Reports

“Early” Middle Stone Age Lithic Technology of the Kapthurin Formation (Kenya)

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The production of Levallois flakes is considered a hallmark of many Middle Stone Age (MSA) sites, but this aspect of African Pleistocene hominin technology remains poorly documented relative to that from adjacent regions. The site of Koimilot, from the Kapthurin Formation of Kenya, preserves stratified artifact assemblages that show use of multiple Levallois methods to produce flakes of varied shapes and sizes, comparable to that described from Levantine and European Middle Paleolithic sites. Koimilot has an age of ∼200,000 years on the basis of geochemical correlation with dated volcanic tephra and therefore joins a small but growing number of “early” MSA sites which antedate the last interglacial (∼130,000) years ago and provide the most relevant comparisons for understanding the end of the Acheulian. The Kapthurin Formation archaeological sequence suggests that it is the diversification of Levallois technology rather than its origin that characterizes early MSA assemblages. MSA Levallois technology may have developed from local Acheulian antecedents.

The end of the Acheulian and the beginning of the Middle Stone Age (MSA) reflect the most important later Middle Pleistocene archaeological event in Africa (Clark 1999; McBrearty 2001; Tryon and McBrearty 2002). Acheulian sites are typologically defined by the presence of large cutting tools (handaxes, cleavers, and knives). These are replaced at MSA sites by smaller stone and bone points, presumably hafted as composite tools, and more frequent use of various Levallois methods of flake production. These shifts in artifact type and technology, which first occurred ∼250,000–300,000 years ago, underlie more profound changes. The end of the Acheulian marks the end of a highly successful, relatively stable hominin behavioral adaptation that persisted for over a million years throughout much of the Old World (e.g., Petraglia and Korisettar 1998). MSA sites record hominin expansion into new habitats, increased foraging range, selection for finer-grained raw materials from increasingly distant sources, geographic patterning in artifact styles, a broadened dietary base, use of sophisticated hunting techniques, and early evidence for symbolic representation (see McBrearty and Brooks 2000; Henshilwood and Marean 2003 for recent reviews). These behavioral innovations are significant because of their broad temporal and geographic coincidence with the origin of *Homo sapiens* as this is currently understood (Howell 1999; Lahr and Foley 1998; McBrearty and Brooks 2000; McDougall, Brown, and Fleagle 2005; Tishkoff and Williams 2002; White et al. 2003). The relations and timing of these biological and behavioral changes are therefore a central issue for the origin of our species.

Unfortunately, the Acheulian-MSA transition is poorly understood, in part because most MSA sites are Later Pleistocene in age (Klein 1999; McBrearty and Brooks 2000), substantially more recent than the youngest Acheulian sites. To call attention to this bias in the available evidence, McBrearty and Tryon (2005) identify an “early” Middle Stone Age that includes sites that date to the Middle Pleistocene, that is, >130,000 years ago, and are therefore more relevant to understanding the transition. The rarity of such sites potentially exaggerates behavioral contrasts between Acheulian and MSA hominins and confounds our attempts at understanding the precise relationship between the technological changes initiated at the end of the Acheulian and biological changes within the *Homo* lineage. My goal in this paper, complementing previous studies of the complex record of the Acheulian-MSA transition in the Kapthurin Formation of Kenya (Tryon and McBrearty 2002, n.d.), is to describe the methods of flake production at the early MSA site of Koimilot. I focus on flake production because this approach has been shown to be an effective means of isolating local trajectories of technological change in MSA artifact industries, which frequently lack the retouched tools necessary for most typological analyses (Wurz 2002). I emphasize Levallois flakes and cores because they are considered a hallmark of many MSA industries (Clark 1988). However, Levallois technology has not been the subject of the same level of detailed study at African sites as at European and Levantine Middle Paleolithic ones (but see Pleurdeau 2003; Van Peer 1998), where there is demonstrable geographic and temporal patterning in the production methods and morphologies of Levallois flakes, blades, and points (Bar-Yosef 2000; Boëda 1994; Inizan et al. 1999; Tuffreau 1995). Data from Koimilot are used to construct a framework for changes in lithic technology that can be used to address other later Middle Pleistocene hominin adaptations.

