



16 The Kapthurin Formation: What We Know Now that We Didn't Know Then

Sally McBrearty

Introduction and Background

In this chapter I take the opportunity to reflect upon how my conception of archaeological events in the East African Middle Pleistocene has changed in the last twenty-five years, and how David Pilbeam has influenced the evolution of my ideas. I first met David in 1979 in Nairobi where he was engaged in the reorganization of The International Louis Leakey Institute for African Prehistory (TILLMIAP). I visited the Baringo region in the Central Kenya Rift Valley on a number of occasions during the 1980s, and participated in some of the work of the Baringo Paleontological Research Project (BPRP) after Andrew Hill had assumed leadership of the project. But my own interests lay in western Kenya, where David's group had carried out work at Kanjera on the Homa Peninsula a few years earlier. My thesis research dealt with the transition from the Acheulian, thought to be made by *Homo erectus*, to the Middle Stone Age (MSA), thought to be made by *H. sapiens*, at sites around the Winam Gulf of Lake Victoria (McBrearty 1988, 1991). When I completed that research, David offered me a position at Harvard, and I had the happy experience of writing up my dissertation in his lab. The synergy in the early 1980s between David and Glynn Isaac in their efforts to integrate paleontological and archaeological data to understand human evolution has very much affected the trajectory of my subsequent work.

Desmond Clark, my undergraduate mentor at Berkeley, has exerted an equally profound influence. His 1975 paper, "Africa in prehistory: peripheral or paramount?" questioned the Eurocentric framework then universally applied to the interpretation of world prehistory (Clark 1975). He questioned the view of Africa as a "cultural backwater," a place well off the main stage in cultural innovation, always an importer of ideas conceived elsewhere. Subsequent years have seen

this picture turned completely on its head, as we now interpret human evolutionary history as a succession of species and innovations arising in Africa, and spreading beyond Africa in a series of waves of migration.

Critical to establishing Africa's central role in later human evolution was establishing an accurate chronology for events on the continent. Ironically, Desmond's own acceptance of estimates of ~60 ka for the Acheulian levels at Kalambo Falls, Zambia (Clark 1969), based upon his failure to recognize that most of the African prehistoric record lies beyond the limits of accuracy for the radiocarbon method, led to a "short chronology" for Africa, and to the impression that events there lagged far behind those elsewhere. Subsequent amino acid racemization dates of ~125 ka for Kalambo Falls (Clark 1982) still seemed to be gross underestimates, in light of Shackleton's (1982) oxygen isotope work at Klasies River, South Africa (which he presented at Harvard in 1984) showing that modern *H. sapiens* was present there before 100 ka.

I was eager to test the link between the technological changes visible in the archaeological record and the events in human evolution seen in the fossil record. The main impediment at that time was "the dating gap", the lack of a reliable dating method between the limits of reliability for radiocarbon, at about ~20 ka (Gowlett and Hedges 1986), and the limit for K/Ar, at about 500 ka (Curtis 1966). The development and refinement of the $^{40}\text{Ar}/^{39}\text{Ar}$ method over the last twenty years (Ludwig and Renne 2000) now permit accurate and precise age determinations as young as 2 ka (Renne et al. 1997). In western Kenya, the critical ingredient missing to develop a sound chronology was dateable volcanics. In the early 1990s I transferred my research focus to the Kapthurin Formation in the Rift Valley of Kenya, where Acheulian artifacts and human fossils had been recovered, and where lava and tephra are not in short supply.

History of Research in the Kapthurin Formation

The Kapthurin Formation forms the Middle Pleistocene portion of the sedimentary sequence of the Tugen Hills, west of Lake Baringo (Figure 16.1). The Tugen Hills region has been known to be fossiliferous since the 1930s (Fuchs 1950), and the record is now known to extend beyond 16 Ma (Hill et al. 1986). The post-Miocene portion of the section formed the basis for Leakey's (1955) Kamasia pluvial (see Kingston and Hill this volume). When examined in more detail, these deposits were found by McCall et al. (1967) to be comprised of Pliocene sediments unconformably overlain by Middle Pleistocene sediments. McCall et al. designated these the Pliocene Chemeron Formation and the Middle Pleistocene Kapthurin Formation.

The Baringo region became the research focus of members of the East African Geological Research Unit (EAGRU) under the direction of Basil King, and later, Bill Bishop. Their work provides the geologic framework for

all subsequent research, and their students focused more closely upon fossils and sediments. The basic stratigraphic scheme for the Kapthurin Formation was provided by Martyn (1969) and subsequently elaborated by Tallon (Figure 16.2; Tallon 1976, 1978). The formation is about 125 m thick, and is exposed over an area of about 150 km². It includes three fluviolacustrine and deltaic members, the Lower, Middle, and Upper Silts and Gravels Members (K1, K3, and K5), and two major tephra units, the Pumice Tuff Member (K2) and the Bedded Tuff Member (K4). An additional, unnumbered tephra, the Grey Tuff, lies within K3, and the extraformational Upper Kasurein Basalt is intercalated within the lacustrine facies of the Middle Silts and Gravels Member (K3').

