INTRODUCTION
The record of east Africa is rich in the fossils of Middle Pleistocene hominids and the detritus that represents the material record of their behaviour. For archaeology and human palaeontology, as for any historical discipline, the order in which discoveries are made has a profound impact on the growth of knowledge and on the interpretation of new finds. This chapter therefore begins with a brief review of the history of research into the Middle Pleistocene of east Africa and a discussion of its hominid fossil record. It seeks to correct two misapprehensions about the Middle Pleistocene of east Africa: first, that the Middle Pleistocene may be equated with the handaxe and with the Acheulian industry, and second, that handaxes and the Acheulian are uniform both across space and through time. In fact, the Middle Pleistocene record of east Africa is highly variable. Aspects of heterogeneity in Acheulian lithic technology discussed here include variability in biface shape, differences in approaches to biface production, and specialised and unspecialised flake production techniques. A further aspect of variety is the presence of many occurrences that lack bifaces altogether. The disappearance of the Acheulian and its replacement by MSA technology is an important Middle Pleistocene phenomenon. It seems to be related to the origin of the Homo sapiens lineage and is accompanied by a number of novel behavioural markers. This review emphasises evidence from the Kapthurin Formation, Kenya, which provides a well-calibrated sequence spanning much of the Middle Pleistocene (see figure 7.1).

HISTORY OF RESEARCH
Research into the Middle Pleistocene of east Africa has been centred upon the Rift Valley, which has served as a sediment trap preserving fossils for at least 20 Ma. Advantages of the Rift Valley for the study of human evolution include the essential facts that hominids seem to have occupied the region more or less continuously from the earliest times, and that conditions are good for preservation and dating of fossils. Vulcanism at this active plate boundary renders possible dating by K/Ar, palaeomagnetism, and now $^{40}\text{Ar}/^{39}\text{Ar}$, which enjoys enhanced accuracy and precision (Kappelman 1993; Deino & Potts 1990; Renne et al 1997; Feibel 1999; Ludwig & Renne 2000; Deino & McBrearty, under review).

In much early work, the African Middle Pleistocene was equated with the Acheulian, though recent redating efforts show that most of the lifespan of the Acheulian lies in the Earlier Pleistocene, and that Middle Stone Age technology appeared in the latter part of the Middle Pleistocene. Nonetheless, interpretations of the east African Middle Pleistocene archaeological record have been greatly influenced by the four ‘classic’ Acheulian sites of Olduvai Gorge, Olorgesailie, Isimila, and Kalambo Falls, where work was active in the 1950s and 1960s (Howell 1961; Leakey 1971; Isaac 1977; Clark 1964, 1969, 1974; Howell et al 1962, 1972; Hansen & Keller 1971). These provided the basis for the standard typology of the east African Acheulian of Kleindienst (1962) and for a spate of volumes on the Middle Pleistocene that appeared in the 1970s (Howell & Bourlière 1963; Bishop & Clark 1967; Bishop & Miller 1972; Butzer & Isaac 1975; Bishop 1978).

The Middle Pleistocene is nearly universally agreed to commence with the shift from reversed to normal magnetic polarity at the Matuyama–Brunhes boundary, now estimated at ~780 ka (Butzer & Isaac 1975; Imbrie & Imbrie 1980; Berger et al 1984; Martinson et al 1987; Cande & Kent 1992; Baksi et al 1992; Schneider, 1992; Singer & Pringle 1996). Van Couvering (2000) is alone in arguing on faunal grounds that the lower limit of the Middle Pleistocene is more correctly set at ~900 ka, and the now conventional date of ~780 will be used here. The Middle Pleistocene ends at the beginning of the last interglacial, at ~130 ka (Butzer & Isaac 1975; Imbrie & Imbrie 1980; Berger et al 1984; Martinson et al 1987).

It has long been clear that much of the sequence at Olduvai and Koobi Fora predates 780 ka and thus lies in the Earlier Pleistocene (Isaac 1975). Application of the $^{40}\text{Ar}/^{39}\text{Ar}$ technique and recalibration of the palaeomagnetic timescale now shows that large portions of the sequences at Olduvai Gorge (Kimbel 1995; Tamrat et al 1995; Walter et al 1991, 1992; White 2000; Delson & Van Couvering 2000) and Olorgesailie (Bye et al 1987; Gowlett 1987; Deino & Potts 1990), formerly thought to
Figure 7.1  Map of east Africa with locations of sites mentioned in the text.
represent the Middle Pleistocene, actually also accumulated during Earlier Pleistocene times. Although the Acheulian has its roots in the Earlier Pleistocene, study of this time interval in the last twenty years has focused primarily upon Oldowan technology. Much recent work at Olorgesailie (Potts 1994, 1996; Sikes et al 1999; Potts et al 1999, 2000; Koobi Fora (Rogers et al 1994), and Olduvai Gorge (Sikes 1994; Peters & Blumenschine 1995; Blumenschine & Peters 1998) has emphasised palaeohabitat reconstruction and landscape use, and the nature and causes of change through time in the mammalian faunal communities, including hominids (Potts 1996, 1998a, 1998b; Potts & Deino 1995). Recent treatments provide new information on the Acheulian technology from these classic localities (Leakey & Roe 1994; Isaac & Isaac 1997; Ludwig & Harris 1998).