Koimilot Age and Context

Koimilot (GnJh-74) is one of numerous Acheulian and Middle Stone Age sites from the Kapthurin Formation, sediments of which crop out west of Lake Baringo, in the central Rift Valley of Kenya (fig. 1). The Kapthurin Formation also pre-

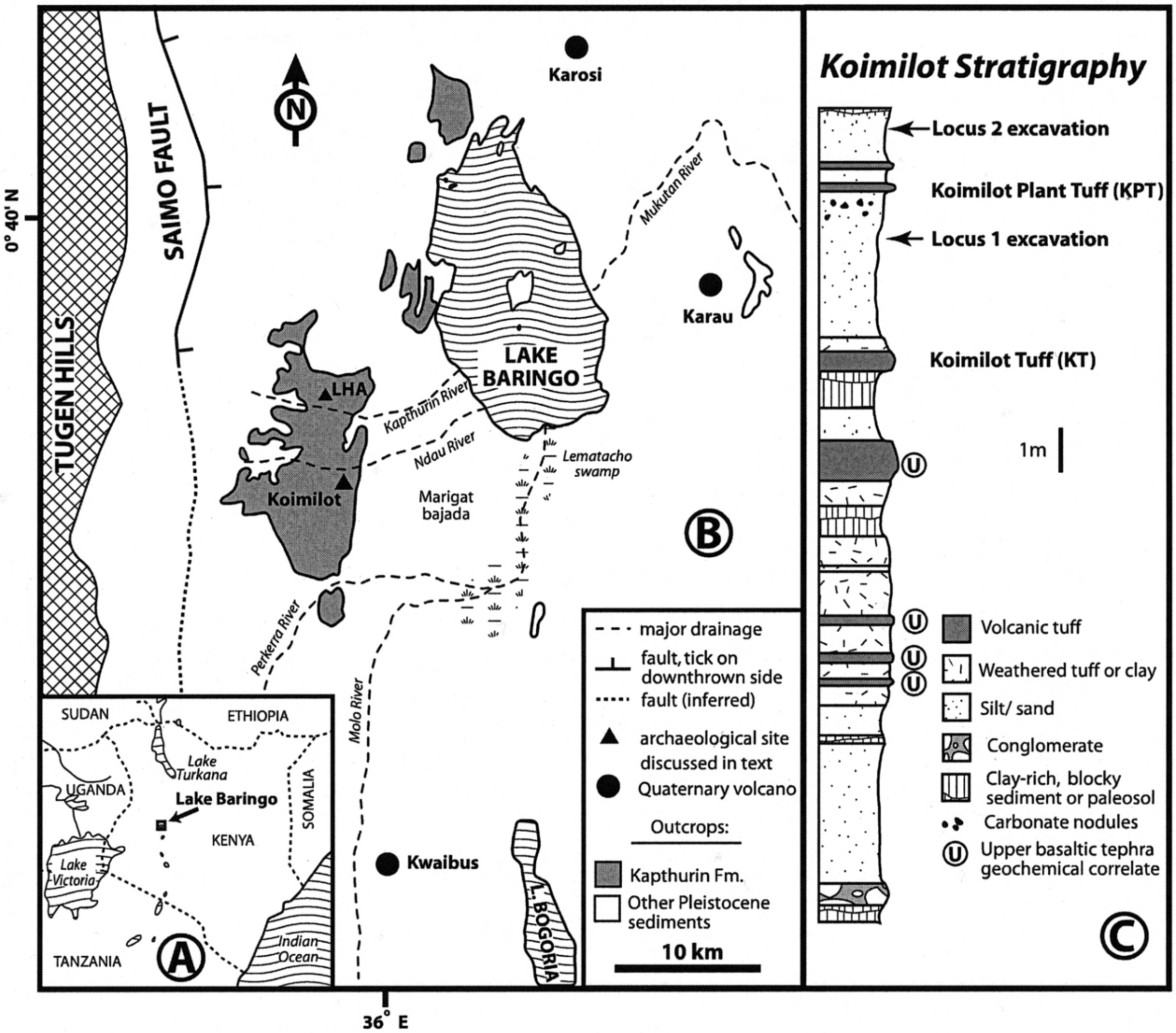

Fig. 1. Inset map (*A*) and detail (*B*), showing location of Koimilot and other Kapthurin Formation sites discussed in the text, and (*C*) schematic stratigraphic section of Koimilot.

