Transitions Before The Transition

Evolution and Stability in the Middle Paleolithic and Middle Stone Age

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From Acheulean to Middle Stone Age in the Kapthurin Formation, Kenya

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ABSTRACT

The Acheulean to Middle Stone Age (MSA) transition is examined from an evolutionary perspective. The replacement of Acheulean handaxes by MSA points represents a shift from hand-held to hafted technology, but the timing and nature of this process are poorly understood due to the rarity of sites from the early MSA (EMSA), here defined as the portion of the MSA predating 130,000 years ago. The well-calibrated sequence in the Kapthurin Formation, Kenya, spans the transition, and shows that MSA technology was present before 285,000 years ago. This date coincides with the age of known African fossils that most likely represent the earliest members of the *Homo sapiens* lineage. Occurrences with characteristic Acheulean and EMSA artifacts are interstratified in the Kapthurin Formation, demonstrating that the transition was not a simple, unidirectional process. A variety of flake production techniques is present at both Acheulean and MSA sites in the formation. The Levallois tradition begins before 285,000 BP in an Acheulean context; Levallois production methods diversify in the MSA. The precocious appearance of blades, grindstones, and pigment in the Kapthurin Formation before 285,000 BP shows that the array of sophisticated behaviors known in the later MSA (LMSA) began at the Acheulean to MSA transition, and it is suggested that such technological changes are among the causes or consequences of the origin of our species.

INTRODUCTION

During the later Middle Pleistocene in Africa, large bifaces disappear from the archaeological record and are replaced by smaller points, marking the transition from the Acheulean to the Middle Stone Age (MSA). New dates from the Kapthurin Formation establish that the transition was underway in East Africa before 285,000 years ago. We examine here data relevant to understanding the significance of this large scale archaeological change. The difference between the Acheulean and the MSA is poorly understood because most well documented MSA sites date to the later Middle Stone Age (LMSA) after 130,000 years BP. We therefore concentrate upon the early MSA (EMSA), which we define as that part of the MSA lying within the Middle Pleistocene, that is, before 130,000 years BP. This period has greater relevance for understanding the transition and provides the basis for understanding later behavioral developments within the MSA.

In the first part of this paper we examine general issues relating to the transition, including functional contrasts between handaxes and points, and the influence that different methodological and analytical approaches have upon inferences regarding the nature and timing of archaeological change. In the second part we discuss the transition as seen in the Middle Pleistocene Kapthurin Formation of Kenya where a number of well-dated sites span the transition. We examine the Kapthurin Formation record from the point of view of diagnostic formal tools as well as methods of flake production. In the third section, we introduce the African fossil hominids of this period, in order to establish the evolutionary context of the technological change. We suggest that the abandonment of Acheulean technology is part of a package of increasingly complex hominid behaviors that appears with the earliest members of the *H. sapiens* lineage.

THE NATURE OF THE TRANSITION

Handaxes and the Acheulean

The handaxe is emblematic of the Acheulean. Its wide geographic distribution (Africa, Europe and parts of Asia), and longevity (~1.3 million years) demonstrate that the handaxe was a successful adaptive device useful in a wide range of environments and situations (see papers in Petraglia and Korisettar 1998). Current interpretations suggest that handaxes were handheld, portable, multipurpose implements, and possibly sources of flakes (Clark 1994; McBrearty 2001). Experimental work and microwear analyses of edge damage have shown the handaxe to have been used for a variety of purposes, including butchery and woodworking (*e.g.*, Jones 1980; Binneman and Beaumont 1992; Roberts and Parfitt 1999; Dominguez-Rodrigo *et al.* 2001). In cases of exceptional preservation, traces of a several tasks may be preserved on different edges of the same piece, as reported by Keeley (1993).

Chronological or geographic patterning among Acheulean sites remains poorly understood, and it is possible that the ubiquity of the handaxe masks other important aspects of variability. For example, cleavers are frequent in Africa, but are not common in European sites; cleavers made on Kombewa flakes have been used as a marker for out-of-Africa emigration in the Levant (Goren-Inbar 1992; Goren-Inbar *et al.* 2000). Cleavers and handaxes are produced by a variety of flaking methods and techniques, as is the flake, core and small tool component at Acheulean sites (Clark 1994, 2001c; Roche and Texier 1995; McBrearty 2001). There is clear evidence for raw material selection at some Acheulean sites, although predominantly durable, locally available types were used (Clark 1980; Féblot-Augustins 1990; Jones 1994; Merrick *et al.* 1994; Raynal *et al.* 1995). Finally, archaeological projects at Isimila, Tanzania, and Olorgesailie, Kenya, document local hominid landscape use, and have shown variable patterns of Acheulean site distribution and composition that can be broadly correlated with paleoecological features (Kleindienst 1961; Hansen and Keller 1971; Cole and Kleindienst 1974; Isaac 1977; Potts 1994; Potts *et al.* 1999).

Points and the Middle Stone Age

The point is the characteristic implement of the MSA. The presence of points rather than handaxes in the MSA is significant because points represent the replacement of handheld artifacts by hafted, composite tools (Clark 1988; McBrearty and Brooks 2000). They show the development of complex hunting armatures, and unlike Acheulean handaxes, they show regional diversity in shape.