Field investigation was active in the 1960s and 1970s at other east African Middle Pleistocene localities including Bodo (Kalb et al 1980, 1982), Gadeb (Clark & Kurashina 1979), and the site complex of Melka Kunturé, Ethiopia (Hours 1976; Chavaillon et al 1978; Chavaillon 1979); Kilombe (Bishop 1978; Gowlett 1978, 1984, 1991, 1999), Kariandusi (Leakey 1931; Gowlett & Crompton 1994), and the Kaphthurin Formation, Kenya (Leakey et al 1969; Tallon 1978); Peninj, Tanzania (Isaac 1975; Isaac & Curtis 1974); Nsongzei, Uganda (Cole 1967); and Mwanganda, Malawi (Clark & Haynes 1970; Clark et al 1970). Recent or ongoing projects with an emphasis upon the Earlier to Middle Pleistocene are those at Isenya near Kajiado, Kenya (Brugal 1986; Brugal & Denys 1989; Roche et al, 1987, 1988), in the Kaphthurin Formation in the northern Kenya Rift (McBrearty et al 1996; McBrearty 1999a; Deino & McBrearty under review; Tryon & McBrearty under review), at Olorgesailie in the southern Kenya Rift (Plummer & Potts 1989; Deino & Potts 1990; Potts 1994; Potts et al 1999; Sikes et al 1999), and at Konso-Gardula (Asfaw et al 1992; Clark 1994; Beyene et al 1996; Katoh et al 2000) and in the Middle Awash region of Ethiopia (Clark et al 1984, 1994). Work has also resumed at the site complex at Kanjera, Kenya, which had assumed importance in the early years of the discipline due to the claims of Leakey (1936a, 1936b, 1972) for the occurrence of fossils of anatomically modern Homo sapiens in Middle Pleistocene deposits there. The situation became confused by suggestions of poor stratigraphic integrity (Boswell 1935), possible archaic features in the fossils (Tobias 1968), and the inconclusive results of fluorine analysis (Oakley 1974). Recent work at Kanjera has now clarified the situation. Much of the sequence dates to the late Pliocene and earlier Pleistocene and contains Oldowan artifacts (Behrensmeyer et al 1995; Plummer et al 1999; Ditchfield et al 1999), but the hominids discovered by Leakey are clearly derived from post-Middle Pleistocene context (Plummer & Potts 1989, 1995; Plummer et al 1994). The Middle Pleistocene at Kanjera is represented by the Apoko Formation, which is known to contain Acheulian artefacts, and, possibly, new hominin fossils (Ditchfield et al 1999).

African Middle Pleistocene Hominidae

Recent recalibration of the Olduvai sequence (Walter et al 1991, 1992; Tamrat et al 1995) makes it clear that known fossils of African Homo erectus (=Homo ergaster), all predated 1 Ma. Fossils that have been attributed to the taxon Homo helmei make their appearance in sub-Saharan Africa during the Middle Pleistocene. It has been suggested that there may be grounds for sinking Homo helmei into Homo sapiens (Lahr 1996; Stringer 1996, 1998) and if so, our species’ lifespan extends back to at least 260 ka, the ESR date obtained for the type specimen at Florisbad, South Africa (Grün et al 1996; Brink & Grün 1998). At any rate, the origin of Homo sapiens is clearly a Middle Pleistocene event (Howell 1998), because Homo sapiens was present both in South Africa at Klasies River (Shackleton 1982; Deacon 1989, 1995, 1998; Deacon & Shurman 1992; Brooks et al 1993) and in east Africa in the Kibish Formation, Ethiopia (Butzer 1969; Day & Stringer 1982; Feibel et al 1989) by the end of the Middle Pleistocene at 130 ka. The ancestor of Homo sapiens/Homo helmei is most likely to have been Homo rhodesiensis (formerly attributed to ‘archaic’ Homo sapiens), dating to perhaps more than 1 Ma to ~400 ka, and represented by fossils such as those from Bodo, Ethiopia, and Kabwe, Zambia (see McBrearty & Brooks 2000, for a recent review of the hominin fossil evidence).

While nearly all authors accept a fairly high degree of species diversity among the Hominidae in the Pliocene and Earlier Pleistocene, most treatments of Middle Pleistocene hominid evolution treat it as a unilinear process. Earlier hominid evolution appears to have proceeded through a series of adaptive radiations, and a similar process may well have operated in the Middle Pleistocene. Thus while the chronology of Middle Pleistocene fossils is too imperfectly known to demonstrate contemporaneity among species, the possibility of multiple hominin species during this range of time should not be dismissed.

Handaxes and their functions

The handaxe is the one element common to all Acheulian assemblages throughout the Old World. Perhaps understandably, early work focused upon sites like Olorgesailie and Isimila, with their large numbers of highly visible handaxes and cleavers, and in fact a goal of early research was to explain the superabundance of
bifaces at these sites. This was effectively accomplished for Olorgesailie by Isaac (1977) and for Isimila by Howell (1961; Howell et al 1962, 1972), who showed that the massive quantities of large cutting tools that greet the observer at some localities are lag deposits that have accumulated through the erosion of many superimposed occupation levels. However, many other intact occurrences do indeed contain impressive numbers of bifaces, as discoveries at Isenya, Kenya (Roche et al 1987, 1988; Texier & Roche 1993; Roche & Texier 1995) and Melka Kunturé, Ethiopia (Chavaillon 1978, 1979), amply demonstrate. Mary Leakey (1971:269) distinguished between the Acheulian and the Developed Oldowan at Olduvai Gorge upon the basis not only of technical features of the bifaces, but also upon biface frequency, requiring that 50 per cent of the tools in an assemblage be handaxes and cleavers for it to qualify as Acheulian. Many authors would now argue that the presence of even a single handaxe in an assemblage renders it Acheulian (eg, Klein et al 1999).

The fundamental question regarding handaxes and cleavers, voiced by Richard Hay 25 years ago, 'But what did they use them for?' (Kleindienst & Keller 1976: 185fn) has yet to find a completely satisfactory answer. Experimental investigation (eg, Jones 1980) clearly shows that 'large cutting tools' (handaxes and cleavers) are well suited for the task of carcass dismemberment and defleshing, but artefact associations do not unequivocally support the early assumption that they were butchery implements. On the one hand, association of bifaces with megafaunal remains at Torralba and Ambrosa, Spain, for example (Howell 1966; Shipman & Rose 1983), does support their use in butchery, as do artefact association, retouch, and microwear at Boxgrove, England (Roberts & Parfitt 1999). On the other hand, many Middle Pleistocene single carcass occurrences that appear to represent butchery episodes have few handaxes or lack bifaces altogether. These include the *Elephas recki* skeletons from Member 1 at Olorgesailie, Kenya (Potts et al 1999), and from FLKN at in Bed I at Olduvai Gorge, Tanzania (Leakey 1971), and the partially dismembered elephant from the contact between the Chiwondo and Chitimwe Formations at Mwanganda, Malawi (Clark & Haynes 1970, Clark et al 1970). Partially dismembered *Hippopotamus* skeletons have been discovered in the Lukingi Member at Isimila, Tanzania (Cole & Kleindienst 1974), and from Gadeb 8F, Ethiopia (Clark & Kurashina 1979). The artefact assemblages in all these occurrences are made up primarily of small flakes, cores, and scrapers, with the addition of rare bifaces or heavy duty implements. Binford (1972) many years ago identified the light-duty artefact array as the essential butchery kit of the Plio-Pleistocene.