serves a diverse fauna that includes hominin mandibles and postcrania recently attributed to *Homo rhodesiensis*, as well as the first chimpanzee fossils, in a sequence dated by multiple $^{40}Ar/^{39}Ar$ age determinations to ∼250,000–550,000 years ago (Deino and McBrearty 2002; McBrearty 1999; McBrearty and Brooks 2000; McBrearty and Jablonski 2005; Tallon 1976, 1978).

Excavations at Koimilot in 2001–2 revealed two spatially segregated, stratified archaeological components (Tryon 2002, 2003). Both Locus 1 and the younger Locus 2 overlie a >20-m-thick succession of volcaniclastic, alluvial fan, and possibly lacustrine sediments of the Bedded Tuff Member (fig. 1). Artifacts occur in sediments that represent different facies of a distal-alluvial-fan depositional environment near a fluctuating lake shoreline. The vicinity of the site during these occupations probably differed little from the area west of Lake Baringo today. The Locus 1 excavated assemblage consists of 3,782 artifacts from a single ∼10-cm-thick layer exposed in a 38-m^2 excavation. Artifacts occur immediately beneath portions of a weakly expressed paleosol that developed on poorly sorted, sheetflood-deposited sands. In addition, 251 artifacts were collected from the surface at Locus 1, with some surface-recovered artifacts refitting with excavated material. Lithic debitage clusters of different raw-material types, multiple refitting artifact sets, and a lack of evidence for size-sorting suggest a high degree of spatial integrity, with archaeological deposits interpreted as the result of a succession of brief occupations (Tryon 2003). At Locus 2, a 26-m^2 excavation produced 310 artifacts, and 33 artifacts were found at the surface. Excavated artifacts occur in coarse sands and sand-supported pebble conglomerates, apparently conforming to relict channel margins within a palaeotopographic low. The assemblage has been winnowed, but the presence of refitting debitage sets and the fresh state of the artifacts suggests only limited transport.

Electron microprobe geochemical analysis of the Koimilot tephra allows integration into the established succession of Bedded Tuff Member volcaniclastic deposits (Tryon and McBrearty 2002). The results, described in detail elsewhere (Tryon 2003; Tryon and McBrearty n.d.), show that both archaeological loci at Koimilot overlie tephra that are geochemical correlates of upper basaltic portions of the Bedded Tuff Member. All other known sites occur beneath the upper basaltic portions of the sequence. Koimilot is therefore the youngest excavated site from the Kapthurin Formation, extending the existing archaeological succession. The "Koimilot Tuff" is a locally distinct marker bed that may allow future correlation with other Pleistocene depositional basins. Its grain size and chemical composition suggest derivation from a distant source. The "Koimilot Plant Tuff" that stratigraphically lies between the Locus 1 and Locus 2 excavations contains basaltic glass shards geochemically comparable to those intermixed within both trachytic deposits $^{40}Ar/^{39}Ar$-dated to 28,400 ± 12,000 and 235,000 ± 2,000 years ago by Deino and McBrearty (2002). This suggests its eruption and deposition immediately prior to or concurrent with the later trachytic eruptive phases of the Bedded Tuff Member (Tryon 2003; Tryon and McBrearty n.d.). On this basis, an age of ~250,000 years ago is estimated for Koimilot, pending confirmation by future isotopic dating. Minimum age estimation is rendered difficult by a lack of datable overlying sediments. However, the termination of Kapthurin Formation sedimentation and the onset of the current erosional regime is defined by a major faulting episode. Recent U-series age estimates of ~198,000–345,000 years ago on thermal silica in-filled cracks within lavas related to this faulting are consistent with a later Middle Pleistocene age for Koimilot (Le Gall et al. 2000; Tallon 1976).