Initial archaeological exploration of the formation was carried out in the 1960s by Leakey et al. (1969), who discovered a hominin mandible (KNM-BK-67) and postcranial remains (KNM-BK 63-66) within K3 sediments immediately below the Grey Tuff. They also

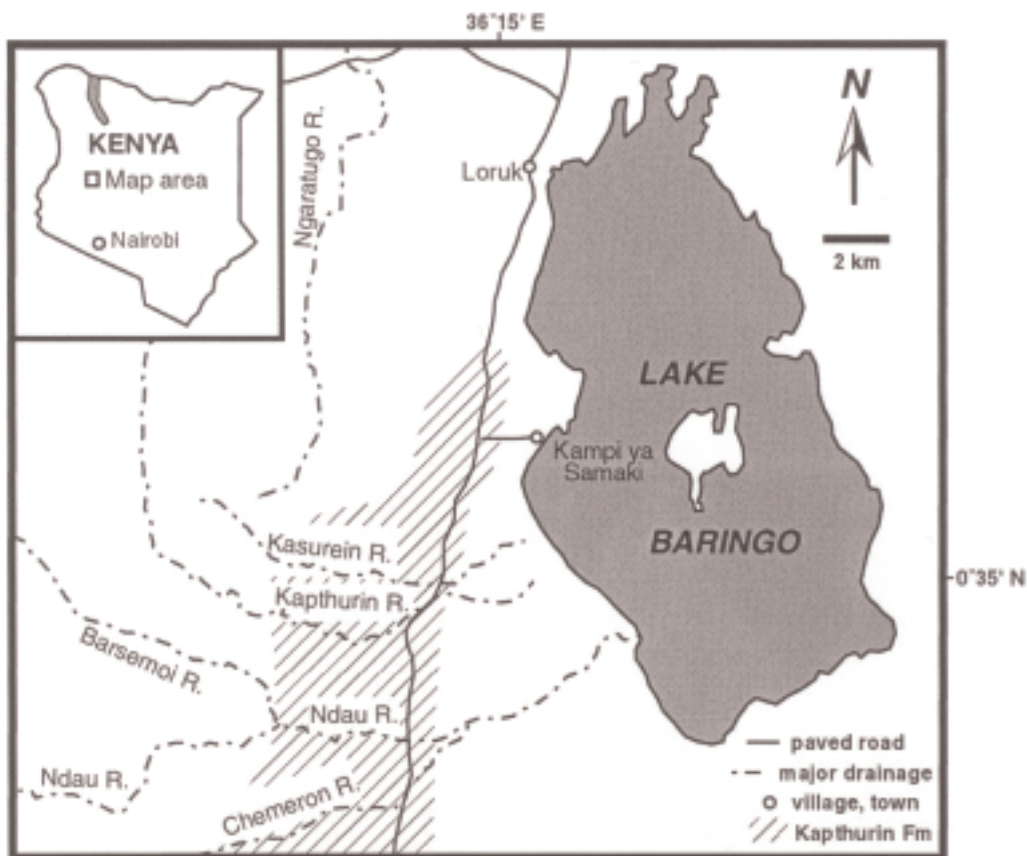


Figure 16.1. Map of the Baringo region showing the location of the Kapthurin Formation. Map by Christian Tryon.

reported three archaeological sites from slightly higher in the section. In the 1980s a Belgian team headed by Van Noten explored a number of archaeological sites (Van Noten et al. 1987a, 1987b; Cornelissen et al. 1990; Cornelissen 1992) and found a second hominin mandible (KNM-BK-8518) from a locality at approximately the same stratigraphic position as the initial hominin discoveries (Van Noten and Wood 1985; Wood and Van Noten 1986).

The chronology of the formation was at that time imperfectly known. A date of 1.57 Ma on the Ndau Trachymugearite near the top of the underlying Chemeron Formation (Hill et al. 1986) provided a maximum age for the Kapthurin Formation. Because all sampled rocks within the formation were known to be normally magnetized (Dagley et al. 1978), Kapthurin fossils and artifacts could be presumed to be younger than 780 ka (Cande and Kent 1992; Baksi et al. 1992). Conventional K/Ar dates ranging between 620 ± 6 ka and 890 ± 260 ka for K2, the Pumice Tuff Member, and between 250 ± 120 ka and 240 ± 8 ka for K4, the Bedded Tuff Member, had been reported (Tallon 1978; Cornelissen et al. 1990), and the age of ~ 240 ka is frequently cited as the terminal date for the African Acheulian. MSA technology was at that time unknown from the Kapthurin Formation.

I carried out my first independent field season in the Kapthurin Formation in 1993. In the pages that follow I will recount what we know now that we did not know when I initiated the research, and how this new knowledge relates to larger evolutionary questions that lie at the intersection of archaeology and human paleontology.

Kapthurin Hominins

Nearly every available name within the genus *Homo* has been applied to the Kapthurin hominins at one time or another. Mandible KNM-BK-67 and the associated ulna, metatarsal, and phalanges were first assigned to *H. cf. erectus* by Tobias (Leakey et al. 1969). Van Noten (1983) initially referred mandible KNM-BK 8518 to *cf. H. erectus* or *H. habilis*. Both mandibles were allocated to *H. sp. indet.* (aff. *erectus*) by Wood and Van Noten (1986), although Wood (1992) later referred them to *H. erectus*. Subsequently Wood and Aiello (1998) attributed them to a broad category designated *H. ergaster*/late African *H. erectus*. I refer the material to *H. rhodesiensis* (McBrearty and Brooks 2000), whereas Stringer (2002)