No doubt the handaxe, a long-lived and geographically widespread implement, served a variety of purposes in the many different contexts in which it was used. No microwear has yet been detected on east African handaxes, most of which are made of lava. But studies of usewear on handaxes found elsewhere serve to confirm the impression that the handaxe was a multipurpose implement. Binneman and Beaumont (1992) report usewear observed on two late chert handaxes from Wonderwerk Cave, South Africa, dated by U-series and amino acid racemisation on ostrich eggshell to 350–200 ka. Traces resemble those produced experimentally by sedge or wood worked in the presence of abrasive materials, and are comparable to those observed on Later Stone Age adzes. Mitchell (1997) describes microwear on 33 flint handaxes from Boxgrove, England, dating to 400–500 ka (Roberts & Parfitt 1999). Remarkably, all exhibit traces of butchery. Handaxes from Hoxne, England, described by Keeley (1993) exhibit microwear resulting from different activities on different sections of their edges, showing that this single implement was useful in performing a variety of tasks.

**INTERPRETATION OF BIFACE SHAPE**

Gowlett (1984) and Wynn (1979) have maintained that the cognitive requirements for handaxe production are more stringent than those for the manufacture of Oldowan artefacts. Gowlett (1984, 1999) and Gowlett and Crompton (1994) have demonstrated the symmetry and consistency of the ovate shape among the handaxes at Kilombe, Kariandusi, and in the Kapthurin Formation, Kenya, and Gowlett (1984) favours the idea of a target form or mental map. Jones (1994), however, has convincingly shown that the familiar tear-drop shape is a compromise between the minimising of weight and the maximising of the length of cutting edge. That is, handaxes approaching a disc shape are heavy for the length of their edges, whereas long thin handaxes are more difficult to make, break more easily, and have less potential for resharpening.

It would seem indisputable, though, that some idea of a target form was present in the minds of handaxe makers for three reasons. First, specialised techniques are often used for the production of biface preforms. Second, the action of flaking during shaping must be constantly altered or ‘updated’ as the individual maker responds to new flaking angles and irregularities in raw material. And third, the same general form is attained by different means at different localities. The major distinction among industries consists of differences in the type of blank selected or produced, the degree of retouch, and the amount of resharpening of the tool before abandonment.

Dibble (1984, 1987) is to be credited with the ground-breaking insight that Mousterian scrapers owe the form of their edges not to deliberate shaping by their makers, but to the point in the resharpening sequence at
which they were discarded. A subsequent body of thoughtful research on lithic technology focuses upon differences in retouch intensity rather than tool types or target forms as a key to the explanation of variability in lithic assemblages (e.g., Rolland 1981; Dibble 1988; Barton 1990; Davidson & Noble 1993; Jones 1994; Kuhn 1995). McPherron (2000) applies Dibble’s line of reasoning to Acheulian handaxes, and concludes that the broadness of small handaxes is a result of reduction intensity. That is, repeated episodes of resharpening remove more material from a handaxes’s length than from its width. While this may apply to European bifaces made on flint cobbles, it is clearly untrue for east African handaxes. In east Africa, bifaces are most frequently made on large flakes, sometimes produced by specialised methods, such as the Levallois and Tachengit techniques, that predetermine their form. In the Kaphurin Formation, Kenya, for example, broad ovate handaxe preforms are produced by the Levallois technique and transformed into handaxes with minimal retouch (figure 7.2a).

From his observations at Olorgesailie, Isaac (1977) observed nearly 25 years ago that handaxe length and elongation are not independent variables. Clark and Kurashina (1979), through multivariate analysis of handaxes from Gadeb, Ethiopia, came to much the same conclusion. Longer handaxes tend to be narrower, and shorter handaxes are relatively broader. Cole (1961) and Roe (1968, 1981) have both stressed the broad shape of late Acheulian handaxes, but this is to be expected considering their small size. Jones (1994) has clearly shown how the design constraints of knapped stone determine handaxe shape, and the dimensions of the human hand may provide a further constraint on the breadth of these hand-held implements.

Though Wynn (1995) rejects the idea that handaxes had a symbolic function, for some modern researchers the contemplation of handaxe shape has assumed a near-religious intensity. Kohn and Mithen (1999) have even suggested that the manufacture of handaxes functioned as sexual display, and that males demonstrated their fitness by the production of large, symmetrical handaxes. It seems implausible that stone tool manufacture was confined to one sex, and, if so, there is certainly no evidence to establish which sex that was. In addition, Jones (1994) has demonstrated experimentally that handaxes take only a few minutes to make, and thus where raw material is plentiful, they are not expensive in terms of effort. I would go further and suggest that the massive size of some handaxes can be explained in least-effort terms in the same way that the ‘overbuilt’ 14-inch beams of an eighteenth-century New England house are explained. That is, when one begins with a large tree, it is more effort to reduce it in size than to hoist the large beam into place, and since the forest is full of trees, wood need not be conserved. For the large-bodied tropical hominids of the Middle Pleistocene (Walker & Leakey 1993; Kappelman 1997), these handaxes were not overly large or heavy, and a purely functional explanation of their symmetry cannot be dismissed without a better idea of their function.