Lithic Technology at Koimilot

The artifacts >3 cm in maximum dimension from the Locus 1 excavation include complete flakes, flake fragments including angular debris, cores, core fragments, and split cobble fragments, hammerstones, and a single shaped implement (table 1, fig. 2). The lithic assemblage consists of at least ten lithologically distinct types of fine-grained trachyphonolitic lava with sparse phenocrysts ≤ 2 cm. Rounded ~10–20-cm clasts of these and other lavas occur in conglomerates that crop out within 50 m of the site. Cobble-dominated bars and thalwegs in stream channels, now exposed as conglomerates, served as a locally available raw-material source at Koimilot. Comparison of thin sections shows that both Koimilot artifacts and adjacent cobble deposits are petrographically comparable to lavas that crop out ~15–20 km upstream from the site in the Tugen Hills (e.g., Chapman 1971; Tryon 2003). The groundmass grain size of some of the archaeological material overlaps with that of some varieties of chert or flint and suggests deliberate selection for fine-grained, homogeneous raw material.

Table 1. Excavated Artifacts from Koimilot Locus 1 and Locus 2, following a Nested Classification Scheme Based on Isaac, Harris, and Kroll (1997)

	Locus 1 (n = 1,412)	Locus 2 (n = 310)
Detached pieces		
Flakes	235	65
Flake fragments	1,125	236
Flaked pieces		
Casual cores	12*	0
Platform cores	2	2
Radial cores	10	4
Misc. core fragments	8	3
Shaped tools	1	0
Pounded pieces		
Hammerstones	4	0
Unmodified stones	15	NC

Note: The Locus 1 total does not include 2,370 sieve-finds < 3 cm in maximum dimension. NC = not collected; *includes 9 split cobble fragments. Totals are revised from Tryon (2003) and include a larger sample.

The split cobbles and casual cores (the latter defined by < 5 flake removals [after Isaac 1977]) demonstrate initial phases of cobble testing and discard at Locus 1. Other evidence suggests preservation of extended knapping episodes of some of these locally procured cobbles. This includes the presence of hammerstones and cortical "first flakes" or *entames* (Tixier 1974) and the retention of typical stream cobble cortex on flakes and flake fragments in proportions comparable to experimental artifact replications (22.61%) (e.g., Bradley and Sampson 1986; Geneste 1985, 170–270).

I divide the remainder of the cores into two broad categories. Platform cores show flake removals from single or multiple striking platforms, often with little or no preparation, with steep flake-removal angles that may approach 90° (Conard et al. 2004 Mehlman 1989). Radial or centripetal cores (defined after Kuhn 1995), are typically oval in plan view, with invasive flake removals directed toward the center from all or part of the circumference of the piece; striking-platform preparation is variable. Radial cores may have one or two flake removal surfaces; surfaces on bifacial cores are often asymmetrical, typically with biconvex or biconical cross sections. I subsume centripetally flaked Levallois cores and discoidal cores from Koimilot as radial core subtypes (see Mourre 2003), in part to simplify comparison with similar cores that form a common component of many African Pleistocene assemblages (e.g., Clark 2001; Isaac 1977) but also to emphasize the difficulty in distinguishing from discarded cores alone what may have been different approaches to flake production (e.g., Marks and Volkman 1987).