Direct evidence for hafted points includes tangs on Aterian implements (Clark 1970), the basal thinning of many other African stone points (Brooks, this volume), and grooves at the base of bone harpoons from sites at Katanda, Zaire (Yellen 1998). Points, and possibly backed crescents found at some MSA sites, were most likely designed as weapons to dispatch game or rival humans, as components of stabbing or throwing spears, and possibly as arrows (McBrearty and Brooks 2000; Waweru 2004). Impact damage consistent with the use of stone points as projectiles has been observed on the tips of MSA points from ≠Gi, Botswana (Kuman 1989). Importantly, these weapons convey the ability to inflict "death at a distance," supplying an adaptive advantage to the hunters using them by reducing their risk of injury through close physical encounters with large menacing animals (Berger and Trinkaus 1995; Cattelain 1997; Churchill 2002).

MSA points are made of bone as well as stone, and are produced using a variety of technological approaches. Some MSA stone points are unifacial, others bifacial. Levallois points, retouched or unretouched, are found in some regions. Bone points may be fashioned through several possible combinations of incision, grinding and polishing (Yellen 1998; Henshilwood *et al.* 2001a; Barham *et al.* 2002). Stylistic variation among points shows geographic patterning, often corresponding to broad paleoecological zones, suggesting regional traditions (Clark 1988, 1993; McBrearty and Brooks 2000).

Chronological change, as described below, is detected within the MSA at some locations. Variety in raw material use likewise reflects new approaches to resource procurement. Lithic source data suggest increased hominid ranging areas, with a selective shift towards finer-grained material, frequently from distant sources (Clark 1980; Merrick *et al*. 1994; Raynal *et al*. 1995). Similarly, MSA sites occur in a number of previously unoccupied, often water-poor environments, with a sophisticated strategy of landscape use implied by occupation of ecotones to maximize resource access (Helgren 1997; Ambrose 2001). Specialized hunting and fishing sites were recurrently used, possibly on a seasonal basis (Brooks *et al*. 1995; Yellen *et al*. 1995; Marean 1997; Clark 2001a; Henshilwood *et al*. 2001b).

The Sangoan and Fauresmith Industries

In Africa, the Sangoan and Fauresmith industries were at one time considered "intermediate" between the Acheulean and the MSA (Clark 1957a:xxxiii). The "intermediate" terminology was formally abandoned at the 1965 Burg Wartenstein symposium (Bishop and Clark 1967:987), but discussion of these industries remains central to understanding the Acheulean-to-MSA transition. Both the Sangoan and Fauresmith industries are poorly dated, but the Sangoan, characterized by heavy-duty tools, has been found to overlie the Acheulean and to underlie the MSA at a number of sites (*e.g.*, Cole 1967; McBrearty 1988; Clark 2001b). McBrearty (1991) and Clark (2001b) have argued for the status of the Sangoan as an independent entity, though Clark (1982) formerly regarded it as an activity variant of either the Acheulean or the MSA, and Sheppard and Kleindienst (1996) consider it part of the MSA. The Fauresmith, characterized by small, well-made handaxes, is considered a phase of the final Acheulean (Sampson 1974; Binneman and Beaumont 1992). The Sangoan has long been considered a forest or woodland adaptation, whereas the Fauresmith has been thought confined to savanna zones (Clark 1988), though this dichotomy has been questioned by McBrearty (1992; McBrearty *et al.* 1996).

Methodological Challenges

We argue here that the replacement of handaxes by points and other hafted implements is significant, but the attempt to pin down the timing and circumstances of this process suffers from a number of conceptual and practical difficulties. Chronological issues are discussed below. A serious concern is definition of the term MSA itself. As originally conceived by Goodwin and Van Reit Lowe (1929), the MSA is characterized by the absence of the handaxes of the preceding Acheulean and the absence of microliths of the succeeding Later Stone Age (LSA), and by the presence of points. The ambiguity of the term "Middle Stone Age" has long been recognized (Clark *et al.* 1966). In part this ambiguity stems from its definition as both a typological-technological unit and a temporal unit. The equation of the MSA with Clark's (1977) Mode 3 is inaccurate, as not all MSA sites exhibit Levallois technology, and some contain blades (Mode 4) or microliths

(Mode 5) (see McBrearty and Brooks 2000). Furthermore, prepared core (Mode 3) and blade (Mode 4) elements are sometimes found in Acheulean (Mode 2) contexts (*e.g.*, Leakey *et al.* 1969; McBrearty *et al.* 1996; Kuman 2001). While arguably a semantic issue, it is important to emphasize that simplified terminology (Acheulean *versus* MSA) creates the impression that the transition to the MSA was a well-defined event, rather than a process of adaptive change. Furthermore, rates of technological change, artifact discard, and sediment deposition vary independently, and our inferences about the nature of the transition are founded on rare, possibly non-representative sites scattered across time and space.