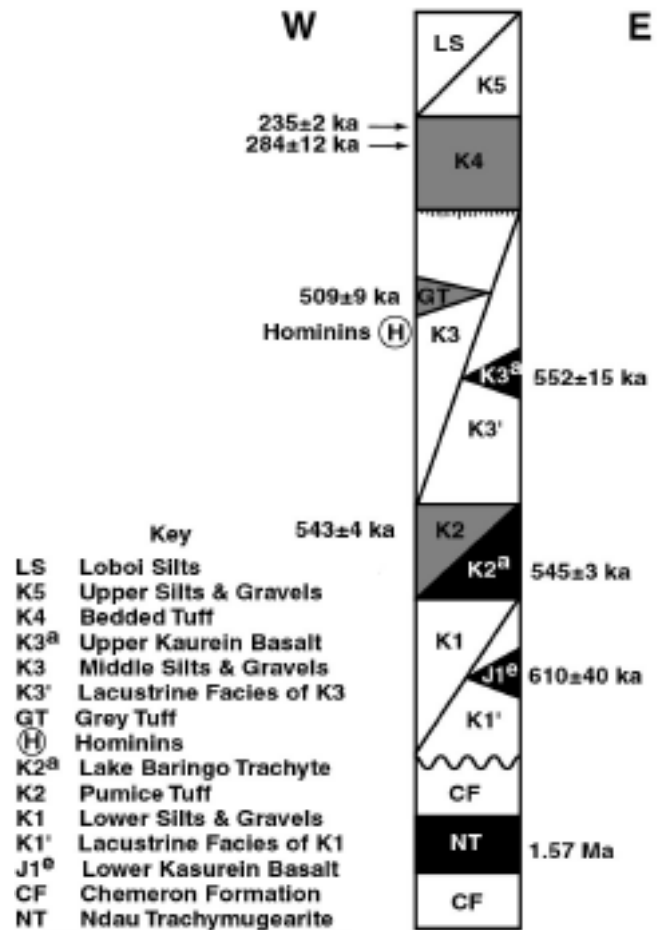


Figure 16.2 Idealized stratigraphic column of the Kapthurin Formation. Stratigraphic terminology after Martyn (1969) and Tallon (1978). Dates are $^{40}\text{Ar}/^{39}\text{Ar}$ determinations from Deino and McBrearty (2002). Illustration by Christian Tryon.

and Rightmire (1998) favor *H. heidelbergensis*. This taxonomic history reveals more about views of the evolution of *H. erectus* and the origin of *H. sapiens* than it does about any intrinsic features of the fossils themselves, as neither the mandibles nor the postcrania contain many features that are particularly useful for specific diagnosis. They do, however, demonstrate the observation of Pilbeam (1975) that Middle Pleistocene hominins are extremely variable in body size and robusticity. Reexamination of the Kapthurin Formation postcranials (Fisher and McBrearty 2002, in prep.; Pearson 2000) show them to occupy the very gracile end of a robusticity spectrum, the other end of which is occupied by specimens such as the Bodo cranium or the hyperrobust Berg Aukus femur (Kappelman 1997).

The age of the Kapthurin hominins was difficult to determine, largely because the Grey Tuff that overlies the hominin localities is fine grained and discontinuously distributed. Previous attempts to date it using conventional K/Ar techniques had failed (Cornelissen personal communication). Use of both single crystal total fusion (SCTF) and laser incremental heating (LIH) $^{40}\text{Ar}/^{39}\text{Ar}$ methods enabled us to date the Grey Tuff at 509 ± 9 ka, and the underlying Pumice Tuff (K2) at 543 ± 4 ka (Deino and McBrearty 2002). The Kapthurin hominins, at roughly 510–545 ka, are thus a bit younger than those from Bodo, Ethiopia, dated by the same method at 640–550 ka (Clark et al. 1994), but the approximate contemporaries of OH 11, OH 23, and the Ndutu cranium, from Olduvai Gorge, estimated at 490–780 ka (White 2000; Delson et al. 2000).

Technological Variety

As a result of our research, the number of known archaeological and fossil sites in the Kapthurin Formation now exceeds 60. A series of papers has described these and the ancient habitats in which they were preserved (McBrearty et al. 1996; McBrearty 1999, 2001). Two archaeological industries, the Sangoan and Fauresmith, are known from sites elsewhere in Africa to overlie the Acheulian and underlie the MSA. It had previously been believed that these industries were confined to distinct physiographic zones, the Sangoan to the forested habitats of Central Africa, and the Fauresmith to the savanna of East and South Africa (Clark 1965, 1972, 1988). Discovery of both industries in close geographic proximity in the Kapthurin Formation shows that this was not the case, and their position in the same stratigraphic interval with both Acheulian and MSA artifacts suggests that all four entities may well be contemporary.

Age of the Acheulian to MSA Transition

The shift from Acheulian to MSA technology involves the abandonment of the long-lived tradition of handaxe manufacture for the production of points, which are considered diagnostic of the MSA (Goodwin 1928). While a single point had been reported from the Kapthurin Formation site of GnJh-17 by Cornelissen (1992), its MSA diagnostic character was not emphasized. We have since found additional points at several sites in the formation,

and, perhaps more importantly, discovered several sites in the southern part of the formation with undoubted MSA Levallois technology (Tryon 2004).

The Kapthurin Formation now provides the age of the earliest MSA artifacts yet found anywhere in Africa. Prior to our work, the maximum age for MSA technology was provided by a K/Ar date of 235 ka from Gademotta, Ethiopia (Wendorf et al. 1994). Application of the $^{40}\text{Ar}/^{39}\text{Ar}$ method to volcanics in the Kapthurin Formation now shows that the large scale archaeological turnover from Acheulian to MSA technology occurred in this part of the Rift Valley before 285 ka (Deino and McBrearty 2002). The age range of MSA technology is thus now increased by 50 ka, a period of time 10 ka longer than the total known span of the occupation of Europe by *H. sapiens*. This new age estimate brings the appearance of MSA technology more into line with the appearance of *H. sapiens*, if that species is taken to include the Florisbad cranium, dated directly by gamma ray spectroscopy at 265 ka (Grün et al. 1996).