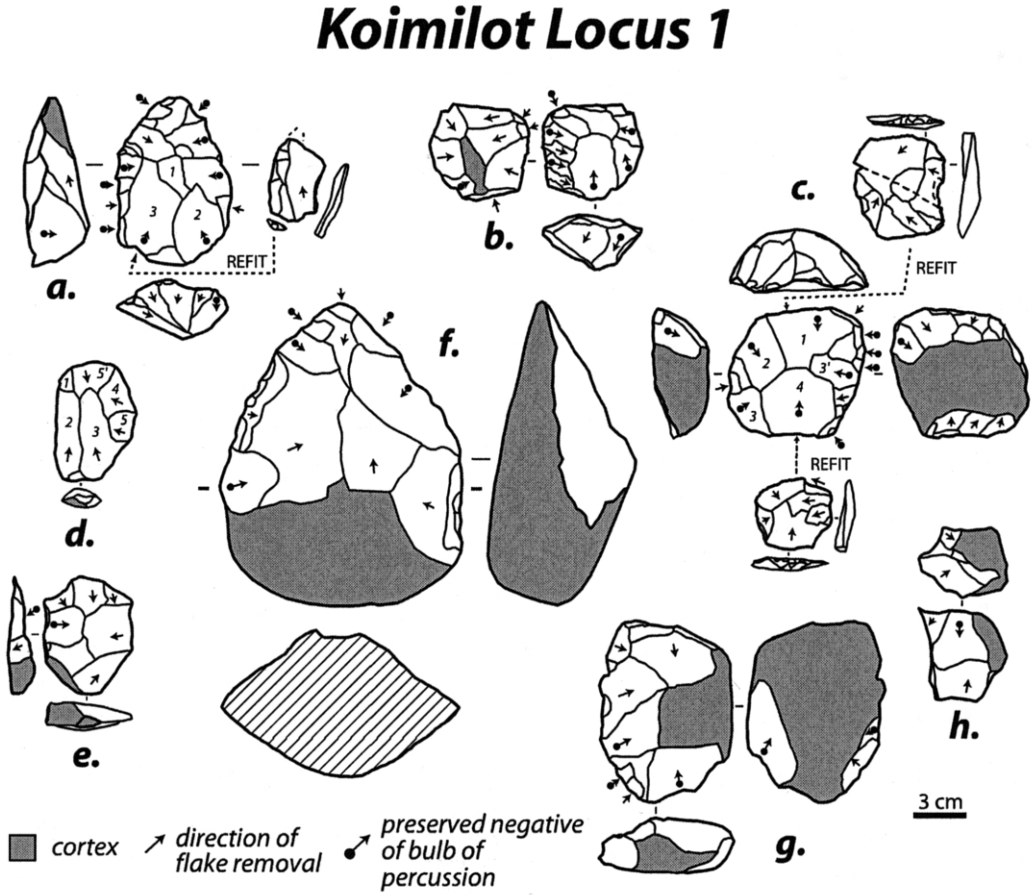

Fig. 2. Artifacts from Koimilot Locus 1, including centripetally prepared Levallois cores and refitted flakes (*a, c*), a preferential Levallois core (*b*), a Levallois flake produced by the recurrent method (*d*), an *éclat débordant a dos limité* (*e*), a pointed uniface (*f*), a Levallois core discarded during the initialization phase (*g*), and a multiplatform core from opportunistic exploitation of an irregular chunk (*h*). All Locus 1 artifacts are from the excavated sample, and all are of fine-grained lava. Numbers indicate order of flake removal where determinable. Arrows show the direction of flake removal and presence or absence of the negative of the bulb of percussion. Blank scars are those for which flake removal orientation is unclear.

Two platform cores from Locus 1 show opportunistic exploitation of unprepared striking platforms on irregular chunks (fig. 2, *h*). Radial or centripetal cores are the more numerous type. Seven of the radial cores result from application of preferential and recurrent Levallois methods (as defined by Boëda 1994; Inizan et al. 1999; Van Peer 1992) for the production of single or multiple Levallois methods per prepared surface, respectively (fig. 2, *a–c*). Such cores are distinguished by asymmetrically convex opposed flaking surfaces, the maintenance of lateral and distal convexities on an "upper" flaking surface opposite a cortical base, and refitting Levallois flakes with faceted platforms (fig. 2, *a, c,* d). Some radial cores show a discoidal approach (see Boëda 1993), whereas others likely result from a Levallois approach but were discarded during an early initialization phase (fig. 2, *g*). Also recovered were core-trimming flakes (pseudo-Levallois points or *eclats débordants a dos limité* [Meignen 1996]) that preserve a portion of the former core margin along the lateral edges, reflecting a centripetal pattern of flaking during core reduction (fig. 2, *e*).