UNIFORMITY OR VARIABILITY IN THE ACHEULIAN? TEMPORAL TRENDS

Louis Leakey (1951) believed that the concept of progression of increasingly refined handaxes through time was the key to understanding the development of the Acheulian at Olduvai Gorge. ‘Refinement’ in biface shape is generally understood to reflect a high overall number of flake scars and regularity in plan form and cross-section. Cole and Kleindienst (1974) could find little evidence for progressive development in the Isimila Acheulian sequence. Mary Leakey (1971) demonstrated that the degree of refinement in bifaces in the Olduvai sequence does not increase through time. In her words, ‘It can be stated that there is no progressive trend, in the manufacture of bifaces, from Bed II to the Masek Beds, nor does the degree of trimming become more refined in the later occurrences’ (Leakey 1975:492). Handaxes at EF–HR, among some of the most ‘refined’ in the sequence, derive from upper Bed II, date to c. 1.6 Ma (Delson & Van Couvering 2000; Tamrat et al 2000), and are contemporary with Developed Oldowan occurrences containing ‘crude’ protobifaces. On the other hand, ‘crude’ handaxes, with less symmetrical shapes, persist into Beds III and IV at sites such as PDK and WK. Heavy duty artefacts, such as picks, also have a ‘crude’ appearance. They appear in varying proportions in many Acheulian assemblages, such as at Isimila, Tanzania (Kleindient 1961; Cole & Kleindient 1974), Kalambo Falls, Zambia (Clark 1964, 1965; Clark & Kleindient 1974; Sheppard & Kleindient 1996), and Konso-Garduла, Ethiopia (Asfaw et al 1992; Clark 1994), and are the characteristic implement of the Sangoan industry, which succeeds the Acheulian at some sites in tropical Africa (Clark 1970, 1988; McBrearty 1991).

Leakey (1971) explained her observations in the Olduvai sequence through the presence of two traditions, the Acheulian and the Developed Oldowan, which she believed to have been produced by members of different hominid lineages, Homo erectus, maker of Acheulian artefacts, and Homo habilis, responsible for those of the Oldowan and Developed Oldowan. Developed Oldowan assemblages contain essentially the same artefact array as Oldowan samples, with the addition of a few bifaces, and a new implement, the protobiface. According to Leakey (1971:266), protobifaces from Developed Oldowan assemblages in Beds I and II at Olduvai Gorge, ‘do not conform to any particular
Figure 7.2  Middle Pleistocene artefacts from the Kapthurin Formation: (a) unifacial handaxe on Levallois flake, GnJh-03; (b, c) Levallois cores, GnJi-28; (d) blades, GnJH-03; (e) cores, lacustrine facies; (f) point rough-out, GnJH-63; (g) informal point, GnJi-28; (h) point, GnJh-17; (i) small handaxe, GnJH-63; (j) pick, GnJh-51. Scale in centimeters.
pattern or technique of manufacture but appear to represent attempts to achieve a rudimentary handaxe by whatever means was possible.’ These date to c.1.65–1.3 Ma (Delsom & Van Couvering 2000; Tamrat et al 2000). Leakey (1971) noted, however, that protobifaces may in fact exhibit more flake scars than Acheulian handaxes. Jones (1994) interprets these as very retouched handaxes that were discarded when their edges had become too obtuse for further resharpening, and whose symmetry is marred by failed attempts at flake detachment.

Isaac (1972a, 1972b) provided an alternate explanation for the lack of stylistic or technical ‘progress’ in the Acheulian through his ‘random walk’ model. He emphasized the random variation to be expected both across space and through time in the skill with which artefacts were made (Isaac 1972b, 1977). His model involves a small number of morphologically and socially acceptable traditional tool patterns, low population densities, and a lack of ethnic boundaries. Operating over long spans of time, he saw these factors as resulting in a homogenous tradition with great resistance to fundamental change. Isaac envisioned change through time as a result of random drift of craft norms within fairly wide technological and social limits, seldom producing any discernible directional trends. Random variation and stochastic events operating within such a system can explain the persistence of early tool types, such as choppers, or ‘crudely’ executed tools, such as protobifaces, with no need to invoke the persistence of distinct cultural traditions or hominid lineages.

The views of Isaac and Leakey are difficult to reconcile in the current state of our knowledge. It would seem logical that stone tools produced by different hominid species should be readily distinguishable, because artefacts are part of an adaptive system, and the adaptations of hominid species are to some extent differentiated by competitive exclusion. Stone tools seem to have appeared at the same time as the genus Homo at ~2.5 Ma (Hill et al 1992; Semaw et al 1997). With the proliferation of species of Homo recognised in the Earlier Pleistocene (eg, Wood 1992) it seems inescapable that more than one of them was responsible for making Oldowan tools, but the design constraints imposed by this simple technology increase the likelihood that tools produced by different groups will resemble one another. There is some evidence, though, for industrial differences in the Earlier Pleistocene of east Africa. The Oldowan in lower Bed I at Olduvai Gorge and the KBS industry in Interval I of the Koobi Fora Formation are nearly precisely contemporary at 1.9–1.8 Ma. These industries are very similar in nearly all aspects save artefact size, which is a function of raw material size. Yet spheroids and subspheroids are present in the Oldowan and absent in the KBS industry (Leakey 1971; Isaac & Isaac 1997). It has been suggested that spheroids were used as missiles (Leakey 1971) or as plant processing implements (Willoughby 1990, McBrearty 1990), or that they are simply repeatedly used hammerstones (Sahnouni et al 1997). In Interval III in the Koobi Fora at 1.6–1.4 Ma, the Karari industry exhibits the distinctive Karari scrapers that thus far appear to be unique to the sites on the Karari escarpment. These artefacts may have functioned as pushplanes or may simply be unusual cores. The Karari industry, while contemporary with the Acheulian elsewhere, lacks handaxes and cleavers (Harris & Isaac 1976; Isaac & Isaac 1997). Whatever the function of spheroids, handaxes, or Karari scrapers, the geographic distributions of these artefacts suggest, at the very least, differences in adaptation or motor habits on the order of that seen as ‘cultural’ differences in tool use among populations of chimpanzees (Boesch 1993; Boesch-Achermann & Boesch 1994). It is also possible that they were made by members of different hominid species.

The record shows that the manufacture of handaxes was not confined to a single hominid species. The earliest handaxes from Kokisele 4, West Turkana, at ~1.75 Ma (Feibel et al 1989; Roche & Kibunjia 1994), and at EF–HR in upper Bed II, Olduvai Gorge, at 1.6 Ma (Walter et al 1991, 1992; Tamrat et al 1995), are contemporary with Homo ergaster at Koobi Fora and Nariokotome (Feibel et al 1989; Wood 1991, 1992; Brown 1994), but handaxes persist in Africa into the span of Homo rhodesiensis and Homo helmei (McBrearty & Brooks 2000). Handaxes are known from India where they were probably produced by the population represented by the Narmada cranium, and from the Arabian Peninsula, where the identity of their makers is unknown. It has recently been demonstrated that handaxes, presumably made by Homo erectus, are present in China, where they date to 800 ka (Yamei et al 2000; Potts et al 2000).

