment and thus a change in the foraging ecology of hominin populations.

Other Behaviors

We synthesize three other attributes of MSA hominin populations in eastern Africa: foraging behavior, territorial range inferred from raw material treatments, and symbolic behavior. Specifically, symbolic behavior concerns the treatment of the dead and the use of ornaments.

Foraging Behavior

As many stone tools served either directly or indirectly in the food quest, we expect shifts in hominin diet to be reflected in lithic assemblage composition. Although stone tools are abundant, direct evidence of eastern African hominin diet is sparse. Plants likely made up the bulk of the diet of any hominin population living at or near the equator (Kelly 1995), but at present there is no direct evidence for plant consumption from eastern African MSA sites. As Marean (1997) notes, our models of reconstructing past foraging systems in the region are limited by the lack of modern or historic foragers (rather than pastoralists) from tropical grasslands, an environment that characterizes much of eastern Africa now and in the Pleistocene.

Site location and faunal data provide two alternative means of investigation. Sites such as Porc Epic, Ethiopia, and Nasera, Tanzania, have been interpreted as overlook sites situated near game pathways (Clark 2001*a*; Mehlman 1989). Hunters appear to have used natural features such as topographic lows, streams, or springs to acquire game at site GvJm46 at Lukenya Hill (Marean 1990; 1997; Miller 1979) and Rusinga Island (Jenkins et al. 2012; Tryon et al. 2010) in Kenya. Ambrose (2001) has argued that MSA populations in the central part of the Rift Valley in Kenya positioned themselves at or near the ecotone between grassland and forest habitats in order to best access resources from both environments. The use of coastal environments is demonstrated by MSA artifacts embedded within an ∼125 ka coastal reef off the coast of Eritrea (Walter et al. 2000) and an undated but well-stratified MSA artifact sequence in coastal dune sands at Mtongwe, Kenya (Omi 1984, 1986, 1988, 1991). Despite the importance of coastal environments for many out-of-Africa dispersal scenarios (e.g., Bulbeck 2007), these two sites provide the only, albeit sparse, evidence for use of these environments from eastern African MSA sites.

The faunal assemblages from GvJm46 at Lukenya Hill (Marean 1990) and Porc Epic (Assefa 2006) provide the only large, well-studied, and published archaeofaunal MSA assemblages from eastern Africa. Human exploitation of large mammals is also documented at other sites, including Rusinga Island, Kenya (Jenkins et al. 2012; Tryon et al. 2010), and Loiyangalani, Tanzania (Thompson 2005). Although the sample is small, these studies suggest that at least by the later parts of the Pleistocene, MSA foragers hunted a variety of large and small ungulates and selectively transported meat-rich elements to central places such as caves for further processing and consumption. Long-distance carcass transport to central places may distinguish MSA foraging strategies from those documented at other ESA sites in East Africa (e.g., Faith, Domínguez-Rodrigo, and Gordon 2009).

Territory and Movement Inferred from Raw Material Transport Data

Site-to-source distances for stone raw material provide the best empirical estimate of the size of the physical and social landscapes familiar to early hominin populations. Compared with ESA hominins, groups making MSA artifacts used finer-grained rocks, particularly obsidian, more frequently (Féblot-

Augustins 1990; Merrick, Brown, and Nash, 1994). An extensive, ongoing program to geochemically characterize Rift Valley obsidian sources and artifacts provides the most detailed raw material transfer data (Ambrose et al. 2012; Merrick, Brown, and Nash 1994; Negash, Brown, and Nash 2011), summarized in table A2 in CA+ online supplement A). ESA site-to-source distances are <60 km, whereas eastern African MSA site-to-source distances exceed 300 km. This increase suggests expanded physical and social landscapes through which stone artifacts were carried by highly mobile foragers and/or transferred through exchange.

MSA hominins apparently regularly transported obsidian cores, flakes, and finished tools ≤30 km, and in the case of Porc Epic, 139 km (table A2). Beyond this and up to a distance of 305 km, obsidian frequency declines, and only finished tools and (resharpening?) flakes are found. These differences may reflect shifts in raw material procurement strategies driven by increased source distance relative to a group's territorial range (from provisioning of places to provisioning of individuals; Kuhn 2004) or perhaps the trade/exchange of finished pieces rather than cores among different groups. Although sample size is small, sites at a similar distance (~130–200 km) from the nearest source within the Rift Valley (Porc Epic) and outside of Rift Valley to the west in the Lake Victoria region (Songhor and Muguruk) show very different patterns (table A2). Obsidian is more rare (8% vs. <0.5%) and limited to tools and flakes in the Lake Victoria region. This may result from the relative difficulty of movement across the steep, often densely vegetated margins of the Rift rather than along the grassy, open valley floor, suggesting a possible biogeographic control to hominin movement within the region. Similarly, in central Europe, open habitats are associated with greater stone transport distances (≤300 km) than in the topographically complex region of western Europe (Féblot-Augustins 1993).

Symbolic Behavior: Mortuary Practices and Ornaments

The 154–167 ka hominin skulls from the Herto Member of the Bouri Formation, Ethiopia, represent the only example of peri- or postmortem treatment of the dead found at eastern African MSA sites. Here, cut and polish marks on the skulls have been interpreted as evidence of mortuary practice (Clark et al. 2003; White et al. 2003). The defleshed hominin skull from the ~500 ka Acheulian site of Bodo (White 1986) lies only 30 km away, possibly indicating significant time depth for similar behaviors in the region.

Beads are the earliest direct evidence for personal ornamentation from eastern African sites (fig. 3*i*). At Porc Epic, gastropod opercula were arguably worn as beads, co-occur with MSA artifacts, and have been directly dated by the AMS radiocarbon method to between ~33 and >43 ka (Assefa, Lam, and Mienis 2008). Ostrich eggshell beads and manufacturing debris have been reported from Bed V and lower Bed III at Mumba Rockshelter, Tanzania, now dated to 30–60 ka by Gliganic et al. (2011). Mehlman (1989) considered Bed V and lower Bed III to contain industries intermediate between the MSA and LSA, whereas Diez-Martín et al. (2009) and Eren, Diez-Martin, and Domínguez-Rodrigo (2013) ascribe these layers to the LSA, making the association of these beads with the MSA uncertain. Conard (2004) reports directly dated ~29–33 ka ostrich eggshell beads from MSA/LSA strata at Mumba. At Enkapune ya Muto, ostrich eggshell beads date to ~40 ka from an MSA/LSA stratum that overlies an industry attributed to the LSA (Ambrose 1998). It is unclear whether examples from >30 ka at Kisese II Rockshelter should be attributed to the MSA or LSA (Inskeep 1962; Leakey 1983: 21).

In short, there are few demonstrable examples of bead use by MSA hominins in eastern Africa, and the behavior is a relatively late phenomenon. The appearance of beads marks one of the few apparent sharp breaks in the MSA record. Whether this is due to the appearance of a neural mutation that led to the development of language and modern human behavior (Klein 2009), a shift to more durable forms of personal expression (as suggested by Kuhn and Stiner 2007), or sampling bias due to a small sample of caves or rockshelters is unclear. Rare, well-preserved Holocene burials such as Njoro River Cave, Kenya (Leakey and Leakey 1950), are also powerful reminders of the widespread use of seed beads or other perishable materials unlikely to preserve at MSA sites, potentially exaggerating the importance of the use of ostrich eggshell as a medium for bead production.

Interassemblage Variability

To explore the nature of interassemblage variability among eastern African MSA sites, we use presence/absence data for artifact classes (listed in table 1). Although variable artifact typologies in use among researchers can reduce the utility of such approaches (Vermeersch 2001), the categories used here are sufficiently broad to minimize this problem. The data are used to examine (1) temporal variability among EMSA and LMSA sites (e.g., Shea 2011*b*), (2) geographic variability across eastern African sites (Clark 1988; McBrearty and Brooks 2000), and (3) local, site-specific sources of variation. In the following analyses, we conservatively treat all artifact classes whose presence is uncertain (those with a question mark in table 1) as absent.

A correspondence analysis illustrating the association of different MSA assemblages with different artifact classes (fig. 4, *top*) reveals temporal patterning among EMSA and LMSA assemblages. The EMSA artifact assemblages overlap in multivariate space with many of the LMSA assemblages, but there is a subset of LMSA assemblages that are distinct (Axis 1 scores > 0). These include the LMSA assemblages dated to <75 ka from Mumba, Nasera Rockshelter, Porc Epic Cave, Mochena Borago, and the undated middle and upper assemblages from Mtongwe, which differ from EMSA sites by the more frequent presence of beads, ochre, backed pieces, bipolar