Dorsal scar patterns and platform attributes from the analyzed complete flake sample support observations from cores and refitted flakes (table 2). Most flakes have either simple dorsal scar patterns or plain platforms not specific to any flake production method. Relatively high proportions of flakes with subradial and radial scar patterns (29.73%) and flakes

Table 2. Attribute Data for *In Situ* Complete Flakes from Koimilot

	Locus 1		Locus 2	
	n	%	*n*	%
Platform type				
Cortical	25	11.26	6	9.52
Plain	128	57.66	32	50.79
Dihedral	58	26.13	18	28.57
Faceted	8	3.60	6	9.52
Other	3	1.35	0	0
Total	222	100.00	63	100.00
Dorsal scar pattern				
Cortical/plain/simple	137	61.71	31	49.21
Radial and subradial	66	29.73	25	39.68
Convergent	8	3.60	3	4.76
Other	11	4.95	4	6.35
Total	222	100.00	63	100.00

Note: Striking-platform types as defined by Inizan et al. (1999); dorsal scar pattern categories adapted from Isaac (1977). Totals are revised from Tryon (2003) and include a larger sample.

with dihedral and faceted platforms (29.73%) are consistent with experimentally produced flake assemblages from centripetally prepared Levallois cores (e.g., Boëda and Pelegrin 1979).

A single shaped implement was recovered from Locus 1. Termed a "pointed uniface" after Villa (1983), this tool underlines the difficulty of a typological approach to hominin behavioral variability in the African later Middle Pleistocene. Following the typology of Clark (2001), the pointed uniface (fig. 2, *f*) could be classified as a pick with an untrimmed base, a core-axe, or a unifacial handaxe with an untrimmed base. Alternatively, it may be an "unfinished" handaxe discarded prior to completion or even a core (see Ashton, McNabb, and Parfitt 1992). However, the pattern of small flake removals at the tip and the bilateral symmetry of the piece (after Inizan et al. 1999), visible in cross section (fig. 2, *f*), suggest deliberate shaping. The size (∼15 cm) and weight (1.2 kg) suggest that it was a heavy-duty tool (*sensu* Clark 2001). Similar examples of shaped elongated cobbles are a characteristic feature of several other assemblages in the Kapthurin Formation (Cornelissen 1992, 1995) and may suggest affinities with the Sangoan industrial complex, found elsewhere stratified between Acheulian and MSA assemblages (Clark 1999, 2001; McBrearty 1987). However, heavy-duty tools are poorly defined in general and occur at African sites from throughout the Pleistocene and Holocene (e.g., Clark 2001; Gowlett 1999). Rather than being indicative of a particular tool industry, they may simply reflect an expedient technology that satisfies a persistent hominin need for heavy-duty tools.

The younger Locus 2 lithic assemblage consists of flakes, flake fragments, cores, and core fragments (table 1, fig. 3) made of the same raw materials found at Locus 1 but in different frequencies. This assemblage also has proportions of cortical pieces (28.95%) suggesting close proximity to cobble sources. Casual cores, split cobbles, and hammerstones, however, are all absent. Radial cores are the most frequent type in the small excavated sample. This sample includes a recurrent Levallois core with a refitting flake removed to maintain the convexity of the main flake-release surface (fig. 3, *h*). Complete flake attributes from Locus 2 suggest the predominance of centripetal flaking, with 39.68% of flakes with radial or subradial dorsal scars and 38.09% of flakes with dihedral and faceted platforms.

The Locus 2 assemblage differs from that of Locus 1 in several ways. First, one of the two platform cores has blades or bladelets removed from opposed platforms (fig. 3, *g*). Elsewhere in the Kapthurin Formation, at the Leakey Handaxe Area, blade production is a rare but notable feature of the local late Acheulian (Leakey et al. 1969; McBrearty 1999; Texier 1996). Secondly, the most conspicuous feature of the Locus 2 assemblage is the presence of five large (∼10 cm) elongated or triangular preferential Levallois flakes, two from the surface and three from the excavation (fig. 3, *a–e*). The dorsal scar pattern on these flakes indicates primarily unidirectional or convergent flaking, and their morphology is consistent with that of Levallois points. A core collected from the surface at Locality 117 (GnJh-75), ∼100 m west of Locus 2, suggests the probable means of flake production (fig. 3, *f*), although no such cores were found during excavation of Locus 2. Flake removals are primarily parallel to the long axis of the core, with the Levallois flaking surface shaped by the removal of elongated *éclats débordants* ("edge-of-core flakes" [Beyries and Boëda 1983]), probably cortically backed, from both lateral margins of the core. Such large flakes are not found in the assemblage, nor do other complete flakes show convergent or parallel scar patterns. The lack of large *éclats débordants* or similar flakes or cores and the absence of other flakes or flake fragments of raw material similar to that of the pieces illustrated in figure 3 (*a*, *c*) suggest that the large elongated Levallois flakes were manufactured elsewhere and transported to Locus 2 complete. No deliberately shaped or retouched tools were found there.