Nature of the Acheulian to MSA Transition

The abandonment of Acheulian handaxes and cleavers for points and other small flake tools signals the shift from hand-held to hafted artifacts and a lighter, more portable toolkit. The nature of this change has not been critically examined by archaeologists, who have adopted a model of gradual transformation, presumably by members of a single evolving hominin lineage. Application of a program of tephrostratigraphy now enables us to establish stratigraphic relationships within exposures of the Kapthurin Formation that could not be correlated through field mapping alone (Tryon and McBrearty 2002, under review). Sites containing handaxes, diagnostic of the Acheulian, have been shown to be interstratified with those containing points and other MSA tools (Figure 16.3). This situation is consistent with at least two interpretations. Separate hominin demes, lineages, or species, each employing unique technology, may have occupied this part of east Africa for much of the later Middle Pleistocene. Alternatively, African Middle Pleistocene hominins may have had a much broader range of artifact making traditions at their disposal than we have previously appreciated, and they were able to employ quite distinct techniques as situations demanded.

Lacustrine Facies (K3') and Its Technology

A window of exposures in the Kapthurin Formation of no more than a few thousand square meters in extent has been a source of some confusion to previous researchers. This area, termed K3' (see Figure 16.2), is bounded to the west by a fault, and to the east by flows of Upper and Lower Kasurein Basalt and upfaulted blocks of Lake Baringo Trachyte. It contains sands, silts, and zeolitized clays that clearly represent the shore of a fluctuating hyperalkaline lake (McBrearty 1999; Renaut et al. 1999, 2000). Recent detailed investigation by Roure (in preparation) and Ashley et al. (in press) has documented a contemporary fresh water spring that was intermittently extensive. Fossil fauna is abundant and shows the area to have supported a diverse habitat (McBrearty 1999), but it is the archaeological content of these sediments that is the object of interest here. Artifacts are almost exclusively simple flakes and cores made on small cobbles. It is an expedient technology that with few exceptions lacks handaxes, formalized flake production methods, or retouched tools.

Van Noten's team believed K3' sediments to underlie the Kapthurin Formation, and they termed them the Kwaibus Formation (Cornelissen et al. 1990). These investigators speculated that the artifacts found here belonged to the Oldowan tradition and were of a Pliocene or Early Pleistocene age (Cornelissen personal communication). Our detailed mapping has demonstrated that the initial interpretations of Martyn (1969) and Tallon (1976, 1978) are correct, and that these sediments are firmly stratified within the Kapthurin Formation. Our program of $40\text{Ar}/39\text{Ar}$ dating has established the age of the archaeological occurrences in K3' at between 543 ± 4 ka 509 ± 9 ka, the same age as the Kapthurin hominins. An inversion in the $40\text{Ar}/39\text{Ar}$ sequence is presented by the apparent date of 552 ± 15 ka on the Upper Kasurein Basalt in K3'. This anomalous age estimate is probably due to argon loss from this weathered, vesicular unit (Deino and McBrearty 2002), and determining its true age is a goal of my current research.

In any case, this interval lies well within the timespan of the Acheulian industrial tradition, and the absence or rarity of large bifaces perhaps requires explanation. The phenomenon of "handaxe free" assemblages has a long intellectual history. In England such occurrences have

been referred to the Clactonian (White 2000), on the European continent to the Tayacian (Rolland 1986), and in Africa to the Hope Fountain industry (Clark 1970). However Isaac (1977) long ago pointed out that bifaces may be rare or absent at East African Middle Pleistocene sites; for example they make up between 0% and 95% of the artifacts at Ologesailie localities. Retouched tools are infrequent at many Kapthurin Formation sites, and the flake and core component of the Acheulian, MSA, and even Oldowan can be difficult to distinguish (McBrearty 2001; Tryon and McBrearty 2002; McBrearty and Tryon in press). Expedient mode 1 technology is found in all stratigraphic intervals in the Kapthurin Formation, and serves to illustrate the underappreciated fact that such technology persisted into historic times on many parts of the globe.

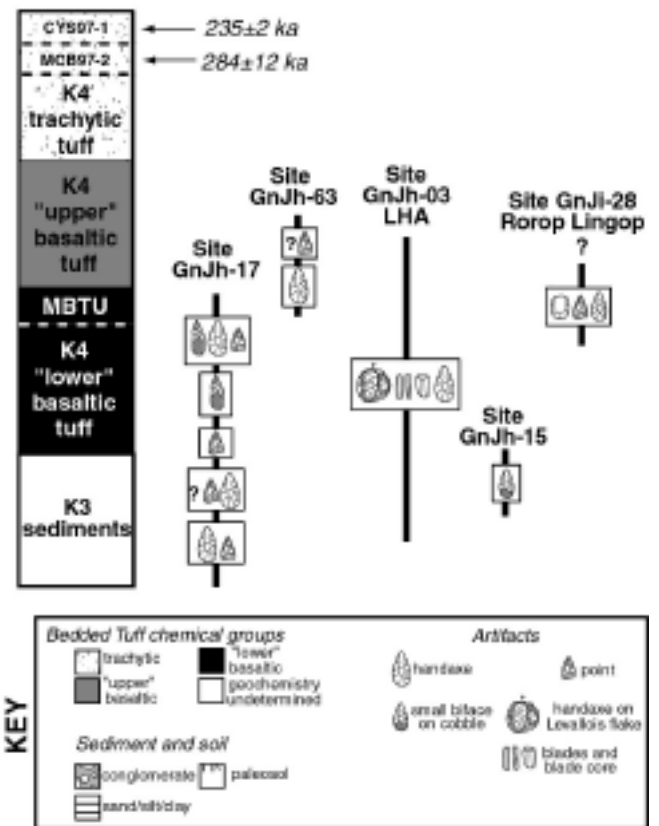


Figure 16.3 Summary stratigraphic relationships between units of the Kapthurin Formation. Bedded Tuff, radiometric dates, and archaeological assemblages, showing interstratification of sites containing diagnostic artifact types. Illustration by Christian Tryon, after Tryon and McBrearty (2002).