Clearly no single hominid species was ‘hardwired’ to produce handaxes. The handaxe may have remained part of the hominid adaptive repertoire that was called upon when needed, or it may have been repeatedly reinvented. In Europe, small handaxes, made by Neanderthals, are found in the Mousterian of Acheulian tradition (MTA). Redating of the classic French Mousterian sites, primarily by TL and AMS $^{14}$C shows that the MTA occurs late in the Middle Paleolithic, at 55–40 ka (Valladas et al 1987; Mellars 1996, 1998), overlying deposits many metres thick that lack handaxes and represent an interregnum lasting tens of thousands of years. The Lazarus-like reappearance of the handaxe implies the rediscovery of the form by hominids who presumably had no tradition of biface manufacture. This is less puzzling in light of the work of Jones (1994), who shows that the compromise between weight and length of cutting edge converges upon the familiar teardrop
shape. It can be argued that the foliate shapes of projectile points in Africa, Europe, the Near East, and even the New World likewise demonstrate the design constraints inherent in fractured stone that were rediscovered repeatedly throughout prehistory.

**UNIFORMITY OR VARIABILITY IN THE ACHEULIAN? GEOGRAPHIC TRENDS**

Wynn and Tierson (1990) have examined the notion of global uniformity in the ‘Later’ Acheulian through an application of analysis of variance and discriminant function analysis to handaxe plan form measured by means of a system of polar coordinates. Their unexpected results distinguish between a ‘narrow’ English group, a ‘wide’ Israeli group, and a ‘normal’ east African group. Interestingly, they were able to duplicate the results of Roe (1968, 1981), who, by means of his now familiar method of comparison of length, breadth, and thickness indices, had discovered shape differences in British biface shape that he believed to represent a temporal trend in biface shape from narrow to broad. Wynn and Tierson (1990) discount the role of raw material as an explanation for biface shape, noting that in the Israeli sample, all the bifaces are broad despite their having been manufactured in tabular flint at one site and on flint pebbles at another. They suggest that variation in learned technological traditions, that is, cultural differences, may explain the variation in handaxe shape, but they are unable to dismiss the possibility of temporal change. Indeed, the precise ages of the sites from which their measured handaxes are drawn are poorly known, and recent redating of the east African sites (eg, Deino & Potts 1990) shows that they do not represent ‘Later’ Acheulian occurrences, but in fact probably predate the English occurrences by ~500 ka (cf Roebrooks 1994; Roebrooks & van Kolfschoten 1994, 1995). Furthermore, through discriminant function analysis, Crompton and Gowlett (1993) have distinguished between concentrations of ‘narrow’ and ‘broad’ handaxes excavated at different locations on the same occupation horizon at Kilombe, Kenya, where shape differences are clearly not the result of geographic or temporal trends. Within site variation may simply be a function of artefact size, or it may reflect differences in functional requirements, stylistic traditions, or individual motor habits among knappers.

Because handaxes are found nearly everywhere in Africa, and because they persist in the record for well over a million years, archaeological uniformity for the Middle Pleistocene of Africa has repeatedly been asserted. In fact when east African Middle Pleistocene assemblages are examined, three different kinds of variety emerge: first, different handaxe manufacturing methods; second, different flake production methods; and third, the presence assemblages lacking handaxes altogether. These three sources of variability are briefly discussed here.

**BIFACE PREFORMS AND THE AFRICAN CLEAVER**

The thinness and regularity of shape of many African handaxes is not due to a greater degree of retouch, but to the fact that they are made on large flakes, whose proportions to some extent predetermined those of the finished product, and which required minimal retouch. The detachment of large flakes for biface manufacture was thought by Isaac (1969) to have been a significant technological advance of *Homo erectus* over *Homo habilis*, and he hypothesised that ‘the primary innovation was the discovery of how to strike the big flake, with the form of the handaxes and cleavers being later fixed because these shapes proved to be particularly useful’ (Isaac 1982:239f). This method of manufacture of course requires raw material in the form of large blocks, whereas choppers and, perhaps, protobifaces can be made on cobbles. The distribution of lava outcrops may thus go far to explain differences between Acheulian and Developed Oldowan occurrences at Olduvai (Stiles 1991).

This approach seems to have been brought to its logical conclusion in African stone working techniques that produced biface preforms (eg, Texier & Roche 1993; Roche & Texier 1995). In South Africa, the method of producing large flakes from radially prepared cores was termed the ‘Victoria West’ technique by Goodwin (1934), after a surface locality in the Northern Cape Province. The resulting flakes have been termed ‘para-Levallois’ by Bordes (1961), though there seems little basis upon which to distinguish them from ‘true’ Levallois débitage (cf Isaac 1982:240). Their flaking axis is generally perpendicular or oblique to their long axis. In the Kapthurin Formation, the method used to produce biface preforms is clearly Levallois in concept (cf Boëda 1990, 1995; Van Peer 1992), and their flaking axes and long axes coincide (Gowlett 1984; McBreairey et al 1996; McBreairey 1999a). South African assemblages containing ‘Victoria West’ elements are undated (Goodwin 1934; Mason 1962; Sampson 1974; Volman 1984), but in the Kapthurin Formation the Levallois approach to biface blank production dates to between ~285 ka and ~510 ka (Deino & McBreairey under review).