Discussion and Conclusions

The Koimilot assemblages show Levallois flake production by the preferential method and the recurrent method (*sensu* Inizan et al. 1999) from centripetally prepared cores. In addition, the Locus 2 assemblage preserves large (∼10 cm) elongated triangular Levallois flakes or points struck from cores prepared by unidirectional and convergent flaking. This demonstrates considerable variability in the methods of producing Levallois flakes of different morphologies at ∼250,000 years ago in eastern African lithic assemblages, variability comparable to that seen among European and Levantine Middle Paleolithic sites. Artifact assemblages from both loci are attributed to the MSA because of the presence of Levallois

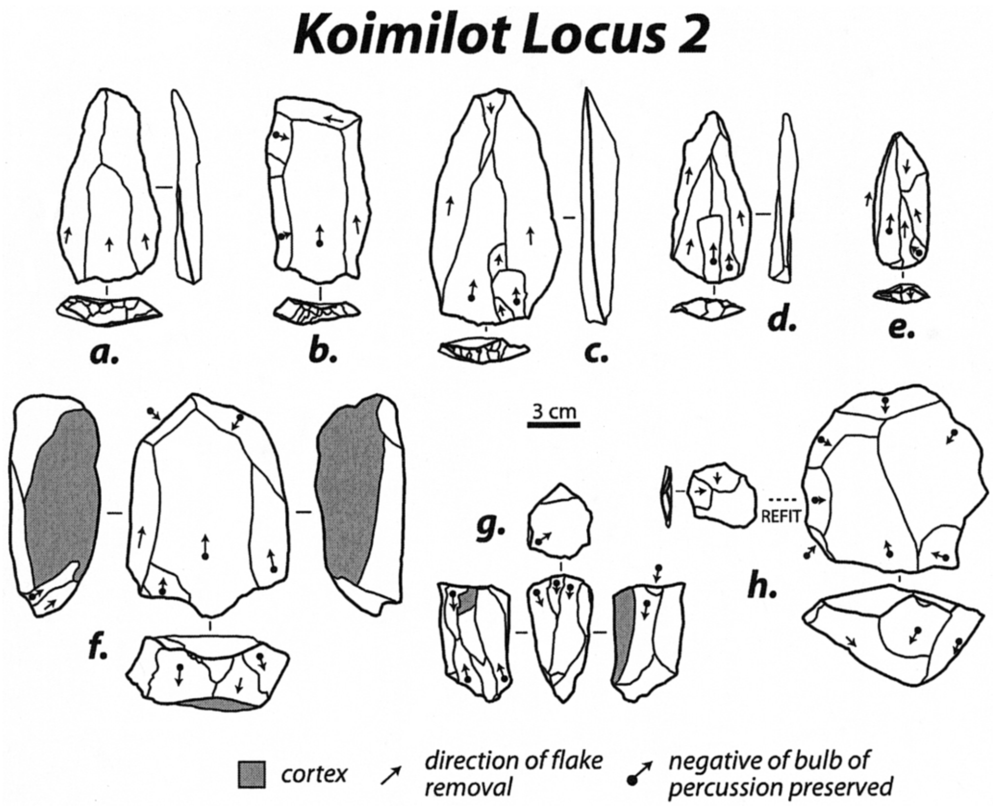

Fig. 3. Artifacts from Koimilot locus 2, including elongated preferential Levallois flakes primarily produced by unidirectional or convergent flaking (*a–e*) and a core from which such flakes were produced (*f*) from nearby Locality 117 at the same stratigraphic interval, a blade or bladelet core (*g*), and a centripetally prepared recurrent Levallois core with refitting shaping flake (*h*). Artifacts *d* and *e* are from the surface; all other Locus 2 artifacts are from excavation, and all are of fine-grained lava. Arrows show the direction of flake removal and presence or absence of the negative of the bulb of percussion. Blank scars are those for which flake removal orientation is unclear.

technology and the absence of handaxes, cleavers, or other Acheulian tools. Because of its antiquity, Koimilot is an early MSA site.