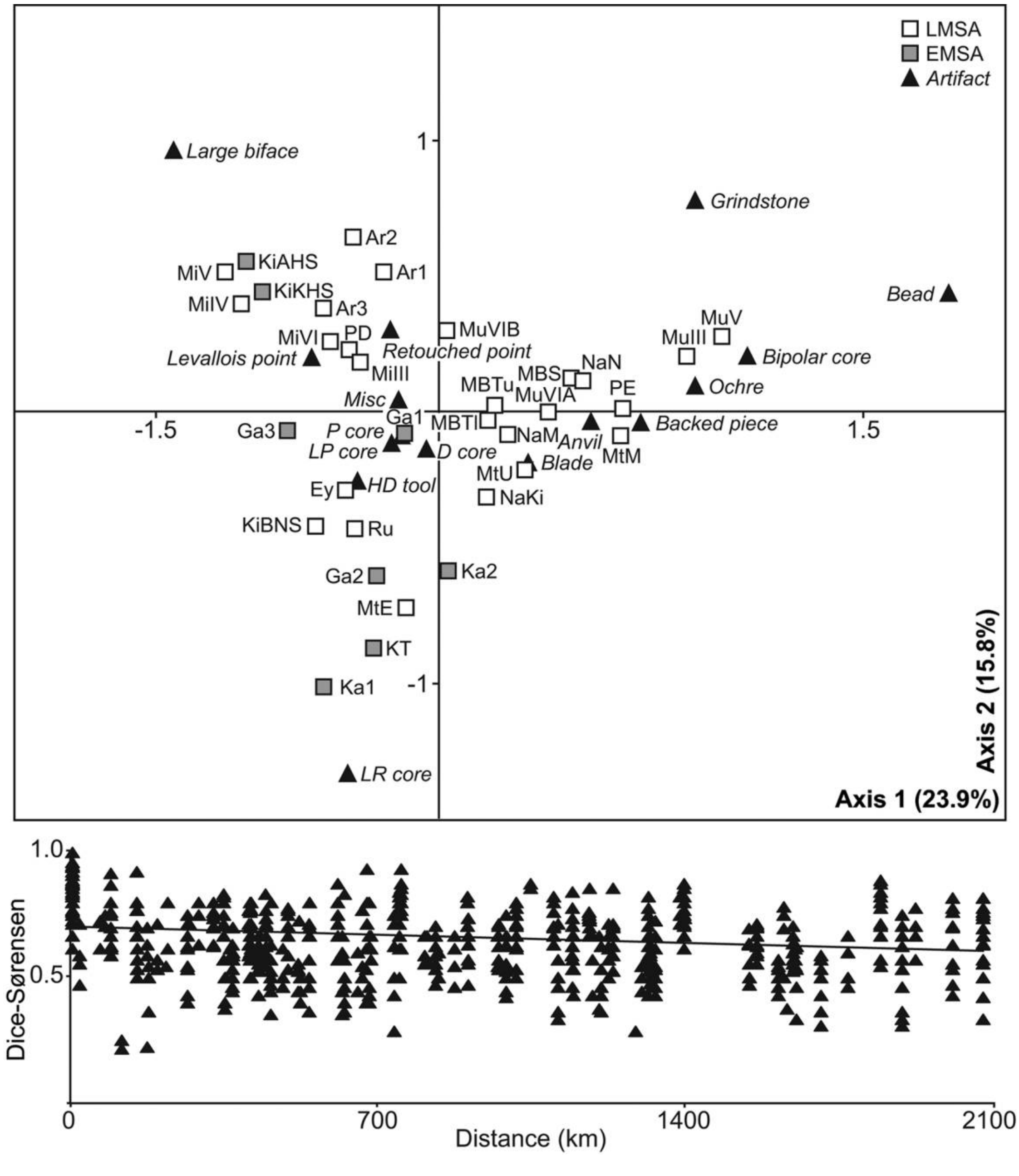

Figure 4. Correspondence analysis of artifact assemblage composition (*top*; table 1) across MSA localities. Site abbreviations: MuIII = Mumba Bed III; MuV = Mumba Bed V; MuVI-A = Mumba Bed VI-A; MuVI-B = Mumba Bed VI-B; Ey = Eyasi Beds; NaN = Nasera (Nasera Industry); NaM = Nasera (Mumba Industry); NaKi = Nasera (Kisele Industry); Ru = Wasiriya Beds; MiIII = Midhishi 2 LSU III; MiIV = Midhishi 2 LSU IV; MiV = Midhishi 2 LSU V; MiVI = Midhishi 2 LSU VI; PE = Porc Epic; PD = Prolonged Drift; MtU = Mtongwe Upper Group; MtM = Mtongwe Middle Group; MtL = Mtongwe Lower Group; Ar1 = Ardu Beds B/C; Ar2 = Ardu Beds B; Ar3 = Ardu Beds B (base); KiBNS = Kibish site BNS; KiAHS = Kibish site AHS; KiKHS = Kibish site KHS; Ka1 = Kapthurin Formation, Koimilot Locus 1; Ka2 = Kapthurin Formation, Koimilot Locus 2; Ga1 = Gademotta Formation (ETH72-5); Ga2 = Gademotta Formation (ETH72-6, ETH72-9); Ga3 = Gademotta Formation (ETH72-7b, ETH72-1); Ga4 = Gademotta Formation (ETH72-8B); KT = Kapedo Tuffs. Artifact abbreviations: Misc = miscellaneous retouched piece; P core = platform core; LP core = Levallois preferential core; D core = discoidal core; HD tool = heavy-duty tool; LR core = Levallois recurrent core. The relationship between intersite distance (km) and the Dice-Sorensen coefficient calculated between all MSA assemblages (*bottom*). Solid line represents least squares regression.

cores, blades, grindstones, and anvils (fig. 4, *top*; table 1). Many of these artifact types are also found in the early LSA at Enkapune ya Muto (Ambrose 1998), and the LMSA sites in which they are found have been characterized by some as transitional between the MSA and the LSA (e.g., Diez-Martín et al. 2009; Marks and Conard 2008). Our quantitative analysis supports their characterization as distinct from other "typical" EMSA and LMSA assemblages.

If geography is a meaningful correlate of assemblage composition, we expect assemblages from sites that are closer together to be more similar to one another than they are to more distant sites. To quantify similarity between MSA assemblages, we calculated Dice-Sørensen coefficients for all pairs of assemblages, measuring distance using latitude and longitude coordinates (listed in table 1). For any given pair, the Dice-Sørensen coefficient is calculated as $2j/(a + b)$, where j is the number of artifact classes that co-occur at assemblages A and B, a is the number of artifact classes at site A, and b is the number of artifact classes at site B. As illustrated in figure 4 (*bottom*), there is a weak but significant inverse relationship between pairwise site distance and the Dice-Sørensen coefficients ($r = -0.194$, $P < .001$), meaning that pairs of assemblages that are nearby are more similar than pairs of assemblages that are distant. This correlation is largely driven by the tendency for assemblages from the same site (distance = 0) to be very similar to each other (fig. 4, *top*). Removing these from the analysis results in a much weaker, although still significant, correlation ($r = -0.084$, $P = .035$). To the extent that the presence and absence of particular artifact classes can be interpreted as a measure of regional variation, our results suggest that geography plays a role in driving assemblage variability but that its effect is minimal.

Both the correspondence analysis (fig. 4, *top*) and the relationship between geographic distance and assemblage similarity (fig. 4, *bottom*) indicate that assemblages from the same locality tend to be more similar to each other than they are to other sites. This is confirmed by a Mann-Whitney U-test on Dice-Sørensen coefficients calculated for assemblage from same locality versus assemblages from different localities ($z = -7.906$, $P < .001$). This implies that local factors are a dominant force driving interassemblage variability. These local factors might include site function, stone raw material quality or abundance, or more speculatively small or restricted networks of information exchange within which traditions of artifact manufacture and use were shared and maintained.

Environmental Controls

The environment structures aspects of the material record of human foragers and environmental change may explain some of the variability among eastern African MSA sites. Archaeological sites are unevenly distributed among four different environmental or biogeographic zones defined by the distributions of endemic flora and fauna (fig. 1). Most sites occur within White's (1983) Somali-Masai center of regional endemism (SMCRE). The SMCRE is the familiar dry savanna of eastern Africa characterized by habitats that range from *Acacia-Commiphora* deciduous bushland/thicket to semidesert grassland and shrubland with distinctive arid-adapted fauna such as the oryx (*Oryx beisa*) and Grévy's zebra (*Equus grevyi*; Grubb et al. 1999). Faunal data from eastern African MSA sites consistently show hominin occupation of grassland habitats broadly similar to those found in the SMCRE (Tryon et al. 2010, 2012). Other sites occur in the Eastern Forest transitional zone along the Indian Ocean coast, the Lake Victoria regional mosaic (LVRM), or near the ecotone between the SMCRE and scattered highland Afromontane areas (fig. 1).

We have a poor understanding of the relationship between environmental and behavioral variability in eastern Africa because of disparate spatial and temporal scales among paleoenvironmental and archaeological data sets (Blome et al. 2012). The composition and boundaries of the biogeographic zones defined here likely shifted over time, providing different environmental conditions for local hominin populations (see discussion in Basell 2008), and it is these local conditions that our analyses of interassemblage variability suggest are most important in structuring archaeological variability. Coarse-grained analyses of hominin demography suggest that compared with other regions of Africa, hominin populations in eastern Africa responded to environmental change by minor shifts in settlement location (Blome et al. 2012). On a smaller scale, Ambrose (2001) suggested that MSA hominins, particularly in the Lake Nakuru/Naivasha basin of Kenya, may have tracked ecotonal boundaries as they shifted in elevation with environmental change.