Because the definitions of Acheulean and MSA emphasize handaxes and points, a practical challenge for the archaeologist lies in the fact that many sites lack large numbers of diagnostic formal tools. In part this is due to variable recovery and preservation, but it also reflects functional and environmental factors operating in the past. Formal tools are vastly outnumbered at nearly all sites by flakes, cores, and expedient tools, and the basic flake and core artifact inventories of the Acheulean, MSA, Sangoan, and Fauresmith are in many cases indistinguishable. Many methods of direct percussion flake detachment were mastered by early hominids practicing Oldowan technology, and were retained in some cases until quite recent times, rendering them inappropriate as chronological markers (Clark *et al*. 1994; Roche *et al*. 1999). Also, some *fossiles directeurs* may not be truly temporally diagnostic. Although the handaxe and point are characteristic of the Acheulean and MSA, there may be a size continuum between them, and there are no formal criteria for distinguishing small handaxes from large bifacially flaked points. Functional approaches that may provide distinguishing criteria, such as those of breakage patterns, wear traces, and metrical features (*e.g.*, Thomas 1978; Shea 1988; Dockall 1997; Shott 1997; Hughes 1998), have not been widely applied in Africa. Although picks and other heavy-duty tools are characteristic of the Sangoan, similar tools also occur in Acheulean, MSA and even LSA contexts (Clark 2001b), and the qualities formerly thought to render Fauresmith handaxes unique may derive from physical properties imposed by the raw material (Humphreys 1970).

Despite its flaws, the *fossile directeur* approach has not yet been supplanted as a means to compare African Acheulean with MSA occurrences or MSA sites with each other. Statistical comparison of artifact class frequencies (*e.g.*, Mason 1962) has not proved fruitful. The method of Bordes (1961, *cf.* Debènath and Dibble 1994), although widely used in European and Levantine sites, relies heavily upon the presence of retouched tools, and, as mentioned previously, retouched pieces are rare or absent at many African Acheulean and MSA sites. A factor contributing to the rarity of retouched tools is the durability of the lava and metamorphic rocks available in sub-Saharan Africa, compared to the flint used elsewhere. While comparison of large cutting tools documents differences in raw material selection and artifact discard patterns between Acheulean and Sangoan assemblages at Kalambo Falls (Sheppard and Kleindienst 1996), few significant differences between Acheulean and MSA sites have been detected through comparison of flake and core metric attributes (*e.g.*, McBrearty 1981; Sheppard and Kleindienst 1996). This observation stands in contrast to the diminution in artifact dimensions through time seen within long MSA sequences such as Mumba, Klasies River, or Cave of Hearths (Sampson 1974; Thackeray and Kelly 1988; Mehlman 1989; see Brooks *et al*. this volume). Systematic comparisons of other shared tool classes, such as scrapers, are rare, although McBrearty (1986) reports differences in the degree and placement of retouch between Sangoan-Lupemban and overlying MSA horizons at Muguruk, Kenya.

The *chaîne opératoire* approach focuses upon the method, rather than the product, of stone tool fabrication (*e.g.*, Pelegrin *et al.* 1988; Boëda *et al.* 1990; Inizan *et al.* 1999; Bar-Yosef 2000:113–116). The emphasis is shifted from archaeological types to analysis of the entire process of core reduction, from raw material acquisition to eventual discard. Importantly, it does not rely on the presence of *fossiles directeurs*. Analyses of European material have shown that variability in modes of flake production and tool shaping may crosscut traditional industrial categories such as Acheulean or Mousterian (*cf.* Boëda 1991; Tuffreau *et al.* 1997). Application of the approach in Africa, however, remains rare (but see Roche and Texier 1995; Roche *et al*. 1999; Würz 2002; Pleurdeau 2003).

The Timing of Archaeological Change

The earliest dates for the African MSA are derived from the Kapthurin Formation sequence, where points predate 285,000 years BP (Deino and McBrearty 2002; Tryon and McBrearty 2002). This date is in general agreement with the age of the earliest MSA layers at Florisbad, South Africa, estimated by Electron Spin Resonance (ESR) on overlying units at ∼280,000 years BP (Grün *et al.* 1996; Kuman *et al.* 1999), but is considerably older than age estimates of 235,000 years BP from Gademotta, Ethiopia (Wendorf *et al.* 1994), and ≥230,000 years BP from Twin Rivers, Zambia (Barham and Smart 1996). The switch from handheld to hafted technology most likely did not occur at the same time everywhere, and the tradition of biface manufacture appears to have persisted later in some parts of the continent than in others (*cf.* Clark *et al*. 1994). For example, handaxes are present in the Herto Member of the Bouri Formation in the Middle Awash, Ethiopia as late as 160,000 years BP (Clark *et al*. 2003).

The MSA is replaced across most of the African continent by sites attributed to the LSA at about 40,000 years BP (*e.g.*, Ambrose 1998; McBrearty and Brooks 2000). The time span of the MSA therefore exceeds 240,000 years. However, the majority of documented MSA assemblages post-date the onset of the Last Interglacial (Oxygen Isotope Stage 5) at ∼130,000 years BP (Klein 1999; McBrearty and Brooks 2000). Our information for the preceding ∼155,000 years, or more than half the duration of the MSA, is derived from a handful of sites scattered across over 13 million km^2 of the African continent (Figure 1). Furthermore, at many localities, the Acheulean and MSA layers are separated by unconformities, and chronological resolution is generally poor (see Clark 1982; Tryon and McBrearty 2002 for recent reviews). Combined, these gaps have a clear effect on our perceptions of change. In this paper we stress the role of information from the EMSA in clarifying the situation.