Signs of Precocious Behaviors in the Kapthurin Formation

At present there are two competing views regarding the behavior of the hominins who lived during the Middle and Later Pleistocene. According to one view, while the fossil record shows that anatomically modern *H. sapiens* was present in Africa well before 100 ka, these hominins were not behaviorally modern. Rather, a neural reorganization at ~40 ka, possibly caused by a genetic mutation, drastically altered hominin cognitive abilities, and this dramatic change is reflected in the appearance of Later Stone Age technology in Africa, and Upper Paleolithic technology elsewhere. Significant to this scenario is the presence of items representing symbolic thought, such as art objects (Klein and Edgar 2002; Mithen 1996; Diamond 1992). The alternate view is that the cognitive capacity in the earliest *H. sapiens* was indistinguishable from that of living people, and that the array of items representing sophisticated behavior were developed over tens or hundreds of thousands of years by early human populations through normal processes of invention and discovery (McBrearty and Brooks 2000). The chief difficulty in testing any proposition regarding the origin of sophisticated behavior is identifying irrefutable material symptoms of such behavior that can survive in the archaeological record. Currently there is no agreement among researchers regarding these criteria (e.g., Deacon and Deacon 1999; Kuhn and Bar-Yosef 1999, Henshilwood et al. 2001; d'Errico et al. 2003).

The Kapthurin Formation now provides evidence for the early existence of a number of items of material culture once thought to have been invented substantially later and to represent evidence of advanced cognition. Evidence for the systematic production of blades and the processing and use of red ochre are present at sites in the formation underlying the Bedded Tuff (K4), and thus they predate 284 ± 12 ka. The maximum age for these occurrences is 509 ± 9 ka. Blades are an economic use of raw material often thought to signal a cognitively advanced approach to the production of stone tools, and the use of red ochre, a coloring medium, may have had a symbolic meaning for Kapthurin Formation Middle Pleistocene hominins.

Points and the Levallois technique are also found in the interval between 509 and 284 ka. Points may represent the development of projectile technology, which provides a

distinct advantage over thrust weapons because dangerous prey need not be so closely approached (Berger and Triankaus 1995; Cattelain 1997). The Levallois technique has been suggested as a technological marker for African hominins in their migration outside Africa (Foley and Lahr 1997). While perhaps not the oldest Levallois material on the continent, the Kapthurin Formation artifacts are the most securely dated. Furthermore, they occur in an Acheulian context; some large Levallois flakes from the Kapthurin Formation were trimmed into handaxes and cleavers, lending credence to the idea that specialized African methods of biface blank production represent the roots of the Levallois approach to working stone (Tryon under review).

Discussion and Conclusions

Determining the taxonomic identity of the makers of the distinct archaeological industries of the African Middle Pleistocene is difficult. This is not merely because investigators cannot agree on nomenclature for these hominins. A more fundamental issue is the nature of evolutionary change during this time period. If there is anything that the fossil record has demonstrated in the last twenty years, it is that human evolution has proceeded as a series of adaptive radiations, and at any point in time during the last five million years there have existed a number of contemporary hominin species. While anagenetic change no doubt occurs within lineages, isolation occurs and recurs throughout the Pliocene and Pleistocene, and results in speciation. The question of species diversity in Africa within the genus *Homo* during the Middle Pleistocene has rarely been addressed (but see Howell 1998; Tattersall 1986; Asfaw et al. 2002; McBrearty and Brooks 2000), but it seems inevitable that in a continent as large and environmentally diverse as Africa, isolation of local populations was the norm. The African Middle Pleistocene hominin fossil record now contains many taxa, and the number is growing (e.g., White et al. 2003). The main problem in clarifying the processes of hominin evolution remains chronology. Redating known material and the discovery of new material in well calibrated sequences must remain a high priority.

A related problem generally ignored by archaeologists is that we are rarely if ever certain which hominin species made the artifacts under study. A well known

example is the situation at FLK in Bed I at Olduvai Gorge. When the remains of *Paranthropus boisei* were recovered there in 1959, this hominin was accepted as the maker of the associated stone tools (Leakey 1959). When fossils of *H. habilis* were later found at the same site, it was pronounced the tool maker (Leakey et al. 1964); *P. boisei* was demoted to the role of onlooker or prey species. Thereafter, archaeologists seem to have accepted the interpretation that larger brained early members of the genus *Homo* were responsible for Oldowan tools, despite suggestions on anatomical and taphonomic grounds that *Paranthropus robustus* and *Australopithecus garhi* were capable of making or wielding tools (Susman 1994, 1998; Asfaw et al. 1999). In practice, archaeologists examining Pliocene or early Pleistocene artifacts rarely attempt to specify the taxon whose behavioral traces are under examination. However some interesting attempts have been made to illuminate the nature of interspecific interaction between *H. neanderthalensis* and *H. sapiens* in the denser and more thoroughly documented Later Pleistocene record of Europe and the Levant (e.g., Harrold 1989; Leiberman and Shea 1994; Shea 2003). In Africa, the earliest members of *H. sapiens* no doubt had contact with individuals of other hominin species. Clarifying the nature of such interactions will be one of the more fascinating aspects of African Middle Pleistocene archaeology in the future. The Kapthurin Formation furnishes both archaeological sites and hominin fossil remains from the time interval during which members of the *H. sapiens* lineage first appeared. It has the potential to contribute to this debate, but a greater density in the fossil and archaeological records is needed to explicate the precise roles played by technology and interspecific competition in the origin of *Homo sapiens*.