Evidence from the LVRM provides another example of the possible relation between environmental and archaeological variability in eastern Africa. Modern distributions of a variety of plant and animal taxa consistently indicate eastward dispersal of forest taxa into and across the LVRM from heavily forested regions in central Africa during humid (i.e., interglacial) phases (e.g., Kingdon 1981; Rodgers, Owen, and Homewood 1982; Wronski and Hausdorf 2008). Conversely, LVRM MSA archaeological sites consistently include arid-adapted fauna such as oryx (*O. beisa*) and Grévy's zebra (*E. grevyi*) that are characteristic of the SMCRE, suggesting westward dispersal during dry (i.e., glacial) conditions (Faith et al. 2013; Tryon et al. 2012). Hominin populations may well have followed a similar environmentally mediated pattern of range shifts. The LVRM conspicuously marks the easternmost limit of Lupemban MSA sites that are most numerous in the forested regions of central Africa and appear to be associated with forested paleoenvironments (Barham 2000; Mercader 2002). In contrast, LVRM MSA sites that co-occur with arid-adapted fauna have small points like those found to the east in the Rift Valley (Tryon et al. 2012), a connection further demonstrated by rare obsidian artifacts at LVRM sites with Rift Valley sources (table A1).

The extent to which modern environments provide precise analogues for Pleistocene eastern Africa is uncertain. Fossil fauna from MSA sites include a number of specialized grazers that became extinct by the Holocene, implying important differences in animal communities and grassland composition (Faith et al. 2011, 2012; Marean 1992, 1997). Five extinct mammals are reported from MSA sites, including an aardvark, *Orycteropus crassidens* (Lehmann 2009; MacInnes 1956), and four bovids characterized by extreme hypsodonty and/or body mass: a relative of the wildebeest, *Rusingoryx atopocranion* (Faith et al. 2011; Pickford and Thomas 1984); the giant wildebeest *Megalotragus* sp. (Kelly 1996; Tryon et al. 2012); an extinct blesbok, *Damaliscus hypsodon* (Faith et al. 2012; Marean and Gifford-Gonzalez 1991); and the giant longhorn buffalo *Syncerus antiquus* (Marean 1992; Tryon et al. 2012). Although extant species are present, extinct taxa are numerically dominant at MSA strata from Rusinga Island and GvJm46 at Lukenya Hill in Kenya (Marean 1992; Tryon et al. 2012). Their dominance implies that dry grassland or scrub habitats were more common than the seasonally moist short grasslands found today.

As Blome et al. (2012) stress, environmental change across eastern Africa is asynchronous, with different areas experiencing variable changes in moisture availability and thus habitat change. The archaeological response to this variability seen among Pleistocene faunas and eastern African MSA sites appears to be small-scale movements (e.g., range expansion, topographic shifts) as an adaptation to changing environmental conditions. At present, there is no strong evidence for environmental change as a driver of behavioral innovation among eastern African MSA sites, but this may reflect a lack of stratified MSA sequences associated with detailed paleoenvironmental data.

Discussion

The high degree of variability characteristic of eastern African MSA lithic technology limits our ability to identify an archaeological signal linking eastern African MSA human populations to those that migrated out of Africa. This problem is exacerbated by the fact that many technical elements used to manufacture MSA/MP artifacts, such as percussion, shaping (*façonnage*), retouch, biface manufacture, and woodworking are also present in older, Acheulian sites. This common technological foundation makes likely the independent invention of particular artifact forms even among dispersed populations of large-brained hominins (Shea 2006*a*; see also Lycett 2007). For example, Levallois technology apparently developed at Acheulian sites in Africa and Eurasia from multiple independent pathways (Tryon, McBrearty, and Texier 2005; White, Ashton, and Scott 2011). Perhaps because of this, the MSA record from eastern Africa consists of lithic types and technologies that are also found at similarly aged sites in other parts of Africa and Eurasia. Our comparative analyses of the eastern African data suggest that assemblages from a single site are more similar to one another than they are to those from other sites (regardless of geographic distance), emphasizing the high diversity among these sites and the difficulty of identifying a regional signature using artifact typology.

While variability poses challenges to identifying a geographic signature unique to the eastern African MSA, there is some evidence for temporal change. The identification of temporal patterning among some LMSA (many <75 ka) assemblages on the basis of the more frequent presence of beads, ochre, bipolar cores, anvils, grindstones, and blades (fig. 4, *top*) suggests important behavioral changes during the later Pleistocene. All of these elements characterize sites of the regional LSA, imply a prolonged shift to LSA technologies, and suggest that the 70–35 ka interval of major population dispersals within and out of Africa (Soares et al. 2012) was one characterized by important technological changes. Some of the artifact forms underlying this technological shift have been suggested as markers of out-of-Africa population dispersals to southern and eastern Asia (Mellars 2006*b*, 2006*c*), although Neanderthal populations in Europe apparently independently invented similar elements during the same time interval (d'Errico and Stringer 2011).

Several authors have noted the absence of a clear archaeological "out-of-Africa" signature, stressing that there is little recognizably (northern or eastern) "African" about the archaeological record of early *Homo sapiens* in Asia, Europe, or Australia (e.g., Shea, 2011*b*; Vermeersch 2001). For example, the oldest members of our species outside of Africa are found at Qafzeh, Israel, in association with artifacts that fit comfortably within the Levantine Mousterian (Hovers 2009). Evidence for symbolic behavior from Qafzeh, including beads and ochre-stained burials, predate the oldest comparable evidence in Africa by at least 40 kyr (Bar-Yosef Mayer, Vandermeersch, and Bar-Yosef 2009; Hovers et al. 2003; Taborin 2003; Vanhaeren et al. 2006). Similarly, although the earliest European fossils of *H. sapiens* have tropical body proportions associated with a recent African origin (Pearson 2000), no features of the Aurignacian (or later) Upper Paleolithic industries suggest a technological link to Africa. The early record from Australasia similarly lacks technological affinities with the African MSA, consisting largely of simple forms of flake production common to all Pleistocene archaeological sites (e.g., Mulvaney and Kamminga 1999). Mellars (2006*b*, 2006*c*) has suggested backed pieces as a candidate artifact form, but repeated reinvention (e.g., during the Upper Pleistocene with the Howiesons Poort and the mid-Holocene with the Wilton industries in South Africa) argues against its use as a marker of population dispersal. Shea (2011*a*) suggests that complex projectile technology (i.e., bow and arrow) may have facilitated the spread of *H. sapiens* out of Africa. However, in the absence of similarities in the preserved (i.e., stone) elements of this technology, the hypothesis remains difficult to test and makes independent evolution impossible to rule out.

Should we expect to find an "out of Africa" signal in the archaeological record at all? The Paleolithic archaeological record is the outcome of behaviors mediated by particular social and physical environments. We expect the archaeological record to reflect changes in either the social or physical landscape, and dispersals out of Africa were likely associated with both. Groups dispersing into the Levant and other parts of Eurasia likely encountered territories occupied by Neanderthal (and other) hominin populations. While the precise nature of this interaction has long been debated, novel social environments may have acted as a catalyst for behavioral change, either through innovation or emulation. It may be that the reason the earliest *H. sapiens* in the Levant have artifact assemblages like those of the Neanderthals is that this represents a successful behavioral strategy for that area. *Homo sapiens* was the first hominin in Australia, and that continent's distinctive biota represent a dramatic change in physical environment, perhaps explaining why the archaeological record from that area is quite different from contemporaneous sites found in Africa (or Europe or the Levant). We do not find an "out-of-Africa" archaeological signature because the eastern African record represents adaptations to that region's unique setting; with new social and physical environments we find new archaeological signatures. The outcome appears to be different behaviors for different regions or environments, at least for hominins using MSA and MP technology, a feature that may be distinct from those using LSA and UP technology (see Kuhn and Stiner 2001; Mercader and Brooks 2001).

From this perspective, evidence for hominin occupation of the Arabian Peninsula is particularly interesting. Rose (2004) and Armitage et al. (2011) used the presence of bifacial tools to link the Arabian and eastern African records. However, the sample size is small, and bifaces have appeared independently multiple times in different areas (e.g., Rose 2007). In what we consider the only convincing archaeological evidence linking Africa and Arabia, Rose et al. (2011) demonstrated strong technological similarities in the specific details of core preparation and Levallois point production of the Nubian Type 1 method. These cores are found largely at sites in the Nile Valley and its drainage basin in northeastern Africa and at sites in Oman dated to a relatively humid interval during the Last Interglacial ~106 ka. What is most striking about this is that multiple lines of evidence demonstrate a contemporary dispersal of eastern African flora and fauna (reviewed in Rose et al. 2011). Initial populations in Arabia may simply reflect an expansion of "Africa out of Africa." African-like physical environments in Arabia mitigated the need to adapt to novel environments, and with no (known) prior hominin populations in the Arabian Peninsula, the social environment may have remained relatively stable. This hypothesis has clear parallels with Dennell and Roebroek's (2005) concept of "Savannahstan," with initial hominins dispersing into Asia remaining within African-like environments. Later (~55 ka) sites from the Arabian peninsula during arid intervals lack Nubian Type 1 cores and suggest instead the development of regionally distinct variants in Arabia and Africa with environmental change (Delagnes et al. 2012).

An emphasis on social and environmental factors shifts our expectations in searching for the origins of "modern human behavior." If the archaeological signature of early *H. sapiens* varies in relation to different social and physical environments, then we should expect temporally and spatially variable patterning in the expression of those elements linked to behavioral modernity. This is consistent with the irregular temporal-spatial distribution of the archaeological signatures associated with modernity (d'Errico 2003; d'Errico and Stringer 2011; Habgood and Franklin 2008; McBrearty and Brooks, 2000) and parallels d'Errico and Stringer's (2011) "cultural model" of modern human behavioral origins and Conard's (2008) model for Mosaic Polycentric Modernity. By reducing emphasis on the link between biological and behavioral modernity (e.g., Hovers and Belfer-Cohen 2006; Kuhn and Hovers 2006; Lieberman and Bar-Yosef 2005) and emphasizing the situational nature of the archaeological evidence (see also Henshilwood and Marean 2003), these models are consistent with several lines of evidence, including an African biological origin for our species but a Eurasian origin for the Aurignacian (Mellars 2006*a*), and the presence at Neanderthal sites of some behaviors classically linked with modern humans (d'Errico and Stringer 2011). Such a perspective has the advantage of shifting approaches to the eastern African MSA record from those that scrutinize it for evidence of "modern human behavior" or archaeological signals of dispersal to one that emphasizes it for what it is: the behavioral traces of early populations of *H. sapiens* and closely related taxa (cf. Shea 2011*b*; comments in Henshilwood and Marean 2003).