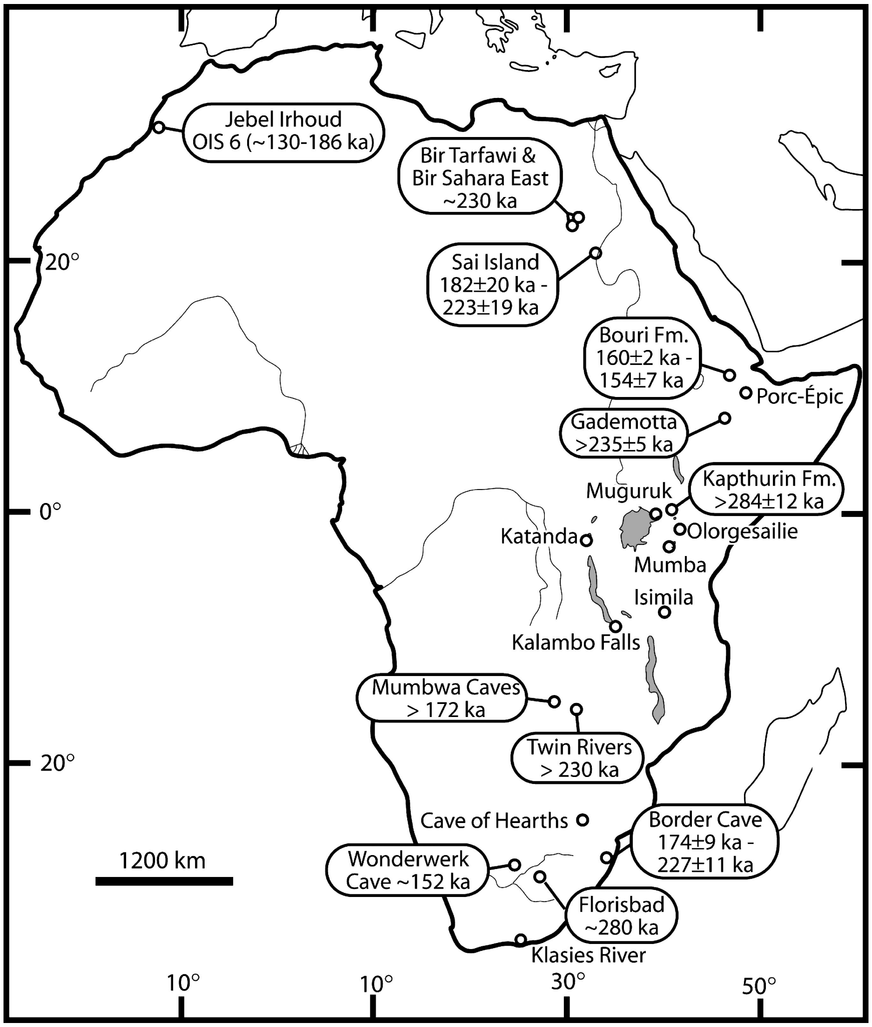

Figure 1. African archaeological sites discussed in the text. Radiometric age estimates shown for all Early Middle Stone Age (EMSA) sites. Data from Barham (2000), Barham and Smart (1996), Clark *et al.* (2003), Deino and McBrearty (2002), Grün and Beaumont (2001), Grün *et al.* (1996), Hublin (2001), Kuman *et al.* (1999), Van Peer *et al.* (2003), Vogel (2001), Wendorf *et al.* (1993, 1994).

Regionalization in artifact traditions (Clark 1988), as well as change through time, can be seen in the latter half of the MSA, but due to the lack of data for the EMSA we can only speculate about when they began. Regionalization of MSA lithic industries results in different trajectories of change in each area. For example, the South African Later Pleistocene MSA (LMSA) succession, based largely upon the sequence at Klasies River, illustrates a number of quantitative and qualitative changes. These include trends towards shorter, wider flake-blades (*e.g.*, Thackeray and Kelly 1988), variation in raw material choice, and a succession of different methods of flake, blade, and point production. These methods vary in the means of preparation of the core's flaking surface, the volume of the core exploited, and the degree of tool retouch (Würz 2002). The Kalambo Falls (Zambia) sequence shows the incremental addition of blades and diverse point forms from early to late MSA (Clark 2001b). In contrast, Porc-Épic Cave in Ethiopia shows a high degree of technological variability within each stratigraphic unit, but reveals no clear trend through its long, essentially undated sequence (Pleurdeau 2003). Few generalizations can be made from these data about the nature of temporal variation on a continent-wide scale or when and how this regionalization first appeared. There is some indication that local traditions of flake and tool manufacture already existed among late Acheulean sites. This phenomenon is suggested by the presence of geographically restricted methods of large flake production at some Acheulean sites, including the Tabelbala-Tachengit method of the northwestern Sahara (Tixier 1957; Alimen and Zuarte y Zuber 1978), the *hoenderbek* cores and flakes found in South Africa (McNabb 2001), and blades and large Levallois cores in the Kapthurin Formation (Leakey *et al*. 1969; McBrearty 1999). What is required to resolve these issues is documentation of well-calibrated EMSA sequences that can be compared with known Acheulean and LMSA occurrences.