Acknowledgements

My work in the Kapthurin Formation has been funded by NSF grants SBR-0217728, SBR-9601419, SBR-9408926, and DBS-9213775, by grants from the L. S. B Leakey Foundation, and by internal awards from Brandeis University and the University of Connecticut. I would like to thank Christian Tryon for drawing the figures, and the G. Harold and Leila Mathers Charitable Foundation for providing the pleasant surroundings in which I was able to set these thoughts down on paper.

References

- Asfaw, B., W. H. Gilbert, Y. Beyene, W. K. Hart, P. R. Renne, G. WoldeGabriel, E. S. Vrba, and T. D. White
2002 Remains of *Homo erectus* from Bouri, Middle Awash, Ethiopia. *Nature* 416:317–320.
- Asfaw, B., T. D. White, C. O. Lovejoy, B. Latimer, S. Simpson, and G. Suwa
1999 *Australopithecus garhi*: A new species of early hominid from Ethiopia. *Science* 284:629–635 .
- Ashley, G. M., C. A. Roure, C. B. De Wet, and V. C. Hovers
2004 A tufa “event” in an arid Rift Valley (Kenya); climate or tectonics? *Geological Society of America Abstracts* 103–104.
- Baksi, A. K., B. Hsu, M. O. Williams, and E. Ferrar
1992 ⁴⁰Ar/³⁹Ar dating of the Brunhes-Matuyama geomagnetic field reversal. *Science* 256:356–357.
- Berger, T. D., and E. Trinkaus
1995 Patterns of trauma among the Neanderthals. *Journal of Archaeological Science* 22:841–852.
- Cande, S. C., and D. V. Kent
1992 A new geomagnetic polarity time scale for the late Cretaceous and Cenozoic. *Journal of Geophysical Research* 97:13917–13951.
- Cattelain, P.
1997 Hunting during the Upper Paleolithic: bow, spearthrower, or both? In *Projectile Technology*, edited by H. Knecht, pp. 213–240. Plenum, New York.
- Clark, J. D.
1965 The later Pleistocene cultures of Africa. *Science* 150:833–847.
1969 *Kalambo Falls Prehistoric Site*, Volume I. Cambridge University Press, Cambridge.
1970 *The Prehistory of Africa*. Praeger, New York.

- 1972 Human Behavioral Differences in Southern Africa during the Late Pleistocene. *American Anthropologist* 73:1211–1236.
- 1975 Africa in prehistory: peripheral or paramount? *Man* 10:175–198.
- 1982 The cultures of the Middle Paleolithic and Middle Stone Age. In *The Cambridge History of Africa, Volume 1: From the earliest times to 500 B.C.*, edited by J. D. Clark, pp. 248–341. Cambridge University Press, Cambridge.
- 1988 The Middle Stone Age of East Africa and the beginnings of regional identity. *Journal of World Prehistory* 2:235–305.
- Clark, J. D., J. de Heinzelin, K. D. Schick, W. K. Hart, T. D. White, G. WoldeGabriel, R. C. Walter, G. Suwa, B. Asfaw, E. Vrba, and Y. HaileSelassie
1994 African *Homo erectus*: old radiometric ages and young Oldowan assemblages in the Middle Awash valley, Ethiopia. *Science* 264:1907–1910.
- Cornelissen, E.
1992 Site GnJh-17 and its implications for the archaeology of the middle Kapthurin Formation, Baringo, Kenya. *Musée Royale de l’Afrique Centrale, Annales, Sciences Humaines* 133, Tervuren.
- Cornelissen, E., A. Boven, A. Dabi, J. Hus, K. Ju Yong, E. Keppens, R. Langohr, J. Moeyersons, P. Pasteels, M. Pieters, H. Uytterschaut, F. Van Noten, and H. Workineh
1990 The Kapthurin Formation revisited. *African Archaeological Review* 8:23–76.
- Curtis, G. H.
1966 The problems of contamination in obtaining accurate dates of young geologic rocks. In *Potassium-Argon Dating*, edited by O. A. Shaeffer and J. Zahringer, pp. 151–162. Springer Verlag, New York.
- d’Errico, F., C. Henshilwood, G. Lawson, M. Vanhaeren, and A.-M. Tillier
2003 Archaeological evidence for the emergence of language, symbolism, and music—an alternative multidisciplinary perspective. *Journal of World Prehistory* 17:1–70.
- Dagley, P., A. E. Mussett, and H. C. Palmer
1978 *Preliminary Observations on the Palaeomagnetic Stratigraphy of the Area West of Lake Baringo, Kenya*. Scottish Academic Press, Edinburgh.
- Deacon, H. J., and J. Deacon
1999 *Human beginnings in South Africa: Uncovering the Secrets of the Stone Age*. David Philip, Capetown.
- Deino, A., and S. McBrearty
2002 40 Ar/39Ar chronology for the Kapthurin Formation, Baringo, Kenya. *Journal of Human Evolution* 42:185–210.
- Delson, E., I. Tattersall, J. A. Van Couvering, and A. S. Brooks
2000 *Encyclopedia of Human Evolution and Prehistory*, Second Edition. Garland/Taylor and Francis, New York.
- Diamond, J.
1992 *The Third Chimpanzee*. Harper Collins, New York.
- Fisher, R. E., and S. McBrearty
2002 The comparative morphology of hominin postcranial remains from the Kapthurin Formation, Baringo District, Kenya. *American Journal of Physical Anthropology* S34:70.
- In prep. Middle Pleistocene hominin first metatarsal and manual phalanges (cheiridia) from the Kapthurin Formation, Kenya.