Conclusions

From an archaeological perspective, the MSA record of eastern Africa is highly variable and contains no typological or technological elements that are uniquely derived relative to other regions. Some change may be the result of subtle population movements or shifts in relation to environmental change rather than innovation. This is superimposed on general trends of point size decrease and a record beginning with the Last Interglacial that occasionally contains backed pieces and beads and the more frequent presence of grindstones and ochre, among other artifact classes. Some of the similarities with other regions likely represent analogous behaviors (such as the origin and spread of Levallois technology), whereas others may indeed be homologous, such as the very particular behavioral "recipes" that define Nubian Type 1 technology found only in northeastern Africa and southeastern Arabia. Our ability to address these issues will certainly increase as more African assemblages are studied in ways comparable with those from other regions and as the number of studied and well-published sites increases. The observed variability of the eastern African MSA record reduces its utility in identifying any sort of archaeological marker for dispersals "out of Africa." Rather, it represents the long-term outcome of a series of local adaptations made by Middle and Upper Pleistocene populations that included *Homo sapiens.*

Acknowledgments

C. A. Tryon would like to thank Erella Hovers, Steve Kuhn, Leslie Aiello, Laurie Obbink, and all the conference participants for the wonderful week in Sweden. Any synthesis such as this is the outcome of years of reflection and discussion, and we would like to acknowledge the following for directly or indirectly contributing to the ideas presented here: Sally McBrearty, Alison Brooks, Erella Hovers, Steve Kuhn, Susan Antón, Terry Harrison, Dan Peppe, Pierre-Jean Texier, John Kingston, Kay Behrensmeyer, Rick Potts, Stanley Ambrose, Curtis Marean, and Nick Conard. We thank Sheila Nightingale for the artifact illustrations. Portions of the research presented here were supported by grants from the National Science Foundation (BCS-0118345, BCS-0841530, BCS-1013199), the Wenner-Gren Foundation, the Leakey Foundation, the National Geographic Society, New York University, and the University of Queensland. Finally, none of this would have been possible without the love and support of Rhonda Kauffman, Violet Tryon, and Cornel Faith.

References Cited

Ambrose, Stanley H. 1986. Hunter-gatherer adaptations to non-marginal environments: an ecological and archaeological assessment of the Dorobo model. *Sprache und Geschichte in Afrika* 7(2):11–42.

———. 1998. Chronology of the Later Stone Age and food production in East Africa. *Journal of Archaeological Science* 25:377–392.

———. 2001. Middle and Later Stone Age settlement patterns in the Central Rift Valley, Kenya: comparisons and contrasts. In *Settlement dynamics in the Middle Paleolithic and Middle Stone Age.* N. J. Conard, ed. Pp. 21–44. Tübingen: Kerns.

———. 2010. Coevolution of composite tool technology, constructive memory, and language: implications for the evolution of modern human behavior. *Current Anthropology* 51(suppl.):S135–S147.

Ambrose, Stanley H., and Alan Deino. 2010. Technological diversity and geochronology of Middle Stone Age industries in the Central Rift Valley, Kenya: implications for the evolution of modern human behavior. *Paleoanthropology* 2010:A1.

Ambrose, Stanley H., Philip Slater, Jeffrey Ferguson, Michael Glascock, and Ian Steele. 2012. Obsidian source survey and Late Quaternary artifact sourcing in Kenya: implications for early modern human behavior. *Paleoanthropology* 2012:A1–A2.

Anthony, Barbara. 1972. The Stillbay question. In *Congrès panafricain de préhistoire, Dakar 1967: actes de 6e session.* H. J. Hugot, ed. Pp. 80–82. Paris: Les Imprimeries Réunies de Chambéry.

Armitage, S. J., S. A. Jasim, A. E. Marks, A. G. Parker, V. I. Usik, and H.-P. Uerpmann. 2011. The southern route "out of Africa": evidence for an early expansion of modern humans into Arabia. *Science* 331:453–456.

Assefa, Zelalem. 2006. Faunal remains from Porc-Epic: paleoecological and zooarchaeological investigations from a Middle Stone Age site in southeastern Ethiopia. *Journal of Human Evolution* 51:50–75.

Assefa, Zelalem, Y. M. Lam, and Henk K. Mienis. 2008. Symbolic use of terrestrial gastropod opercula during the Middle Stone Age at Porc-Epic Cave, Ethiopia. *Current Anthropology* 49:746–756.

Barham, Lawrence S. 2000. *The Middle Stone Age of Zambia, south-central Africa.* Bristol: Western Academic & Specialist Press.

Bar-Yosef Mayer, Daniella E., Bernard Vandermeersch, and Ofer Bar-Yosef. 2009. Shells and ochre in Middle Paleolithic Qafzeh Cave, Israel: indications for modern behavior. *Journal of Human Evolution* 56:307–314.

Basell, Laura S. 2007. An exploration of the Middle Stone Age of Eastern Africa and Excavations at Rambogo Rock Shelter, Kenya. PhD thesis, University of Cambridge.

———. 2008. Middle Stone Age (MSA) site distributions in eastern Africa and their relationship to Quaternary environmental change, refugia and the evolution of *Homo sapiens. Quaternary Science Reviews* 27:2484–2498.

Beyin, Ammanuel. 2011. Upper Pleistocene human dispersals out of Africa: a review of the current state of the debate. *International Journal of Evolutionary Biology* 2011: article ID 615094, doi:10.4061/2011/615094.

Beyries, Sylvie, and Hughes Plisson. 1998. Pointes ou outils triangulaires? données fontionelles dan le Moustérien levantin. *Paléorient* 24:5–24.

Blome, Margaret Whiting, Andrew S. Cohen, Christian A. Tryon, Alison S. Brooks, and Joellen Russel. 2012. The environmental context for the origins of modern human diversity: a synthesis of regional variability in African climate 150,000–30,000 years ago. *Journal of Human Evolution* 62:563–592.

Boëda, Eric 1994. *Le concept Levallois: variabilité des méthodes.* Paris: Centre National de la Recherche Scientifique.

———. 1995. Levallois: a volumetric construction, methods, a technique. In *The definition and interpretation of Levallois technology.* H. L. Dibble and O. Bar-Yosef, eds. Pp. 41–68. Madison, WI: Prehistory Press.

Bordes, François. 1961. *Typologie du paléolithique ancien et moyen.* Publications de l'Institut de préhistoire de l'Université de Bordeaux, Mémoire no. 1 Bordeaux: Delmas.

Bordes, Jean-Guillaume, and Nicholas Teyssandier. 2012. The Upper Paleolithic nature of the Châtelperronian in south-western France: archeostratigraphic and lithic evidence. *Quaternary International* 259:95–101.

Brandt, Steven A., Erich C. Fisher, Elisabeth A. Hildebrand, Ralf Vogelsang, Stanley H. Ambrose, Joséphine Lesur, and Hong Wang. 2012. Early MIS 3 occupation of Mochena Borago Rockshelter, southwest Ethiopian highlands: implications for Late Pleistocene archaeology, paleoenvironments and modern human dispersals. *Quaternary International* 274:38–54.

Brandt, Steven A., and Thomas H. Gresham. 1989. L'âge de la pierre en Somalie. *L'Anthropologie* 94:459–482.

Bräuer, Günter, and Michael Mehlman. 1988. Hominid molars from a Middle Stone Age at the Mumba Rock Shelter, Tanzania. *American Journal of Physical Anthropology* 75:69–76.

Brooks, Alison S., John E. Yellen, Lisa Nevell, and Gidon Hartman. 2006. Projectile technologies of the African MSA: implications for modern human origins. In *Transitions before the transition: evolution and stability in the Middle Paleolithic and Middle Stone Age.* Erella Hovers and Steven L. Kuhn, eds. Pp. 233–256. New York: Springer.

Brown, Francis H., and Chad R. Fuller. 2008. Stratigraphy and tephra of the Kibish Formation, southwestern Ethiopia. *Journal of Human Evolution* 55: 366–403.

Bruggeman, J. Henrich, Richard T. Buffler, Mireille M. M. Guillaume, Robert C. Walter, Rudo von Cosel, Berhane N. Ghebretensae, and Seife M. Berhe. 2004. Stratigraphy, palaeoenvironments and model for the deposition of the Abdur Reef Limestone: context for an important archaeological site from the last interglacial on the Red Sea coast of Eritrea. *Palaeogeography, Palaeoclimatology, Palaeoecology* 203:179–206.

Bulbeck, David. 2007. Where river meets sea: a parsimonious model for *Homo sapiens* colonization of the Indian Ocean rim and Sahul. *Current Anthropology* 48:315–321.

Clark, J. Desmond. 1988. The Middle Stone Age of East Africa and the beginnings of regional identity. *Journal of World Prehistory* 2:235–305.