THE KAPTHURIN FORMATION

The Geological and Archaeological Sequence

Our data from the Kapthurin Formation are critical to addressing these issues of hominid behavioral change. The deposits span much of the Middle Pleistocene, contain a succession of archaeological sites chronologically ordered by tephrostratigraphy, and demonstrate considerable diversity in hominid adaptations in the use of a variety of shaped or retouched tools and flake production strategies. The formation also spans the Acheulean-to-MSA transition, and includes EMSA sites. Some stratigraphic levels preserve multiple archaeological sites that make it possible to assess contemporaneous inter-assemblage variability. These factors allow us to examine the nature of behavior in the MSA, especially EMSA, and to compare it with behavior seen in the Acheulean.

The Kapthurin Formation forms the Pleistocene portion of the sedimentary sequence in the Tugen Hills in the Kenya Rift Valley west of Lake Baringo (Figure 2). The formation is about 125 m thick and is exposed over an area of about 150 km^2. More than 70 archaeological and fossil sites are now documented in the formation (Leakey *et al.* 1969; Cornelissen *et al.* 1990; Cornelissen 1992; McBrearty *et al.* 1996; McBrearty 1999, 2001; Tryon 2002). The basic stratigraphic succession as defined by Martyn (1969) and Tallon (1976, 1978) includes three fluviolacustrine members (K1, K3, and K5) separated by two major tephra members, the Pumice Tuff Member (K2), and the Bedded Tuff Member (K4). An additional, unnumbered