The stratigraphic position of Koimilot in the upper portion of the Kapthurin Formation archaeological succession is established on the basis of field and geochemical correlation of volcanic ash deposits (Tryon 2003; Tryon and McBrearty 2002, n.d.). Sites older than Koimilot are >284,000 years old and demonstrate the persistent manufacture of Acheulian implements after the advent of those considered characteristic of the MSA, resulting in the interstratification of handaxe- and point-bearing strata. Flake production strategies among these sites are variable, and some preserve shaped elongated cobbles comparable to the pointed uniface from Koimilot Locus 1. Koimilot is differentiated from these earlier sites primarily by the shift to a Levallois system of flake and tool blank production strategies. However, in the Kapthurin Formation, the earliest evidence for Levallois technology is found among Acheulian sites dating to ∼284,000–510,000 years ago (Deino and McBrearty 2002). Sites such as the Leakey Handaxe Area show the use of centripetally prepared, boulder-sized lava cores for the production of large (∼10–20 cm) Levallois flakes, some of which were transformed into large cutting tools such as cleavers (Leakey et al. 1969; Tryon n.d.; Tryon, McBrearty, and Texier n.d.) Thus, in the Kapthurin Formation and elsewhere, Levallois flake production is a late Acheulian phenomenon, and it is the diversification rather than the origin of Levallois technology that is the hallmark of the MSA (cf. Balout 1967; Tryon, McBrearty, and Texier n.d.).

Documenting temporal and geographic patterning in Levallois technology found at both Acheulian and MSA sites can make an important contribution to our understanding of industrial change and the origins of regionalization in the African Pleistocene record (Clark 1988; Wurz 2002). Certainly, the Kapthurin Formation evidence argues against any sudden, complete, or unidirectional change across the Acheulian-MSA transition, and similarities between methods of Levallois flake production at Koimilot and older Acheulian sites may indicate technological continuity due to the persistence of local hominin populations (Marean and Assefa 2005). However, despite the recent prominence of Levallois technology as a population marker, similarities may also be due to functional convergence (cf. Brantingham and Kuhn 2001; Foley and Lahr 1997). Numerous factors that affect lithic assemblage composition and artifact form are directly relevant to an understanding of Levallois technology and the Acheulian-MSA transition and may help to explain the patterning observed in the Kapthurin Formation. These factors are being addressed in continued research and include raw-material constraints, site or artifact function, occupation duration, and sampling bias during excavation (e.g., Rolland and Dibble 1990).

Ultimately, the study of lithic artifacts during the Acheulian-MSA transition provides the basic framework needed to initiate a broader understanding of more complex issues such as shifts in hominin subsistence, landscape use, and social behavior. Lithic technological changes throughout the later Middle Pleistocene seen at Koimilot and other Kapthurin Formation sites suggest considerable complexity within a single depositional basin (McBrearty, Bishop, and Kingston 1996), a finding echoed by studies in the Middle Awash region of Ethiopia (Clark et al. 2003) and at Sai Island, Sudan (Van Peer et al. 2003). A synthetic review of evidence from the Kapthurin Formation and elsewhere in Africa suggests the mosaic and incremental addition of novel behaviors by local hominin populations in Africa throughout the Middle and Later Pleistocene (McBrearty and Brooks 2000). The evidence considered here from Koimilot and other sites in the Kapthurin Formation extends this interpretation. In particular, the variable presence or absence of different tool types such as points, variation in the particular method used for Levallois flake production, and the existence of Levallois flakes and cores in the late Acheulian imply that this incremental pattern of change includes the very elements of lithic technology that define the Middle Stone Age.

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