———. 1993. African and Asian perspectives on the origins of modern humans. In *The origin of modern humans and the impact of chronometric dating.* M. J. Aitken, C. B. Stringer, and P. A. Mellars, eds. Pp. 148–178. Princeton, NJ: Princeton University Press.

———. 2001*a*. Ecological and behavioral implications of the siting of Middle Stone Age rockshelter and cave settlements in Africa. In *Settlement dynamics of the Middle Paleolithic and Middle Stone Age.* N. J. Conard, ed. Pp. 91–98. Tübingen: Kerns.

———. 2001*b*. *The earlier cultures: Middle and Earlier Stone Age*, vol. 3 of *Kalambo Falls prehistoric site.* Cambridge: Cambridge University Press.

Clark, J. Desmond, Yonas Beyene, Giday WoldeGabriel, William K. Hart, Paul R. Renne, Henry Gilbert, Alban Defleur, et al. 2003. Stratigraphic, chronological and behavioural contexts of Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature* 423:747–752.

Clark, J. Desmond, James L. Phillips, and Preston S. Staley. 1974. Interpretations of prehistoric technology from ancient Egyptian and other Sources. 1. Ancient Egyptian bows and arrows and their relevance for African Prehistory. *Paléorient* 2:323–388.

Clark, J. Desmond, and G. R. Prince. 1978. Use-wear on Later Stone Age

microliths from Laga Oda, Haraghi, Ethiopia, and possible functional interpretations. *Azania* 13:101–110.
Clark, J. Desmond, Kenneth D. Williams, Joseph W. Michels, and Curtis A. Marean. 1984. A Middle Stone occupation site at Porc Epic Cave, Dire Dawa. *African Archaeological Review* 2:37–72.
Close, Angela E. 2002. Backed bladelets are a foreign country. In *Thinking small: global perspective on microlithization.* S. L. Kuhn and R. G. Elston, eds. Pp. 31–44. Archeological Papers of the American Anthropological Association, vol. 12. Washington, DC: American Anthropological Association.
Conard, Nicholas J. 2004. An overview of the patterns of behavioural change in Africa and Eurasia during the Middle and Late Pleistocene. In *From tools to symbols: from early hominids to modern humans.* F. d'Errico and L. Backwell, eds. Pp. 294–332. Witswatersrand, South Africa: Witswatersrand University Press.
———. 2008. A critical view of the evidence for a southern African origin of behavioural modernity. *South African Archaeological Society Goodwin Series* 10:175–179.
Coulson, Sheila, Sigrid Staurset, and Nick Walker. 2011. Ritualized behavior in the Middle Stone Age: evidence from Rhino Cave, Tsodilo Hills, Botswana. *Paleoanthropology* 2011:18–61.
Day, Michael H., Mary D. Leakey, and Cassian Magori. 1980. A new hominid fossil skull (L.H. 18) from the Ngaloba Beds, Laetoli, northern Tanzania. *Nature* 284:55–56.
Deacon, Hilary J., and Janette Deacon. 1999. *Human beginnings in South Africa: uncovering the secrets of the Stone Age.* Walnut Creek, CA: Altamira.
Delagnes, Anne, and Lillianne Meignen. 2006. Diversity of lithic production systems during the Middle Paleolithic in France: are there any chronological trends? In *Transitions before the transition: evolution and stability in the Middle Paleolithic and Middle Stone Age.* Erella Hovers and Steven L. Kuhn, eds. Pp. 85–108. New York: Springer.
Delagnes, Anne, Chantal Tribolo, Pascal Bertran, Michel Brenet, Rémy Crassard, Jacques Jaubert, Lamya Khalidi, et al. 2012. Inland human settlement in southern Arabia 55,000 years ago: new evidence from the Wadi Surdud Middle Paleolithic site complex, western Yemen. *Journal of Human Evolution* 63:452–474.
de la Torre, Ignacio. 2004. Omo revisited: evaluating the technological skills of Pliocene hominids. *Current Anthropology* 45:439–465.
Dennell, Robin W., and Wil Roebroeks. 2005. An Asian perspective on early human dispersal from Africa. *Nature* 438:1099–1104.
d'Errico, Francesco. 2003. The invisible frontier: a multiple species model for the origin of behavioral modernity. *Evolutionary Anthropology* 12:188–202.
d'Errico, Francesco, and Chris B. Stringer. 2011. Evolution, revolution or saltation scenario for the emergence of modern cultures? *Philosophical Transactions of the Royal Society B* 366:1060–1069.
Diez-Martín, Fernando, Manuel Domínguez-Rodrigo, Policarpo Sánchez, Audax Z. P. Mabulla, Antonio Tarriño, Rebeca Barba, Mary E. Prendergast, and Luis de Luque. 2009. The Middle to Later Stone Age technological transition in East Africa: new data from Mumba Rockshelter Bed V (Tanzania) and their implications for the origin of modern human behavior. *Journal of African Archaeology* 7:147–173.
Domínguez-Rodrigo, Manuel, Fernando Díez-Martin, Audax Mabulla, Luis Luque, Luis Alcalá, Antonio Tarriño, Jose A. López-Sáez, Rebecca Barba, and Pastory Bushozi. 2007. The archaeology of the Middle Pleistocene deposits of Lake Eyasi, Tanzania. *Journal of African Archaeology* 5:47–78.
Domínguez-Rodrigo, Manuel, Audax Mabulla, Luis Luque, Jeroen W. Thompson, William J. Rink, Pastory Bushozi, Fernando Díez-Martin, and Luis Alcala. 2008. A new archaic *Homo sapiens* fossil from Lake Eyasi, Tanzania. *Journal of Human Evolution* 54:899–903.
Donahue, Randolph E., Michael L. Murphy, and Lawrency H. Robbins. 2002–2004. Lithic microwear analysis of Middle Stone Age artifacts from White Paintings Rock Shelter, Botswana. *Journal of Field Archaeology* 29:155–163.
Douze, Katja. 2008. Le Early Middle Stone Age en Ethiopie: le contexte de Gademotta: analyse technologique du site ETH-72-6. Mémoire de Master 2, Université de Toulouse II, Le Mirail.
Eren, Metin I., Fernando Diez-Martin, and Manuel Domínguez-Rodrigo. 2013. An empirical test of the relative frequency of bipolar reduction in Beds VI, V, and III at Mumba Rockshelter, Tanzania: implications for the East African Middle to Late Stone Age transition. *Journal of Archaeological Science* 40:248–256.
Eren, Metin I., and Stephen J. Lycett. 2012. Why Levallois? a morphometric comparison of experimental "preferential" Levallois flakes versus debitage flakes. *PLoS ONE* 7:29723.
Faith, J. Tyler, Jonah N. Choiniere, Christian A. Tryon, Daniel J. Peppe, and David L. Fox. 2011. Taxonomic status and paleoecology of *Rusingoryx atopocranion* (Mammalia, Artiodactyla), an extinct Pleistocene bovid from Rusinga Island, Kenya. *Quaternary Research* 75:697–707.
Faith, J. Tyler, Manuel Domínguez-Rodrigo, Adam D. Gordon. 2009. Long-distance carcass transport at Olduvai Gorge? a quantitative examination of Bed I skeletal element abundances. *Journal of Human Evolution* 56:247–256.
Faith, J. Tyler, Richard Potts, Thomas W. Plummer, Laura C. Bishop, Curtis A. Marean, and Christian A. Tryon. 2012. New perspectives on middle Pleistocene change in the large mammal faunas of East Africa: *Damaliscus hypsodon* sp. nov. (Mammalia, Artiodactyla) from Lainyamok, Kenya. *Palaeogeography, Palaeoclimatology, Palaeoecology* 361/362:84–93.
Faith, J. Tyler, Christian A. Tryon, Daniel J. Peppe, and David L. Fox. 2013. The fossil history of Grévy's zebra (*Equus grevyi*) in equatorial East Africa. *Journal of Biogeography* 40:359–369.
Féblot-Augustins, Jehanne. 1990. Exploitation des matières premières dans l'Acheuléen d'Afrique: perspectives comportementales. *Paléo* 2:27–42.
———. 1993. Mobility strategies in the Late Middle Paleolithic of central Europe and western Europe: elements of stability and variability. *Journal of Anthropological Archaeology* 12:211–265.
Gabel, Creighton. 1984. *Notes on the history of archaeology in sub-Saharan Africa.* Boston University African Studies Center Working Papers, no. 86. Boston: Boston University African Studies Center.
Gliganic, Luke A., Zenobia Jacobs, Richard G. Roberts, Manuel Domínguez-Rodrigo, and Audax Z. P. Mabulla. 2011. New ages for Middle and Later Stone Age deposits at Mumba Rockshelter, Tanzania: optically stimulated luminescence dating of quartz and feldspar grains. *Journal of Human Evolution* 62:533–547.
Goodwin, Astley J. H., and Clarence van Riet Lowe. 1929. The Stone Age cultures of South Africa. *Annals of the South Africa Museum* 27:1–289.
Gossa, Tegenu, Yonatan Sahle, and Agazi Negash. 2012. A reassessment of the Middle and Later Stone Age lithic assemblages from Aladi Springs, southern Afar Rift, Ethiopia. *Azania* 47:210–222.
Gresham, Thomas H. 1984. An investigation of an Upper Pleistocene archaeological site in northern Somalia. MA thesis, University of Georgia, Athens.
Grubb, Peter, Oliver Sandrock, Ottmar Kullmer, Thomas M. Kaiser, and Friedemann Schrenk. 1999. Relationships between eastern and southern African mammal faunas. In *African biogeography, climate change, and early hominid evolution.* T. Bromage and F. Schrenk, eds. Pp. 253–267. Oxford: Oxford University Press.
Gunz, Phillipp, Fred L. Bookstein, Philipp Mitteroecker, Andrea Stadlmayr, Horst Seidler, and Gerhard W. Weber. 2009. Early modern human diversity suggests subdivided population structure and a complex out-of-Africa scenario. *Proceedings of the National Academy of Sciences of the USA* 106:6094–6098.
Habgood, Phillip J., and Natalie R. Franklin. 2008. The revolution that didn't arrive: a review of Pleistocene Sahul. *Journal of Human Evolution* 55:187–222.
Haile-Selassie, Yohannes, Berhane Asfaw, and Tim D. White. 2004. Hominid cranial remains from Upper Pleistocene deposits at Aduma, Middle Awash, Ethiopia. *American Journal of Physical Anthropology* 123:1–10.
Hammer, Michael F., August E. Woerner, Fernando L. Mendez, Joseph C. Watkins, and Jeffrey D. Wall. 2011. Genetic evidence for archaic admixture in Africa. *Proceedings of the National Academy of Sciences of the USA* 108:15123–15128.
Hauck, Thomas C. 2011. The Mousterian sequence of Hummal and its tentative placement in the Levantine Middle Paleolithic. In *The Lower and Middle Paleolithic in the Middle East and neighboring regions.* J.-M. Le Tensorer, R. Jagher, and M. Otte, eds. Pp. 309–323. Études et recherches archéologiques de l'Université de Liège 126. Liège: Centre de recherches archéologiques de l'Université de Liège.
Henshilwood, Christopher S., and Curtis W. Marean. 2003. The origin of modern human behavior: critique of the models and their test implications. *Current Anthropology* 44:627–651.
Hovers, Erella. 2009. *The lithic assemblages of Qafzeh Cave.* Oxford: Oxford University Press.
Hovers, Erella, and Anna Belfer-Cohen. 2006. "Now you see it, now you don't": modern human behavior in the Middle Paleolithic. In *Transitions before the transition: evolution and stability in the Middle Paleolithic and Middle Stone Age.* Erella Hovers and Steven L. Kuhn, eds. Pp. 295–304. New York: Springer.
Hovers, Erella, Shimon Ilani, Ofer Bar-Yosef, and Bernard Vandermeersch.