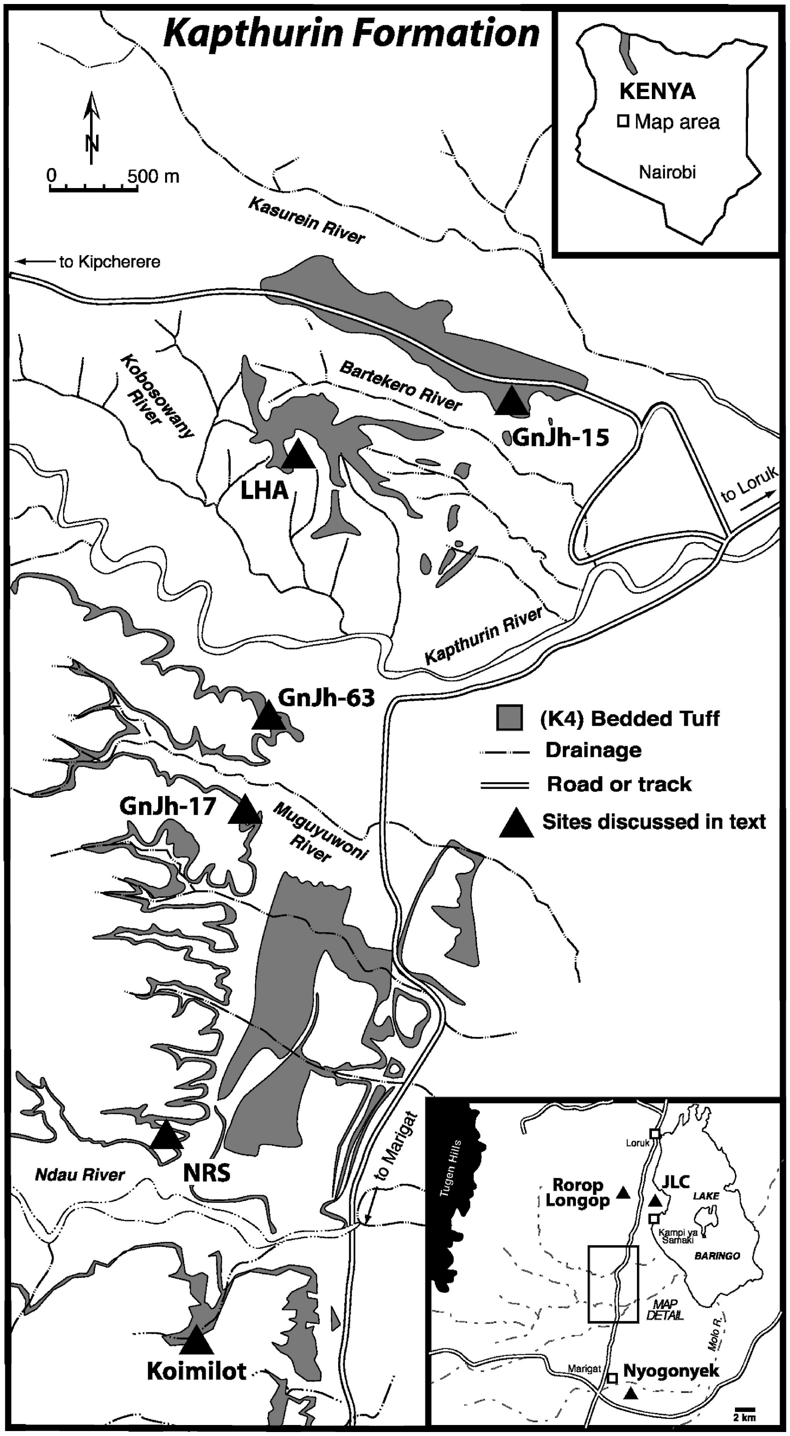

Figure 2. Map showing exposures of the Kapthurin Formation Bedded Tuff Member and the sites discussed in the text.

tephra, the Grey Tuff, lies within K3. Three additional lavas, the Upper and Lower Kasurein Basalts and the Baringo Trachyte, are intercalated with Kapthurin Formation sediments. These volcanic units have now been successfully dated by $^{40}Ar/^{39}Ar$, using both incremental heating of multi-grain samples with a broad-beam CO_2 laser (LIH method), and fusion of individual phenocrysts by laser in a single step (SCTF method) (Deino and McBrearty 2002).

Materials relevant to the Acheulean-to-MSA transition lie above the Grey Tuff, dated to 509,000 ± 9,000 years BP, and within and immediately below the Bedded Tuff Member (K4). The Bedded Tuff Member is a complex of tephra horizons deposited during a period of intermittent volcanism. Intercalated sediments, incipient paleosols, and root casts mark former stable land surfaces upon which assemblages of artifacts and fossil fauna accumulated. On a macro scale, defining these ancient land surfaces and comparing archaeological sites is accomplished using the widespread bracketing layers of tuff. However, it can be problematic to establish stratigraphic relations among sites within K4 exposed over a large area of heavily eroded topography by field mapping alone, and geochemical analysis was used as a basis for tephrostratigraphic correlation among disparate Kapthurin Formation outcrops (see Figure 2) (Tryon and McBrearty 2002; Tryon 2003).

Individual tephra units of the Bedded Tuff Member (K4) were analyzed both petrographically and geochemically with a wavelength dispersive electron microprobe. The Bedded Tuff Member consists of two distinct lithologies: (1) widespread beds of fine-grained mafic ash, overlain by (2) sparse deposits of felsic, locally pumiceous material. Stratigraphic and geochemical trends suggest that the Bedded Tuff Member deposits derive from a single volcanic source that underwent progressive magma compositional change. Periods of quiescence were punctuated by multiple, brief eruptive events. These trends provide a robust correlation tool for tephra deposits and associated sites within the formation (Tryon and McBrearty 2002). $^{40}Ar/^{39}Ar$ age estimates of 235,000 ± 2,000 and 284,000 ± 12,000 years BP from two layers of an upper, pumiceous unit (Deino and McBrearty 2002) date the latest eruptive phases of the Bedded Tuff Member. Most archaeological sites associated with the Bedded Tuff Member occur within, beneath, or immediately above beds of the lower, basaltic ash, which lack material suitable for $^{40}Ar/^{39}Ar$ dating. The date of 284,000 ± 12,000 years BP on the upper, pumiceous unit of K4 at the NRS sampling locality therefore provides a minimum age for these Kapthurin Formation Acheulean and EMSA sites (Figure 3).

Stratigraphic ordering of Kapthurin Formation sites through tephra correlation demonstrates the interstratification of sedimentary units containing Acheulean, Sangoan, Fauresmith, and MSA artifacts (see Figure 3). These findings show that the Acheulean-to-MSA transition predates 284,000 ± 12,000 years BP in this part of the Rift Valley, and that it was not a simple, unidirectional process (Tryon and McBrearty 2002). Instead, this record may represent competition among a number of hominid groups with different technological traditions, or the presence of hominids with broad technological competence responding to differing local contingencies.