- Foley, R. A., and M. M. Lahr
1997 Mode 3 technologies and the evolution of modern humans. *Cambridge Archaeological Journal* 7:3–36.
- Fuchs, V. E.
1950 Pleistocene events in the Baringo Basin. *Geological Magazine* 87:149–174.
- Goodwin, A. J. H.
1928 An introduction to the Middle Stone Age in South Africa. *South African Journal of Science* 25:410–418.
- Gowlett, J. A. J., and R. E. M. Hedges
1986 Lessons of context and contamination in dating the Upper Palaeolithic. In *Archaeological Results from Accelerator Dating*, edited by J. A. J. Gowlett and R. E. M. Hedges, pp. 63–72. British Archaeological Reports International Series 11, Oxford.
- Grün, R., J. S. Brink, N. A. Spooner, L. Taylor, C. B. Stringer, R. G. Franciscus, and A. S. Murray
1996 Direct dating of Florisbad hominid. *Nature* 382:500–501.
- Harrold, F.
1989 Mousterian, Châtelperronian, and Early Aurignacian in Western Europe: continuity or discontinuity? In *The Human Revolution: Behavioural and Biological Perspectives on the Origin of Modern Humans*, edited by P. Mellars and C. B. Stringer, pp. 677–743. Princeton University Press, Princeton, NJ.
- Henshilwood, C. S., F. d’Errico, C. W. Marean, R. Milo, and R. Yates
2001 An early bone tool industry from the middle stone age at Blombos cave, South Africa: implications for the origins of modern human behaviour, symbolism and language. *Journal of Human Evolution* 41:631–678.
- Hill, A. P., G. Curtis, and R. Drake
1986 Sedimentary stratigraphy of the Tugen Hills, Baringo District, Kenya. In *Sedimentation in the African Rifts*, Volume 25, edited by L. E. Frostick and R. T. J. J. Renaut, pp. 285–295. Blackwell, Oxford.
- Howell, F. C.
1998 Evolutionary implications of altered perspectives on hominine demes and populations in the later Pleistocene of western Eurasia. In *Neandertals and modern humans in western Asia*, edited by T. Akazawa, K. Aoki, and O. Bar-Yosef, pp. 5–28. Plenum, New York.
- Isaac, G.
1977 *Olorgesailie: Archaeological Studies of a Middle Pleistocene Lake Basin in Kenya*. University of Chicago Press, Chicago.
- Kappelman, J.
1997 They Might be Giants. *Nature* 387:126–127.
- Kuhn, S., and O. Bar-Yosef
1999 What’s the big deal about blades? *American Anthropologist* **Volume Pages**.
- Leakey, L. S. B.
1955 The climatic sequence of the Pleistocene in Africa. In *Actes de la IIe Session du Congrès Panafricain de Préhistoire*, Alger, 1952, edited by L. Balout, pp. 293–294. Paris.
1959 A new fossil skull from Olduvai. *Nature* 201:967–970.
- Leakey, L. S. B., P. V. Tobias, and J. R. Napier
1964 A new species of the genus *Homo* from Olduvai Gorge. *Nature* 202:7–9.

- Leakey, M., P. V. Tobias, J. E. Martyn, and R. E. F. Leakey
 1969 An Acheulian 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.
- Lieberman, D. E., and J. J. Shea
 1994 Behavioral differences between archaic and modern humans in the Levantine Mousterian. *American Anthropologist* (96):300–332.
- Ludwig, K. R., and R. R. Renne
 2000 Geochronology on the paleoanthropological time scale. *Evolutionary Anthropology* 9:101–110.
- Martyn, J.
 1969 *The Geologic History of the Country Between Lake Baringo and the Kerio River, Baringo District Kenya*. University of London.
- McBrearty, S.
 2001 The Middle Pleistocene of East Africa. In *Human Roots: Africa and Asia in the Middle Pleistocene*, edited by L. H. Barham and K. Robson-Brown, pp. 81–97. Western Academic & Specialist Press, Bristol, UK.
- 1988 The Sangoan-Lupemban and Middle Stone Age sequence at the Muguruk site, western Kenya. *World Archaeology* 19:379–420.
- 1991 Recent research in western Kenya and its implications for the status of the Sangoan industry. In *Cultural Beginnings: Approaches to Understanding Early Hominid Lifeways in the African Savanna*, edited by J. D. Clark, pp. 159–176. Romisch-Germanisches Zentralmuseum, Forschungsinstitut für Vor- und Frühgeschichte, Monographien 19, Bonn.
- 1999 Archaeology of the Kapthurin Formation. In *Late Cenozoic environments and Hominid Evolution: A Tribute to Bill Bishop*, edited by P. Andrews and P. Banham, pp. 143–156. Geological Society, London.
- McBrearty, S., and A. 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, S., and C. Tryon
 In press From Acheulian to Middle Stone Age in the Kapthurin Formation, Kenya. In *Temporal Trends in the Middle Paleolithic and Middle Stone Age*, edited by E. Hovers and K. S. **Last Name**. Kluwer-Plenum, New York.
- McBrearty, S., L. Bishop, and J. Kingston
 1996 Variability in traces of middle Pleistocene hominid behavior in the Kapthurin Formation, Baringo, Kenya. *Journal of Human Evolution* 30:563–580.
- McCall, G. J. H., B. H. Baker, and J. Walsh
 1967 Late Tertiary and Quaternary sediments of the Kenya Rift Valley. In *Background to Evolution in Africa*, edited by W. W. Bishop and J. D. Clark, pp. 191–220. Chicago University Press, Chicago.
- Mithen, S.
 1996 *The Prehistory of the Mind: A Search for the Origins of Art, Religion, and Science*. Thames & Hudson, London.
- Pearson, O. M.
 2000 *Postcranial Remains and the Origin of Modern Humans*, Volume 9, pp. 229–247. **Publisher, City**.
- Pilbeam, D. R.
 1975 Middle Pleistocene hominids. In *After the Australopithecines*, edited by K. W. Butzer and G. L. Isaac, pp. 809–856. Mouton, The Hague.