African cleavers are virtually without exception made on large flakes, and this alone goes far to explain the rarity of cleavers in Europe. While flakes of the appropriate size could be struck from large blocks of tabular flint, it is practically impossible to produce this type of artefact using the nodular flint of the size available throughout much of the European continent. Cleavers are not to be confused with handaxes having
bits achieved by retouch or by a tranchet blow (*biface à biseau transversal ou terminal*) (Inizan et al 1999). Rather, the cleaver, by definition, exhibits a bit formed by the intersection of its untrimmed primary ventral flake surface with its dorsal surface (*hachereau sur éclat*). The cleaver bit itself is never retouched (Tixier 1957; Kleindienst 1962; Clark & Kleindienst 1974; Inizan et al 1999). The production of cleaver preforms by the Levallois method is termed the Tachengit technique (Isaac 1982:240; Clark 1994, 1996), after the site in Algeria where it was first described (Tixier 1957). In the more specialised Tabebula technique, divergent cleavers are made on plunging (*outrepassé*) Levallois flakes (Tixier 1957; Inizan et al 1999). The Kombewa method, first defined by Owen (1940) on the basis of material from a site of the same name in western Kenya, involves the use of a large flake, usually with a prominent bulb of percussion, as a core from which the Kombewa flake itself is detached. The resulting flake, with a bulb on each face, is sometimes referred to as a ‘Janus’ flake. Kombewa flakes are particularly suited for the production of cleavers (Balout 1967; Clark 1994). At Isenya, Kenya, 2–3 per cent of the cleavers from the upper level are made on Kombewa flakes (Tixier 1996b).

**FLAKE PRODUCTION IN THE MIDDLE PLEISTOCENE**

Most research has focused on the *foossiles directeurs* (handaxes and cleavers) of the Acheulian at the expense of the *débitage*, but flakes, cores, and the debris of flake production make up the bulk of the artefact array at most stone age sites. Flaked stone technology is by its very nature conservative, and the basic design principles seem to have been grasped very early. Toolmakers whose handiwork has been recovered at the site of Lokalalei 2C, West Turkana, Kenya, dating to 2.34 Ma, were capable of perceiving and maintaining the correct platform angle, and applying the appropriate force to produce series of more than 20 flakes from a single core (Roche et al 1999). Some design solutions, such as the radially flaked or ‘disc’ core, were arrived at as early as 1.8 Ma (Leakey 1971), and persisted well into the Holocene (Moore 1982; McBrearty 1999b). However, a variety of novel flake production techniques make their appearance in the African Middle Pleistocene. Levallois technology has been considered an ingredient of Terminal Acheulian (‘Fauresmith’) technology (Goodwin & Van Riet Lowe 1929; Van Riet Lowe 1945; Humphreys 1969; Binneman & Beaumont 1992), but this inference was based upon material from undated surface occurrences. The presence of Levallois cores for the production of handaxe blanks before 285 ka in the Kapthurin Formation has already been mentioned. Smaller, very formalised Levallois cores were known from the site of GnJi-28 (Rorop Lingop) in the Kaptthurin Formation (figure 7.2b, c), but until recently the stratigraphic position of this occurrence was unclear (McBrearty et al 1996). Geochemical analysis of tephra units within the Kaptthurin Formation (Tryon & McBrearty, under review) now shows that this occurrence also predates 285 ka (Deino & McBrearty, under review).

Blades are also present, in association with handaxes, in deposits dating to between 510 ka and 285 ka in the Kaptthurin Formation (figure 7.2d). This material is thus roughly contemporary with the Acheulo-Yabrudian at Tabun, Israel (Bar-Yosef 1998), with which it shares a superficial resemblance. At the site of GnJn-03, between 20 per cent and 30 per cent of the cores can be classified as blade cores, while about one-quarter of the excavated flakes can be classified as blades (Leakey et al 1969; Cornelissen, 1992). Refitting of conjoined sets and blade replication shows that both Levallois and non-Levallois techniques of blade production were practised, and blades show both plain and faceted platforms. Both unidirectional and bidirectional blade removals are represented, and some cores approximate a semicylindrical or prismatic plan. The resulting blades (figure 7.2d) are remarkable in their length, thinness, and flatness, and clearly demonstrate the presence of a fully conceptualised, well-executed method of blade production, and high level of technical competence in east Africa before 285 ka (Tixier 1996a; McBrearty et al 1996; McBrearty & Brooks 2000). Blades are very common in the succeeding Middle Stone Age, especially in South Africa.

‘HANDAXE-FREE’ INDUSTRIES

Middle Pleistocene lithic artefact occurrences lacking handaxes have long been known from Europe, where on the continent they are often referred to the Tayacian industry (Bordes & Bourgon 1951, Rolland 1986); in England, they are attributed to the Clactonian industry. A useful review of the current state of research into the Clactonian is provided by White (2000). Early workers in England envisioned a local development of the Acheulian out of the Clactonian (Oakley 1949; Wymer 1974). Others, following Breuil (1932) have considered the Clactonian and Acheulian as evidence for the existence of culturally or biologically distinct ‘parallel phyla’ in Stone Age Britain. In Africa occurrences without handaxes were formerly referred to the ‘Hope Fountain’ and considered a tradition independent of the Acheulian (Jones 1929; Clark 1950; Posnansky 1959; Mason 1962). While there is no *a priori* reason to reject the possibility of multiple contemporary hominid species in either England or east Africa, Acheulian and ‘biface-free’ occurrences do not provide indisputable support for it. The basic flake and core component of the Clactonian, the ‘handaxe-free’ African occurrences, and much of the
Acheulian are indistinguishable (Isaac 1972a, 1977; Clark 1982; Gowlett 1986; White 2000). The Acheulian and the ‘Hope Fountain’ are now normally considered activity variants of a single technological system (Kleindienst 1961; Clark 1970; Isaac 1972a).

Isaac (1977) notes that bifaces make up between 0 and 95 per cent of the assemblages from occurrences at Olorgesailie. Our ability to explain this variation is hampered by our ignorance of biface function, but most attempts at explanation involve environmental factors. Mithen (1994) has speculated that British Acheulian artefacts were produced by hominids living in large groups in cold, open habitats, while Clactonian artefacts were made by hominids living in smaller groups in closed temperate woodlands. According to this scenario, the Acheulian tradition was maintained by enhanced social learning in large groups, while circumscribed communication in small groups encouraged trial and error learning and limited the transmission of innovation. Mithen cites no examples of the effects of forest dwelling on social organisation among living human groups, but it is interesting to note that the Primate order, which is overwhelmingly arboreal, is characterised by heavy reliance on social learning. From site distribution and palaeohabitat reconstruction, Roebrooks et al (1992) have questioned whether European Middle Pleistocene hominids were even capable of subsisting in heavily wooded habitats. McNabb & Ashton (1992) effectively refute Mithen’s hypothesis on empirical grounds, pointing out that the environments indicated for Clactonian and Acheulian are identical, both probably consisting of a mosaic of wooded and more open habitats near sources of water.