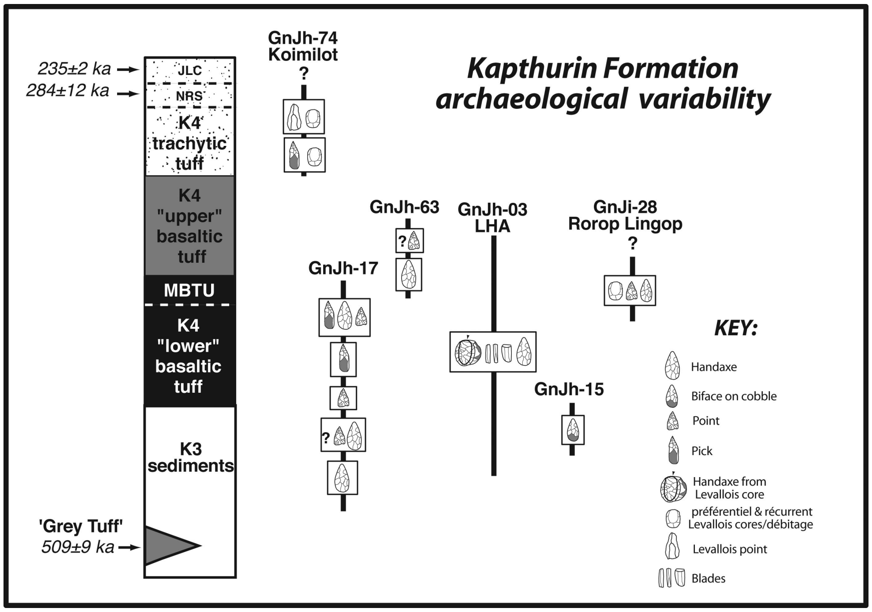

Figure 3. Schematic diagram showing stratigraphic relationships of archaeological assemblages in the Kapthurin Formation, emphasizing typological and technological variability among later Middle Pleistocene sites containing diagnostic artifacts. Modified from Tryon and McBrearty (2002).

Interpretation of the Kapthurin Formation Sequence

Our comparative analysis of Kapthurin Formation site function is in its very early stages. Most presently known Kapthurin Formation sites appear to have been flake production sites. Retouched tools are rare. Plausible sources of the fine-grained lava cobbles that were used for flake production in many cases lie within a few hundred meters of the sites, and exotic raw materials are infrequent.

We examine change through time here by comparing sites from two stratigraphic intervals, the portion of Middle Silts & Gravels Member (K3) above the Grey Tuff, and the overlying Bedded Tuff Member (K4) (see Figure 2). Late Acheulean and EMSA sites are most numerous in the Middle Silts & Gravels Member above the Grey Tuff. One element common to all these sites is a simple flake and core component, characterized by discoidal and opportunistically flaked single and multiple platform cores. In some excavated assemblages, such as the upper paleosol at GnJh-17, these are the only methods of flake production present. Other sites contain additional distinctive items. Blades, Levallois debitage, grindstones, and traces of pigment are found at site GnJh-15. At the Acheulean site of LHA (GnJh-03), large (∼10–20 cm) Levallois flakes were struck by the *préférential* method from centripetally prepared boulder cores and sometimes retouched into handaxes or scrapers. Several refitted series from LHA show regular blade production by both Levallois and non-Levallois methods (Leakey *et al.* 1969; Texier 1996; McBrearty 1999). At site GnJh-52, split lava boulders and cobbles were transformed into scrapers or cores. In the upper paleosol from site GnJh-17, picks or core-axes and scrapers were manufactured from elongated cobbles, as shown by extensive refitting (Cornelissen 1992).

The overlying Bedded Tuff Member (K4) contains fewer sites, but they too show great variety. All share the simple flake and core component seen at K3 sites, but most feature additional distinctive elements. For example Rorop Lingop (GnJi-28) contains small Levallois cores, diminutive handaxes reminiscent of the Fauresmith, and rare points. Site GnJh-63 preserves a single handaxe together with an industry based on the flaking of small cobbles by a number of methods, including bipolar flaking. Recent excavations at Koimilot (GnJh-74) have produced an assemblage containing *préférentiel* and *récurrent* Levallois cores with centripetal preparation, including refitted cores and flakes and an implement resembling a pick or core-axe. This assemblage is overlain by a horizon characterized by large (∼10 cm) unretouched Levallois points or elongated flakes with a dorsal scar pattern suggesting predominantly unidirectional flaking during core preparation (Tryon 2002, 2003). Two additional sites, Nyogonyek (GoJh-1) and Locality 92, contain large amounts of Levallois flakes and cores, and few if any formal retouched tools, though their precise position in the stratigraphy is as yet unresolved.

In summary, Acheulean and EMSA assemblages in the Kapthurin Formation show variation both among contemporary sites and through time. However, a Levallois concept of flaking is present in each, suggesting a shared technological tradition. There is a reduction in size of the Levallois flakes through time, and an increase in the variety of the flake production methods (*cf*. Van Peer 1992; Böeda 1994; Inizan *et al.* 1999). Furthermore, items usually thought characteristic of later prehistory, such as blades, grindstones, and pigment, occur in the Middle Silts and Gravels Member of the Kapthurin Formation where they predate 285,000 years BP.

HUMAN EVOLUTIONARY CONTEXT

Behavioral Change

It has been repeatedly asserted that MSA toolmakers lacked cognitive sophistication, and that a late, sudden genetic mutation at 40,000 to 50,000 years ago explains the modern behavior seen in the LSA (*e.g.*, Diamond 1992; Klein 1992, 1995, 1998; Mithen 1994; Mellars and Gibson 1996; Klein and Edgar 2002). But many behaviors once thought to postdate 40,000 years ago are in fact found in the MSA. These behavioral advances include blade and microlithic technology, formal bone tools, increased geographic range, specialized hunting, the use of aquatic resources, long-distance trade or transport of raw materials, systematic processing and use of pigment, art and decoration, and the habitation of previously unoccupied water-poor environments (Deacon and Deacon 1999;