2003. An early case of color symbolism: ochre use by early modern humans at Qafzeh Cave. *Current Anthropology* 44:491–522.
Hublin, Jean-Jacques, Anee-Marie Tillier, and Jacques Tixier. 1987. L'humérus d'enfant Moustérien (Homo 4) du Jeble Irhoud (Maroc) dans son contexte archéologique. *Bulletin et Mémoire de la Société d'Anthropologie de Paris* 4: 115–142.
Inskeep, Raymond R. 1962. The age of the Kondoa rock paintings in the light of recent excavations at Kisese II Rock Shelter. In *Actes du IVe Congress panafricain de préhistoire et l'étude du quaternaire*. G. Mortelmans and J. Nenquin, eds. Pp. 249–256. Tervuren: Musée Royal de l'Afrique Centrale.
Isaac, Glynn L., Harry V. Merrick, and Charles M. Nelson. 1972. Stratigraphic and archaeological studies in the Lake Nakuru basin, Kenya. *Palaeoecology of Africa and the Surrounding Islands* 6:225–234.
Jenkins, Kirsten, J. Tyler Faith, Christian A. Tryon, Daniel J. Peppe, Sheila Nightingale, Julian A. Ogondo, Cara Roure Johnson, and Steve Driese. 2012. New excavations of a Late Pleistocene bonebed and associated MSA artifacts, Rusinga Island, Kenya. *Paleoanthropology* 2012:A17.
Johnson, Cara Roure, and Sally McBrearty. 2010. 500,000 year old blades from the Kapthurin Formation, Kenya. *Journal of Human Evolution* 58:193–200.
Keeley, Lawrence H. 1982. Hafting and retooling: effects on the archaeological record. *American Antiquity* 47:798–809.
Kelly, Alison J. 1996. Intraregional and interregional variability in the East Turkana (Kenya) and Kenyan Middle Stone Age. PhD thesis, Rutgers University, New Brunswick, NJ.
Kelly, Robert L. 1995. *The foraging spectrum*. Washington, DC: Smithsonian Institution Press.
Kingdon, Jonathon. 1981. Where have the colonists come from? a zoogeographical examination of some mammalian isolates in eastern Africa. *African Journal of Ecology* 19:115–124.
Klein, Richard G. 2009. *The human career*. 3rd edition. Chicago: University of Chicago Press.
Kuhn, Steven L. 2004. Upper Paleolithic raw material economies at Üçağızlı cave, Turkey. *Journal of Anthropological Archaeology* 23:431–448.
Kuhn, Steven L., and Erella Hovers. 2006. General introduction. In *Transitions before the transition: evolution and stability in the Middle Paleolithic and Middle Stone Age*. Erella Hovers and Steven L. Kuhn, eds. Pp. 1–12. New York: Springer.
Kuhn, Steven L., and Mary C. Stiner. 2001. The antiquity of hunter-gatherers. In *Hunter-gatherers: an interdisciplinary perspective*. C. Panter-Brick, R. H. Layton, and P. Rowley-Conwy, eds. Pp. 99–142. Cambridge: Cambridge University Press.
———. 2007. Body ornamentation as information technology: towards and understanding of the significance of early beads. In *Rethinking the human revolution: new behavioural and biological perspectives on the origin and dispersal of modern humans*. Paul Mellars, Katie Boyle, Ofer Bar-Yosef, and Chris Stringer, eds. Pp. 45–54. Cambridge: McDonald Institute.
Kurashina, Hiro. 1978. An examination of prehistoric lithic technology in east-central Ethiopia. PhD dissertation, University of California.
Lachance, Joseph, Benjamin Vernot, Clara C. Elbers, Bart Ferwerda, Alain Froment, Jean-Marie Bodo, Godfrey Lema, et al. 2012. Evolutionary history and adaptation from high-coverage whole-genome sequences of diverse African hunter-gatherers. *Cell* 150:457–469.
Leakey, Louis S. B. 1931. *The Stone Age cultures of Kenya Colony*. Cambridge: Cambridge University Press.
———. 1936. *Stone Age Africa: an outline of prehistory in Africa*. Oxford: Oxford University Press.
———. 1943. The industries of the Gorgora Rock Shelter, Lake Tana. *Journal of the East Africa Natural History Society* 17:199–203.
Leakey, Margaret, Philip V. Tobias, John E. Martyn, and Richard E. F. Leakey. 1969. An Acheulean industry with prepared core technique and the discovery of a contemporary hominid mandible at Lake Baringo, Kenya. *Proceedings of the Prehistoric Society* 3:48–76.
Leakey, Mary D. 1983. *Africa's vanishing art: the rock paintings of Tanzania*. New York: Doubleday.
———. 1984. *Disclosing the past: an autobiography*. New York: McGraw-Hill.
Leakey, Mary D., Richard L. Hay, D. L. Thurber, R. Protsch, and R. Berger. 1972. Stratigraphy, archaeology, and age of the Ndutu and Naisiusiu Beds, Olduvai Gorge, Tanzania. *World Archaeology* 3:328–341.
Leakey, Mary D., and Louis S. B. Leakey. 1950. *Excavations at the Njoro River Cave*. Oxford: Clarendon.
Lehmann, Thomas. 2009. Phylogeny and systematics of the Orycteropodidae (Mammalia, Tubulidentata). *Zoological Journal of the Linnean Society* 155: 649–702.
Lieberman, Daniel E., and Ofer Bar-Yosef. 2005. Apples and oranges: morphological versus behavioral transitions in the Pleistocene. In *Interpreting the past: essays on human, primate and mammal evolution*. D. E. Lieberman, R. J. Smith, and J. Kelley, eds. Pp. 275–296. Boston: Brill Academic.
Lycett, Stephen J. 2007. Why is there a lack of Mode 3 Levallois technologies in East Asia? a phylogenetic test of the Movius-Schick hypothesis. *Journal of Anthropological Archaeology* 26:541–575.
Lycett, Stephen J., and N. von Cramon-Taubadel. 2008. Acheulean variability and hominin dispersals: a model-bound approach. *Journal of Archaeological Science* 35:553–562.
Mabulla, Audax Z. P. 1990. Preliminary report on an archaeological survey of the Ndutu Beds, Olduvai Gorge, Tanzania. *Nyame Akuma* 33:20–25.
MacInnes, Donald G. 1956. Fossil Tubulidentata from East Africa. *Fossil Mammals of Africa* 10:1–38.
Marean, Curtis W. 1990. Late Quaternary paleoenvironments and faunal exploitation in East Africa. PhD dissertation, University of California.
———. 1992. Implications of late Quaternary mammalian fauna from Lukenya Hill (south-central Kenya) for paleoenvironmental change and faunal extinctions. *Quaternary Research* 37:239–255.
———. 1997. Hunter-gatherer foraging strategies in tropical grasslands: model-building and testing in the East African Middle and Later Stone Age. *Journal of Anthropological Archaeology* 16:189–225.
Marean, Curtis W., and Dianne Gifford-Gonzalez. 1991. Late Quaternary extinct ungulates of East Africa and palaeoenvironmental implications. *Nature* 350:418–420.
Marks, Anthony E., and Nicholas J. Conard. 2008. Technology vs. typology: the case for and against a transition from the MSA to the LSA at Mumba Cave, Tanzania. In *Space and time: which diachronies, which synchronies, which scales? typology vs technology*. T. Aubry, F. Almeida, A. C. Araújo, and M. Tiffagom, eds. Pp. 123–131. BAR International Series 1831. Oxford: Archaeopress.
McBrearty, Sally. 1981. Songhor: a Middle Stone Age site in western Kenya. *Quaternaria* 23:171–190.
———. 1986. The archaeology of the Muguruk Site, Western Kenya. PhD dissertation, University of Illinois, Urbana-Champaign.
———. 1988. The Sangoan-Lupemban and Middle Stone Age sequence at the Muguruk site, western Kenya. *World Archaeology* 19:379–420.
———. 1999. Archaeology of the Kapthurin Formation. In *Late Cenozoic environments and hominid evolution: a tribute to Bill Bishop*. P. Andrews and P. Banham, eds. Pp. 143–156. London: Geological Society.
McBrearty, Sally, and Alison S. Brooks. 2000. The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution* 39:453–563.
McBrearty, Sally, and Christian A. Tryon. 2006. From Acheulian to Middle Stone Age in the Kapthurin Formation, Kenya. In *Transitions before the transition: evolution and stability in the Middle Paleolithic and Middle Stone Age*. E. Hovers and S. L. Kuhn, eds. Pp. 257–277. New York: Springer.
McDougall, Ian, Francis H. Brown, and John G. Fleagle. 2005. Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature* 433: 733–736.
McPherron, Shannon P., ed. 2007. *Tools versus cores: alternative approaches to stone tool analysis*. Newcastle: Cambridge Scholars.
Mehlman, Michael J. 1987. Provenience, age and associations of archaic *Homo sapiens* crania from Lake Eyasi, Tanzania. *Journal of Archaeological Science* 14:133–162.
———. 1989. Late Quaternary archaeological sequences in northern Tanzania. PhD dissertation, University of Illinois, Urbana-Champaign.
———. 1991. Context for the emergence of modern man in eastern Africa: some new Tanzanian evidence. In *Cultural beginnings: approaches to understanding early hominid lifeways in the African savanna*. J. Desmond Clark, ed. Pp. 177–196. Monographien (Romisch-Germanisches Zentralmuseum, Forschunginstitut fur Vorund Fruhgeschichte), vol. 19. Bonn: Habelt.
Mellars, Paul. 2006*a*. Archaeology and the dispersal of modern humans in Europe: deconstructing the "Aurignacian." *Evolutionary Anthropology* 15: 167–182.
———. 2006*b*. Going east: new genetic and archaeological perspectives on the modern human colonization of Eurasia. *Science* 313:796–800.
———. 2006*c*. Why did modern human populations disperse from Africa ca. 60,000 years ago? a new model. *Proceedings of the National Academy of Sciences of the USA* 103:9381–9386.
Mercader, Julio. 2002. Forest people: the role of African rainforests in human evolution and dispersal. *Evolutionary Anthropology* 11:117–124.