The discovery of handaxes at Boxgrove probably dating to ~500 ka (Roberts & Parfitt 1999) has demonstrated that the Clactonian does not represent the earliest occupation of England, and has shown that the independent development of the Acheulian out of the Clactonian is unfounded. But White (2000) seems to argue for an updated ‘parallel phyla’ model, a pattern of alternating occupation of England by Clactonian and Acheulian groups. He equates the Clactonian arrivals with the onset of temperate conditions during the Hoxnian and subsequent warm episodes. In each case he believes they were replaced by populations with handaxes in their lithic repertoire. While opening up interesting areas for conjecture, both White’s and Mithen’s reconstructions are flawed by the lack of a precise chronology for Pleistocene Britain. Local habitat reconstructions in many cases are based upon redeposited and time-averaged faunal suites, and age estimates rely upon correlation with isotopic stages recognised in distant marine cores.

In east Africa, where chronology is not dependent upon climatic correlation, a case can be made for an environmental distinction between penecontemporaneous occurrences dominated by bifaces and those in which bifaces are rare or absent. Kleindienst (1961), Isaac (1972a, 1972b, 1977), Binford (1972), and others have demonstrated that the numbers of bifaces and small scrapers are inversely proportional in the Olorgesailie occurrences. At Olorgesailie, in deposits now dated to ~900–700 ka (Deino & Potts 1990), Isaac (1977) showed that biface-dominated assemblages are associated with sandy deposits and channel features, but do not exhibit the size-skewing or abrasion that would suggest winnowing of small pieces by hydraulic processes. Further work in Member I at Olorgesailie (Plummer & Potts 1989; Potts et al 1999), dated to 992–974 ka (Deino & Potts 1990), illustrates flake-dominated assemblages that occur in a lakeshore environment. Leakey (1971) documented a similar dichotomy between Acheulian occurrences in stream deposits and flake-dominated occurrences in palaeolakeshore settings in Bed II at Olduvai Gorge, Tanzania, now dated to 1.33–1.65 Ma (Walter et al 1991, 1992; Tamrat et al 1995; Delson & Van Couvering 2000). At sites in the Middle Awash, Ethiopia, dated to ~600 ka (Clark et al 1994), and at localities in the Kapthurin Formation, Kenya (eg, sites GnJh-31, GnJh-32, GnJh-57), dated to ~540–575 ka (Deino & McBrearty under review), flake and core occurrences lacking handaxes have likewise been documented in lacustrine settings (McBrearty et al 1996; McBrearty 1999a).

At the Kapthurin Formation sites, small cobbles were selected for the production of flakes from simple, adjacent platform, or radial cores (figure 7.2c). The absence or rarity of handaxes does not seem to be explained by raw material availability (McBrearty 1999a), because basalt flows are located in the immediate vicinity of some sites (eg site GnJh-57). These examples lend support to the idea that activities carried out in an African Middle Pleistocene lakeshore environment did not require large numbers of bifacial tools. Before uncritically accepting this hypothesis, though, it would be wise to contemplate the cautionary tale provided by the Clactonian. Although the distinguishing feature of this industry is the absence of bifaces, handaxes are now reported in small numbers from several classic Clactonian sites, including Clacton-on-Sea itself, and both Barnfield and Rickson’s pits at Swanscombe (McNabb & Ashton 1992; Ashton & McNabb 1994; White 2000). It must be recalled that many east African Middle Pleistocene occurrences contain a proportion of formal tools that is <2 per cent of the total assemblage (eg, Isaac 1977; McBrearty 1981, 1988; Tryon & McBrearty under review), and the possibility is high that handaxes may be absent from ‘handaxe-free’ assemblages due to sampling bias. The rarity of formal tools at many sites is also problem in clarifying the end of the Acheulian tradition.
THE ACHEULIAN TO MIDDLE STONE AGE TRANSITION

At some point during the Middle Pleistocene in Africa, handaxes and cleavers ceased to be manufactured, and were replaced by points. This signals the Acheulian to Middle Stone Age (MSA) transition, the most conspicuous archaeological event in the African Middle Pleistocene. It indicates a technological reorganisation involving a switch from hand-held to hafted implements. Early points are present at Gademotta, Ethiopia, dated by K/Ar to 235±5 ka (Wendorf et al 1994), and at Bir Tarfawi and Bir Sahara East, Egypt, dated by a variety of methods (OSL, AAR, ESR, TL, U-series) to ~230 ka (Miller et al 1991; Wendorf & Schild 1992; Miller 1993; Bluszcz 1993; Schwarcz & Grün 1993). Recent dating efforts in the Kaphurin Formation show the Acheulian to MSA transition here to have occurred in this region about 50 ka earlier. The portion of the Kaphurin Formation that preserves late Acheulian and early MSA sites lies within and beneath the Bedded Tuff member, in sediments bracketed by 40Ar/39Ar dates of ~510 ka and ~285 ka (Deino & McBreyt under review). Quantitative geochemical analyses of volcanic tephra with electron microprobe from this part of the section (Tryon & McBreyt under review) have established the precise stratigraphic relationships among sites. Points, though rare, are now known to be present in the Kaphurin Formation at several sites (GnJh-17, GnJh-63, GnJi-28; figure 7.2f–h) in this stratigraphic interval.

Because of the similarity of the basic flake and core artefact inventory shared by Acheulian and MSA sites (cf McBreyt 1988; Sheppard & Kleindienst 1996; Clark 1999), and the rarity of formal tools in many assemblages, the precise timing of the Acheulian–MSA transition remains very difficult to pin down. A few examples from the Kaphurin Formation will serve to illustrate this issue. The site of GnJh-15, dating to ~285–500 ka (Deino & McBreyt under review) was excavated by a Belgian team in the 1980s (Cornelissen et al 1990; Van Noten 1982; Van Noten et al 1987a, 1987b ) and by McBreyt in 1997 (McBreyt & Brooks 2000). Here, artefact density is low, and formal tools infrequent. The total number of artefacts, excavated from an area of >600 m², exceeds 6000, but the number of formal tools, including fragments, is <30, or 0.5 per cent of the total assemblage. Of these, two are small bifaces, and one a bifacially worked pointed piece that could be the tip of either a handaxe or a point. These results are preliminary, and precise numbers may change with further analysis, but one might well query whether this assemblage should be termed Acheulian on the basis of so few diagnostic pieces. Obviously the bifaces might easily have been missed had a smaller area been excavated.