Klein 1999; McBrearty and Brooks 2000; Henshilwood *et al.* 2002). The evidence that we have discussed here shows that some of these technological innovations appeared as early as the late Acheulean. Thus the record of behavioral change commenced at or immediately before the Acheulean-MSA boundary, and continued to accumulate over the entire time span of the MSA. This evidence leads to the conclusion that hominids living as early as 250,000–300,000 years ago possessed the cognitive and technical ability to invent sophisticated items of material culture. The Acheulean-to-MSA transition marks the beginning of an increasingly complex hominid adaptive pattern, the archaeological signature of expanding hominid populations who developed diversified tool kits as a means of coping with novel problems. Hominid postcranial remains from this period show a mosaic of modern and archaic features, indicating that some patterns of modern positional, locomotor, and manipulative behavior are present by 300,000 BP and probably earlier (Pearson 2000; Fisher and McBrearty 2002). It is very likely that technological changes at the Acheulean-to-MSA transition are intimately linked to these anatomical changes.

Taxonomic Issues

The central unresolved issue in understanding the Acheulean-to-MSA transition is the taxonomic identity of the hominids responsible for the formation of the Middle Pleistocene archaeological record. Evidence from both nuclear and mitochondrial DNA strongly supports an African origin for *H. sapiens* (Howell 1999; Relethford 2001; Tishkoff and Williams 2002). Most investigators include African hominid fossils predating ∼500,000, such as Bodo (550,000–650,000 BP), Ndutu (500,000–600,000 BP), and Saldhana (400,000–800,000 BP), in *H. erectus*, but opinion is divided as to the status of other, perhaps slightly later specimens, such as Kabwe (>400,000 BP), for which the names *H. heidelbergensis* or *H. rhodesiensis* are used. The oldest securely dated specimens formally ascribed to our species are the three crania from the Herto Member of the Bouri Formation in the Middle Awash region of Ethiopia, dated to ∼160,000 years BP, attributed to the subspecies *H. sapiens idaltu* (White *et al.* 2003). Other early African representatives of *H. sapiens* predating 100,000 include Omo I from the Kibish Formation, Ethiopia, and the sample from Klasies River, South Africa (see McBrearty and Brooks 2000, for a review of the fossil and dating evidence). For the purposes of understanding the Acheulean-to- MSA transition, the taxonomic identity of specimens dating to ∼200,000–300,000 years BP are critical. Lahr (1996; Lahr and Foley 1998) sees some of the African fossils, including Florisbad (260,000 years BP) and Ngaloba, as representing a distinct species, *H. helmei*, but Stringer (1996, 2002) sees this group as subsumed under *H. sapiens,* though perhaps representing a somewhat archaic form. If specimens of *H. helmei* in fact represent early *H. sapiens,* then our species appeared simultaneously in Africa with MSA technology between 250,000 and 300,000 years BP.

Discussion

Historically the divide between the Acheulean and the MSA was an arbitrary distinction for the convenience of archaeologists (Goodwin and Van Riet Lowe 1929). If the appearance of the MSA and the *H. sapiens* lineage coincide, however, then the Acheulean-to-MSA transition acquires evolutionary significance. Early *Homo* is assumed to be the maker of Oldowan artifacts, and *H. erectus* is thought to be the maker of Acheulean tools because the first appearances of the hominids in the fossil record roughly coincides with that of the artifacts. In similar fashion, members of early *H. sapiens* were no doubt the makers of some Middle Pleistocene assemblages. Speciation assumes separation of populations that formerly belonged to the same reproductive community. The resulting daughter species may coexist in time with the ancestral stock for a considerable period. We can expect these close relatives to share many features of behavior in common, and thus to produce similar archaeological traces (*cf.* Lieberman and Shea 1994). Technological innovation also builds upon existing knowledge, and primitive forms often survive together with newer inventions. Populations of *H. rhodesiensis* may have survived well into the late Middle Pleistocene and created a body of archaeological remains, and we are at present often unable to assign assemblage to maker with any certainty. Our challenge is to detect the signature of the emerging adaptation of early *H. sapiens.*

CONCLUSIONS

The Acheulean-to-MSA transition is a large scale behavioral change that is significant when viewed in an evolutionary context. If, as seems very likely, fossils dating to 200,000–300,000 years BP are in fact early representatives of *H. sapiens,* then the origin of our species occurred simultaneously with the appearance of MSA technology. Linking technological and evolutionary change requires information from the EMSA, which is at present poorly known. Some of the hallmarks of the MSA are seen first in the late Acheulean of East Africa, where they probably represent the behavior of the ancestors of *H. sapiens.* Blades, grindstones, and pigment, for example, appear in the Kapthurin Formation before 285,000 years BP. Technological innovations can be seen as the causes or consequences of anatomical changes that reflect new habitual positional, manipulative, or locomotor behaviors. Reconsideration of the MSA itself reveals evidence of sophisticated behaviors previously thought to appear much later in time during the LSA. The items of material culture known to the LSA hunting and gathering groups required time to invent. The Acheulean-to-MSA transition, marked by new stone tool technology, is among the first visible signs in a record of continuous behavioral development in the African Middle Pleistocene that continued to accumulate over the course of the next 250,000 years.

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