- Renaut, R., J.-J. Tiercelin, and R. B. Owen
2000 Lake BAingo, Kenya Rift Valley, and its Pleistocene precursors. In *Lake Basins through Space and Time*, edited by E. H. Gierowski-Kordesch and K. R. Kelts, pp. 561–568. American Association of Petroleum Geologists, Tulsa.
- Renaut, R., J. Ego, J.-J. Tiercelin, C. Le Eerdu, and R. B. Owen
1999 Saline, alkaline laeolakes of the Tugen Hil-Kerio Valley region, Kenya Rift Valley. In *Late Cenozoic environments and hominid evolution: a tribute to Bill Bishop*, edited by P. Andrews and P. Banham, pp. 41–58. Geological Society of London, London.
- Renne, P. R., W. D. Sharp, A. L. Deino, G. Orsi, and L. Civetta
1997 $^{40}\text{Ar}/^{39}\text{Ar}$ dating into the historic realm. *Science* 277:1279–1280.
- Rightmire, G. P.
1998 Human evolution in the Middle Pleistocene: the role of *Homo heidelbergensis*. *Evolutionary Anthropology* 6:218–227.
- Rolland, N.
1986 Recent findings from La Micoque and other sites in south-western and Mediterranean France: their bearing on the ‘Tayacian’ problem and Middle Palaeolithic emergence. In *Stone Age Prehistory: Studies in Memory of Charles McBurney*, edited by G. N. Bailey and P. Callow, pp. 121–152. Cambridge University Press, Cambridge.
- Roure, C.
In prep. A Middle Pleistocene Landscape Archaeology Project in the Kapthurin Formation, Kenya. University of Connecticut.
- Shackleton, N. J.
1982 Stratigraphy and chronology of the Klasies River Mouth deposits: oxygen isotope evidence. In *The Middle Stone Age at Klasies River Mouth in South Africa*, edited by R. Singer and J. Wymer, pp. 194–199. Chicago University Press, Chicago.
- Shea, J.
2003 *Neandertals, competition, and the origin of modern humans in the Levant, Volume 12*. pp. 173–187. Publisher, City.
- Stringer, C.
2002 Modern human origins: progress and prospects. *Philosophical Transactions Of The Royal Society of London Series B-Biological Sciences* 357:563–579 .
- Susman, R. L.
1994 Fossil evidence for early hominid tool use. *Science* 265:1570–1573.
- 1998 Hand function and tool behavior in early hominids. *Journal of Human Evolution* 35:23–46.
- Tallon, P.
1976 *The Stratigraphy, Palaeo-environments and Geomorphology of the Pleistocene Kapthurin Formation, Kenya*. University of London.
- 1978 *Geological setting of the hominid fossils and Acheulian artifacts from the Kapthurin Formation, Baringo District, Kenya*. Scottish Academic Press, Edinburgh.
- Tattersall, I.
1986 Species recognition in human paleontology. *Journal of Human Evolution* 15:165–175.

- Tryon, C.
 2004 The Acheulian to Middle Stone Age transition: Tephrostratigraphic context for archaeological change in the Kapthurin Formation of Kenya. Ph.D. dissertation. University of Connecticut.
- Under review. 'Early' Middle Stone Age lithic technology of the Kapthurin Formation (Kenya). *Current Anthropology*.
- Tryon, C. A., and S. McBrearty
 2002 Tephrostratigraphy and the Acheulian to Middle Stone Age transition in the Kapthurin Formation, Baringo, Kenya. *Journal of Human Evolution* 42:211–235.
- Under review. Tephrostratigraphy of the Bedded Tuff Member (Kapthurin Formation, Kenya) and the nature of archaeological change in the later Middle Pleistocene. *Quaternary Research*.
- Van Noten, F.
 1983 News from Kenya. *Antiquity* 57:39–40.
- Van Noten, F., and B. Wood
 1985 Un nouvel hominide à Baringo, Kenya. *L'Anthropologie* 89:141–143.
- Van Noten, F., E. Cornelissen, J. Gysels, J. Moeyersons, J. Nijs, and H. Uytterschaut
 1987a The Kapthurin Project, Baringo: the 1984 season. *Nyame Akuma* 28:20–27.
- 1987b The Kapthurin Project, Baringo: the 1985 season. *Nyame Akuma* 29:36–42.
- Wendorf, F., A. E. Close, and R. Schild
 1994 Africa in the period of *Homo sapiens neanderthalensis* and contemporaries. In *History of Humanity, Volume 1: Prehistory and the Beginnings of Civilization*, edited by S. J. De Laet, A. H. Dani, J. L. Lorenzo, and R. B. Nunn, pp. 117–135. Routledge & UNESCO, New York.
- White, M.
 2000 The Clactonian question: on the interpretation of core-and-flake assemblages in the British Lower Paleolithic. *Journal of World Prehistory* 14:1–64.
- White, T. D.
 2000 Olduvai Gorge. In *Encyclopedia of Human Evolution and Prehistory*, Second Edition, edited by E. Delson, I. Tattersall, J. A. Van Couvering, and A. S. Brooks. Garland/Taylor & Francis, New York.
- White, T. D., B. Asfaw, D. DeGusta, H. Tilbert, G. D. Richards, G. Suwa, and F. C. Howell
 2003 Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature* 423:742–747.
- Wood, B.
 1992 Origin and evolution of the genus *Homo*. *Nature* 355:783–790.
- Wood, B., and L. Aiello
 1998 Taxonomic and functional implications of mandibular scaling in early hominins. *American Journal of Physical Anthropology* 105:523–538.
- Wood, B. A., and F. L. Van Noten
 1986 Preliminary observations on the BK 8518 mandible from Baringo, Kenya. *American Journal of Physical Anthropology* 69:117–127.