At the site of GnJh-63, excavations in 1999 revealed a small flake and core assemblage (n < 100) containing one small handaxe (figure 7.2i), overlain by a horizon containing a single point rough-out (figure 7.2f). Sites GnJh-15 and GnJh-63 are bracketed by 40Ar/39Ar dates of 509±9 ka and 284±12 ka (Deino & McBreyt under review), and the point from the site of GnJh-17 excavated by Cornelissen (1992) (figure 7.2h) lies in the same interval. Again, the very small numbers of artefacts and their potential ambiguities warrant caution, but these results indicate that the Acheulian to MSA transition was underway in this part of east Africa before 285 ka. At the site of Rorop Lingop (GnJi-28), surface collection and test excavation reveal an industry containing small handaxes, points (figure 7.2g), and Levallois debitage (figure 7.2b, c). This inventory is consistent with descriptions of material formerly termed Fauresmith, but further examination is needed to determine if the assemblage is in secure context. An additional concern is the intergradation of artefact classes. Handaxes at Rorop Lingop are small, appear to be made on flakes, and grade into points. Handaxes also grade into the class of radial or disc cores, in which elongated examples may resemble bifaces.

Picks, characteristic of the Sangoan industry, have been found at some Kaphurin Formation localities (figure 7.2j), including GnJh-17 and GnJh-51 (Cornelissen 1992, 1995; McBreyt et al 1996). Some occurrences in the Kaphurin Formation (eg, GnJi-28) contain both handaxes and points, mirroring the findings of Chavaillon et al (1978, 1979) at the site complex of Melka Kunturé, Ethiopia. Unlike Melka Kunturé, however, the Kaphurin Formation exhibits interstratification of sites that can be classified as Acheulian, Sangoan, Fauresmith, or MSA on the basis of diagnostic artefacts (Tryon & McBreyt under review). These findings emphasize the dangers of the use of fossiles directeurs and the failings of the African three-age approach. They also demonstrate that the Acheulian–MSA transition was not a simple, unidirectional process.

IMPLICATIONS: THE TRUE MEANING OF THE ACHEULIAN TO MSA TRANSITION

There is undoubtedly a great deal of variability in both the Acheulian and the MSA, and the variation seen within each may be as great as the differences between them. This variety may reflect the presence of different hominin populations or species, or adaptations to different habitats or task-specific situations by populations with substantial technical competence and a wide repertoire of stone-working methods at their disposal. Even stratigraphically intact sites may have accumulated over time and may represent the activities of distinct groups and different prevailing local conditions. This review has highlighted the ambiguities inherent in the
use of the current concepts of the Acheulian and MSA as both technological and temporal entities, and the practical difficulties encountered when relying upon *fossiles directeurs*. The shift from hand-held to hafted tools revealed by the replacement of the handaxe by the point is important, but the total system of technological organisation, and its social context, must be understood in order to appreciate the significance of the Acheulian to MSA transition.

McBrearty & Brooks (2000) have reviewed the evidence in the African MSA for behaviours usually considered characteristic of modern humans. It is not proposed to repeat all this evidence here, but it is worth noting that a number of important behaviours, usually thought to be confined to the Upper Palaeolithic in Europe and the Later Stone Age in Africa, are now known to occur in the African Middle Stone Age. Regions of Africa not inhabited during preceding periods were occupied during the MSA, and this has long been argued by Clark (1965, 1970, 1988, 1993) to indicate the increased competence of MSA hominids.

MSA points are an important development in projectile technology, and, as stated here, they predate 285 ka in the Kaphurin Formation. Well-executed blades of a similar age are found at the site of Gnjh-03 (Leakey et al. 1969). Symbolic behaviour is suggested by the presence of >70 items of red ochre, with a combined total weight of >5 kg, that have been found at the site of Gnjh-15, also dating to >285 ka. Early pigment has also been reported from the site of Twin Rivers, Zambia, at ~230 ka (Barham & Smart 1996; Barham 1998), and pigment is frequently encountered in MSA sites in South Africa postdating ~130 ka. It is suggestive that these behaviours first appear at approximately the same time as *Homo helmei*, dated at Florisbad, South Africa, to ~260 ka (Grün et al. 1996; Brink & Grün 1998). The behavioural similarity of this species to *Homo sapiens* supports the suggestion, made on anatomical grounds, that these two species are identical (Stringer 1996, 1998).

If so, *Homo sapiens* has a time depth that is similar to or identical with that of the MSA, and the new technological and social developments may have driven the anatomical changes seen in the hominid fossils.

Traces of behaviours commonly held to signal modern cognitive abilities and cultural behaviour continued to accumulate during the subsequent late Middle Pleistocene and early Later Pleistocene of east Africa (McBrearty & Brooks 2000). The transport of obsidian for distances ~200 km has been reported for MSA occurrences at Muguruk, Kenya, and Mumba and Nasera, Tanzania (McBrearty 1988; Mehlman 1989; Merrick & Brown 1984, Merrick et al. 1994). U-series dates indicate an age for the occurrence at Mumba of ~130 ka (Mehlman 1989). Elaborate bone points dating to >75 ka are known from three sites at Katanda, People's Republic of Congo (Brooks et al. 1995; Yellen et al. 1995; Yellen 1998). Fishing, use of small scale resources, formal bone tools, incised items of bone, stone, red ochre, and microliths are all present at MSA sites in Africa predating 70 ka; personal adornment in the form of ostrich eggshell beads appear at ~50 ka at Enkapune ya Muto, Kenya, and Mumba, Tanzania (Ambrose 1998; Hare et al. 1993; Mehlman 1989, 1991; McBrearty & Brooks 2000 and references therein). While not strictly speaking part of the Middle Pleistocene record, these items reflect the continuation of a trend begun as early as 300 ka. The abandonment of the handaxe and adoption of the point signal the beginning of a reorganisation of technology. The interplay of cultural processes and anatomical responses that resulted in the modern human adaptation therefore has roots that penetrate deep into the Middle Pleistocene of Africa.

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