———. 2009. Mozambican grass seed consumption during the Middle Stone Age. *Science* 326:1680–1683.
Mercader, Julio, and Alison S. Brooks. 2001. Across forests and savannas: Later Stone Age assemblages from Ituri and Semliki, Democratic Republic of Congo. *Journal of Anthropological Research* 57:197–217.
Mercier, Norbert, Hélène Valladas, Laurence Froget, Jean-Louis Joron, Pierre M. Vermeersch, Phillip Van Peer, and Jan Moeyersons. 1999. Thermoluminescence dating of a Middle Paleolithic occupation at Sodmein Cave, Red Sea mountains (Egypt). *Journal of Archaeological Science* 26:1339–1345.
Merrick, Harry V. 1975. Change in Later Pleistocene lithic industries in eastern Africa. PhD dissertation, University of California.
Merrick, Harry V., Francis H. Brown, and William P. Nash. 1994. Use and movement of obsidian in the Early and Middle Stone Ages of Kenya and northern Tanzania. In *Society, culture, and technology in Africa*, vol. 11 (supplement). S. T. Childs, ed. Pp. 29–44. Philadelphia: MASCA.
Miller, Sheryl F. 1979. Lukenya Hill, GvJm 46, excavation report. *Nyame Akuma* 14:31–34.
Monnier, Gilliane. 2006. The Lower/Middle Paleolithic periodization in western Europe: an evaluation. *Current Anthropology* 47:709–744.
Morgan, Leah E., and Paul R. Renne. 2008. Diachronous dawn of Africa's Middle Stone Age: new ^{40}Ar/^{39}Ar ages from the Ethiopian Rift. *Geology* 36: 967–970.
Mulvaney, Derek J., and Johan Kamminga. 1999. *Prehistory of Australia*. Washington, DC: Smithsonian Institution Press.
Negash, Agazi, Francis H. Brown, and Barbara Nash. 2011. Varieties and sources of artefactual obsidian in the Middle Stone Age of the Middle Awash, Ethiopia. *Archaeometry* 53:661–673.
Newcomer, Michael H., and François Hivernel-Guerre. 1974. Nucleus sur éclat: technologie et utilisation par différentes cultures préhistoriques. *Bulletin de la Societe Préhistorique Française* 71:119–128.
O'Brien, Terence P. 1939. *The prehistory of Uganda protectorate*. Cambridge: Cambridge University Press.
Omi, Giichi, ed. 1984. *Mtongwe: an interim report of the East and Northeast African Prehistory Project 1982*. Matsumoto, Japan: Shinshu University.
———, ed. 1986. *Mtongwe: an interim report of the East and Northeast African Prehistory Project 1984*. Matsumoto, Japan: Shinshu University.
———, ed. 1988. *Mtongwe and Mgonga: an interim report of the East and Northeast African Prehistory Project 1986*. Matsumoto, Japan: Shinshu University.
———, ed. 1991. *An interim report of the East and Northeast African Prehistory Project 1988/1989*. Matsumoto, Japan: Shinshu University.
Pearson, Osbjorn M. 2000. Postcranial remains and the origin of modern humans. *Evolutionary Anthropology* 9:229–247.
———. 2008. Statistical and biological definitions of "anatomically modern" humans: suggestions for a unified approach to modern morphology. *Evolutionary Anthropology* 17:38–48.
Pickford, Martin, and Herbert Thomas. 1984. An aberrant new bovid (Mammalia) in subrecent deposits from Rusinga Island, Kenya. *Proceedings of the Koninklijke Akademie des Wetenschappen B* 87:441–452.
Pleurdeau, David. 2004. *Gestion des matières premières et comportements techniques dans le Middle Stone Age africain: les assemblages lithiques de la grotte du Porc Épic (Dire Dawa, Ethiopie)*. BAR International Series 1317. Oxford: Archaeopress.
Prugnolle, Franck, Andrea Manica, and François Balloux. 2005. Geography predicts neutral genetic diversity of human populations. *Current Biology* 15:159–160.
Robertshaw, Peter, ed. 1990. *A history of African archaeology*. London: James Currey.
Rodgers, William A., Charles F. Owen, and Katherine M. Homewood. 1982. Biogeography of East African forest mammals. *Journal of Biogeography* 9: 41–54.
Rose, Jeffrey. 2004. The question of Upper Pleistocene connections between East Africa and South Arabia. *Current Anthropology* 45:551–555.
———. 2007. The Arabian Corridor Migration Model: archaeological evidence for hominin dispersals into Oman during the Middle and Upper Pleistocene. *Proceedings of the Seminar for Arabian Studies* 37:219–237.
Rose, Jeffrey I., Vitaly I. Usik, Anthony E. Marks, Yamandu H. Hilbert, Christopher S. Galletti, Ash Parton, Jean Marie Geiling, Victor Černý, Mike W. Morley, and Richard G. Roberts. 2011. The Nubian Complex of Dhofar, Oman: an African Middle Stone Age industry in southern Arabia. *PLoS ONE* 6:e28239.
Sharon, Gonen, 2007. *Acheulian large flake industries: technology, chronology, and significance*. Oxford: Archaeopress.
Shea, John J. 2006*a*. The Middle Paleolithic of the Levant: recursion and convergence. In *Transitions before the transition: evolution and stability in the Middle Paleolithic and Middle Stone Age*. E. Hovers and S. L. Kuhn, eds. Pp. 189–212. New York: Springer.
———. 2006*b*. The origins of lithic projectile point technology: evidence from Africa, the Levant, and Europe. *Journal of Archaeological Science* 33:823–846.
———. 2008. The Middle Stone Age archaeology of the Lower Omo Valley Kibish Formation: excavations, lithic assemblages, and inferred patterns of early *Homo sapiens* behavior. *Journal of Human Evolution* 55:448–485.
———. 2011*a*. The archaeology of an illusion: the Middle-Upper Paleolithic transition in the Levant. In *The Lower and Middle Palaeolithic in the Middle East and neighboring regions*. J.-M. Le Tensorer, R. Jagher, and M. Otte, eds. Pp. 169–182. Études et recherches archéologiques de l'Université de Liège 126. Liège: Centre de recherches archéologiques de l'Université de Liège.
———. 2011*b*. *Homo sapiens* is as *Homo sapiens* was: behavioral variability vs. "behavioral modernity" in Paleolithic archaeology. *Current Anthropology* 52:1–35.
Slimak, Ludovic. 2008. The Neronian and the historical structure of cultural shifts from Middle to Upper Paleolithic in Mediterranean France. *Journal of Archaeological Science* 35:2204–2214.
Slimak, Ludovic, John I. Svendsen, Jan Mangerud, Hugues Plisson, Herbjørn P. Heggen, Alexis Brugère, and Pavel Y. Pavlov. 2011. Late Mousterian persistence near the arctic circle. *Science* 332:841–845.
———. 2012. Response to "Comment on late Mousterian persistence near the arctic circle." *Science* 335:167.
Soares, Pedro, Farida Alshamali, Joana B. Pereira, Verónica Fernandes, Nuno M. Silva, Carla Alfonso, Marta D. Costa, et al. 2012. The expansion of mtDNA haplogroup L3 within and out of Africa. *Molecular Biology and Evolution* 29:915–927.
Soriano, Sylvain, Michel Rasse, Chantal Tribolo, and Eric Huysecom. 2010. Ounjougou: a long Middle Stone Age sequence in the Dogon country (Mali). In *West African archaeology: new developments, new perspectives*. P. Allsworth-Jones, ed. Pp. 1–14. BAR International Series 2164. Oxford: Archaeopress.
Taborin, Yves. 2003. La mer et les premiers hommes modernes. In *Échanges et diffusion dans la préhistoire méditerranéenne*. B. Vandermeersch, ed. Pp. 113–122. Paris: Éditions du comité des travaux historiques et scientifiques.
Thackeray, Anne I. 1989. Changing fashions in the Middle Stone Age: the stone artefact sequence from Klasies River main site, South Africa. *African Archaeological Review* 7:33–57.
Thompson, Jessica C. 2005. The impact of post-depositional processes on bone surface modification frequencies: a corrective strategy and its application to the Loiyangalani site, Serengeti Plain, Tanzania. *Journal of Taphonomy* 3:67–89.
Trinkaus, Erik. 2005. Early modern humans. *Annual Review of Anthropology* 34:207–230.
Tryon, Christian A. 2003. The Acheulian to Middle Stone Age transition: tephrostratigraphic context for archaeological change in the Kapthurin Formation, Kenya. PhD dissertation, University of Connecticut.
———. 2006. "Early" Middle Stone Age lithic technology of the Kapthurin Formation (Kenya). *Current Anthropology* 47:367–375.
Tryon, Christian A., J. Tyler Faith, Daniel J. Peppe, David L. Fox, Kieran P. McNulty, Kirsten Jenkins, Holly Dunsworth, and William Harcourt-Smith. 2010. The Pleistocene archaeology and environments of the Wasiriya Beds, Rusinga Island, Kenya. *Journal of Human Evolution* 59:657–671.
Tryon, Christian A., J. Tyler Faith, Daniel J. Peppe, William F. Keegan, Kristen N. Keegan, Kirsten H. Jenkins, Sheila Nightingale, et al. Forthcoming. Sites on the landscape: paleoenvironmental context of late Pleistocene archaeological sites from the Lake Victoria Basin, equatorial East Africa. *Quaternary International*.
Tryon, Christian A., and Sally McBrearty. 2006. Tephrostratigraphy of the Bedded Tuff Member (Kapthurin Formation, Kenya) and the nature of archaeological change in the later Middle Pleistocene. *Quaternary Research* 65:492–507.
Tryon, Christian A., Sally McBrearty, and Pierre-Jean Texier. 2005. Levallois lithic technology from the Kapthurin Formation, Kenya: Acheulian origin and Middle Stone Age diversity. *African Archaeological Review* 22:199–229.
Tryon, Christian A., Daniel J. Peppe, J. Tyler Faith, Alex Van Plantinga, Sheila Nightingale, Julian A. Ogondo, and David L. Fox. 2012. Middle Stone Age artifacts and associated fauna from Rusinga and Mfangano islands, Lake Victoria, Kenya. *Azania* 47:14–38.
Tryon, Christian A., Neil T. Roach, and M. Amelia V. Logan. 2008. The Middle

Stone Age of the northern Kenyan Rift: age and context of new archaeological sites from the Kapedo Tuffs. *Journal of Human Evolution* 55:652–664.

Vallois, Henri. V. 1951. La mandibule humaine fossile de la Grotte du Porc-Epic près Diré-Daoua (Abyssinie). *L'Anthropologie* 55:231–238.

Vanhaeren, Marian, Francesco d'Errico, Chris Stringer, Sarah L. James, Jonathan A. Todd, and Henk K. Mienis. 2006. Middle Paleolithic shell beads in Israel and Algeria. *Science* 1785–1788.

Van Peer, Philip. 1992. *The Levallois reduction strategy*. Madison, WI: Prehistory Press.

———. 1998. The Nile Corridor and the out-of-Africa model: an examination of the archaeological record. *Current Anthropology* 39(suppl.):S115–S140.

Van Peer, Philip, Veerle Rots, and Pierre M. Vermeersch. 2008. A wasted effort at the quarry: wear analysis and interpretation of an MSA lanceolate point from Taramsa-8, Egypt. *Paleoanthropology* 2008:234–250.

Vermeersch, Pierre M. 2001. "Out of Africa" from an Egyptian point of view. *Quaternary International* 75:103–112.

Vermeersch, Pierre M., Philip Van Peer, Jan Moeyersons, and Wim Van Neer. 1994. Sodmein Cave site, Red Sea mountains (Egypt). *Sahara* 6:31–40.

Villa, Paola, Anne Delagnes, and Lyn Wadley. 2005. A Late Middle Stone Age artifact assemblage from Sibudu (KwaZulu-Natal): comparisons with the European Middle Paleolithic. *Journal of Archaeological Science* 32:399–422.

Villa, Paola, and Michel Lenoir. 2006. Hunting weapons of the Middle Stone Age and Middle Paleolithic: spear points from Sibudu, Rose Cottage, and Bouheben. *South African Humanities* 18:89–122.

Villa, Paola, and Sylvain Soriano. 2010. Hunting weapons of Neanderthals and early modern humans in South Africa: similarities and differences. *Journal of Anthropological Research* 66:5–38.

Villa, Paola, Sylvain Soriano, Nicholas Teyssandier, and Sarah Wurz. 2010. The Howiesons Poort and MSA III at Klasies River main site, Cave 1A. *Journal of Archaeological Science* 37:630–655.

Walter, Robert, Richard T. Buffler, J. Henrich Bruggemann, Mireille M. M. Guillaume, Seife M. Berhe, Berhane Negassi, Yoseph Libeskal, et al. 2000. Early human occupation of the Red Sea coast of Eritrea during the last interglacial. *Nature* 405:65–69.

Waweru, Veronica N. 2007. Middle Stone Age technology at Cartwright's Site, Kenya. PhD dissertation, University of Connecticut.

Wayland, E. J. 1934. Rifts, rivers, rain and early man in Uganda. *Journal of the Royal Anthropological Institute of Great Britain and Ireland* 64:333–352.

Wayland, E. J., and M. C. Burkitt. 1932. The Magosian culture of Uganda. *Journal of the Royal Anthropological Institute of Great Britain and Ireland* 62:369–390.

Wendorf, Fred, and Romauld Schild. 1974. *A Middle Stone Age sequence from the Central Rift Valley, Ethiopia*. Warsaw: Institute of the History of Material Culture, Polish Academy of Sciences.

———. 1993. Probable functions of Mousterian points and convergent sidescrapers in the Middle Stone Age of Ethiopia. *Quaternaria Nova* 3:39–51.

White, Frank. 1983. *The vegetation of Africa, a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa*. Paris: UNESCO.

White, Mark, and Paul Pettitt. 1995. Technology of early Palaeolithic western Europe: innovation, variability, and a unified framework. *Lithics* 16:27–40.

White, Mark J., Nick M. Ashton, and Beccy Scott. 2011. The emergence, diversity, and significance of the Mode 3 (prepared core) technologies. In *The ancient human occupation of Britain*. N. M. Ashton, S. G. Lewis, and C. B. Stringer, eds. Pp. 53–66. Amsterdam: Elsevier.

White, Tim D. 1986. Cut marks on the Bodo cranium: a case of prehistoric defleshing. *American Journal of Physical Anthropology* 69:503–509.

White, Tim D., Berhane Asfaw, David DeGusta, Henry Gilbert, Gary D. Richards, Gen Suwa, and F. Clark Howell. 2003. Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature* 423:742–747.

Wronski, Torsten, and Bernhard Hausdorf. 2008. Distribution patterns of land snails in Ugandan rain forests support the existence of Pleistocene forest refugia. *Journal of Biogeography* 35:1759–1768.

Wurz, Sarah. 2002. Variability in the Middle Stone Age lithic sequence, 115,000–60,000 years ago at Klasies River, South Africa. *Journal of Archaeological Science* 29:1001–1015.

———. 2013. Technological trends in the Middle Stone Age of South Africa between MIS 7 and MIS 3. *Current Anthropology* 54(suppl. 8):S305–S319.

Yellen, John E., Alison S. Brooks, David M. Helgren, Martha Tappen, Stanley H. Ambrose, Raymond Bonnefille, James K. Feathers, et al. 2005. The archaeology of Aduma Middle Stone Age sites in the Awash Valley, Ethiopia. *Paleoanthropology* 10:25–100.

Zwyns, Nicolas, Wil Roebroeks, Shannon P. McPherron, Adam Jagich, and Jean-Jacques Hublin. 2012. Comment on "A Late Mousterian persistence near the arctic circle." *Science* 335:167.