Acheulian Large Flake Industries
Technology, Chronology, Distribution and Significance

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by
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Chapter 1: Introduction

Background

The Acheulian culture, which persisted for over one and a half million years, is attested in diverse environments and over wide geographical expanses. The hallmark of Acheulian culture is its large cutting tools (LCTs), primarily handaxes and cleavers (see Isaac 1968 for a comprehensive overview of the history of Acheulian research and the development of its terminology). Indeed, the culture itself was named after the site of St. Acheul on the terraces of the Somme River, France, where handaxes were first identified as prehistoric stone tools (Boucher-de-Perthes 1847, 1864), an identification supported by finds from the Thames Valley (Evans 1872, 1897). LCTs very likely emerged in East Africa more than 1.5 million years ago (mya) but have been reported from a wide range of areas, spanning South Africa to Northern Europe, and India to the Iberian Peninsula. The aim of this study is to compare assemblages from geographically diverse sites characterized by the production of LCTs based on large flakes (see below) in an attempt to assess their technological, morphological, and typological suitability for grouping together as a common stage within the Acheulian techno-complex.

The fact that large flakes (over 10 cm in maximal diameter) were employed as LCT blanks (i.e. the objects on which tools were shaped; see below) was acknowledged from the outset of Acheulian study, although it rarely received due attention. This is somewhat surprising, as this technological feature can potentially reveal information on fundamentals of human behavior during the Early and Middle Pleistocene. A possible explanation for this oversight might lie in the fact that at the close of the nineteenth century Northwestern Europe was the center of prehistoric research. As a result, the Acheulian culture was defined and categorized in accordance with finds from this region, which comprise many types of handaxes, produced almost exclusively from flint nodules and river cobbles. In the next stage of research, an alternative view of the earliest phases of human culture was established in South Africa (Goodwin and van Riet Lowe 1929), but it too was strongly influenced by European views (Breuil 1930; Schlanger 2005). The terminology and approach established by European scholars also provided the basis for most of the early studies on Acheulian assemblages in the Levant (Garrod and Bate 1937; Neuville 1931), East Africa (Leakey 1951), and other regions.

During the 1950s and 1960s, highly significant methodological advances occurred in the study of the European Acheulian. These included Bordes's typological classification of Lower and Middle Paleolithic stone artifacts (Bordes 1961) and the methodology developed by Roe for describing UK handaxes (Roe 1964, 1968). However, outside Europe, particularly in East and South Africa, discoveries were being made that demonstrated the inability of the European format to encompass the full range of the Acheulian techno-complex. Large assemblages from well-excavated sites like Olduvai Gorge (Leakey 1971), Isimila (Howell et al. 1962), and Olorgesailie (Isaac 1968) could not be accommodated by the Western European perspective of the Acheulian scheme. The LCTs in each such site numbered in the thousands, a density of finds unprecedented in most European assemblages. Tool types not represented in Europe (such as cleavers) were present in these assemblages and, in contrast to the almost exclusive use of flint in European tools, many types of raw material were exploited. In addition, a variety of knapping techniques and methods were employed. The African finds also included Pre-Acheulian stone tools, many of which are unparalleled anywhere in Europe. This fact, along with advancing methods of radiometric dating, indicated that finds from Africa range over a much wider timescale than do those originating in the European Acheulian.

As a result of these discoveries, supplementary research methods and approaches were introduced. A framework for the study of such Pre-Acheulian assemblages as the Oldowan and the Developed Oldowan was established by M. D. Leakey (Leakey 1971, 1975); Kleindienst developed an alternate typology for the African Acheulian (Kleindienst 1962); Tixier suggested a cleaver typology based on his study of North African Acheulian assemblages (Tixier 1957); Roe revised his methodology to accord with the new range of African Acheulian LCTs (Roe 1994, 2001a); and in his investigations of the site of Olorgesailie, Isaac (1968, 1977) introduced new approaches to the study of the Acheulian. All of these notwithstanding, European sites and approaches have apparently remained the focal point of a large segment of Acheulian research. It is the purpose of this study to address other regions, concentrating on large-flake-based (LFB) Acheulian industries, their implications and their significance.

Large-Flake-Based (LFB) Acheulian Industries and Cultural Change

The systematic use of large flakes as blanks was reported to have been common practice in the Acheulian technology of South Africa (Goodwin and van Riet Lowe 1929; Söhnge et al. 1937; van Riet Lowe 1945, 1952), East Africa (Howell and Clark 1963; Kleindienst 1962), North Africa (Balout and Tixier 1957; Biberson 1961; Tixier 1957), the Levant (Stekelis 1960), India (Corvinus 1983b), and other LFB regions. Kleindienst defined a "large flake" as one larger than 10 cm (Kleindienst 1962), a definition accepted by most researchers. Isaac (1969, 16) was the first to suggest that the production of large flakes may have played a significant role in the development of human culture:

> "It appears possible that a 'threshold' exists in stone technology, so that certain techniques are either present or absent and intermediate expressions are virtually non-existing. The tools and debitage of two assemblages may differ markedly as a consequence of application or non-application of only one specific technique: a possible example of this is the removal of blades with a punch. All African Acheulian industries of confirmed early Middle Pleistocene date involve the manufacturing of tools from large flakes (i.e. greater than 10 cm); whereas no series of flakes of this size have been reported from any Oldowan assemblage… It is suggested that the striking of large flakes involved the 'formulation' of a set of deliberate techniques quite separated from those used in the flaking practiced throughout the time span of the Oldowan."

Isaac was followed by M. D. Leakey, who adopted the ability to strike large flakes as a technological boundary separating the Developed Oldowan from the Acheulian cultures of Olduvai Gorge (Leakey 1975). However, to date no extensive study has been devoted exclusively to the role of large-flake technology in the development of the Acheulian.

The Earliest Acheulian and Large-Flake Production

A virtually unknown age, about which little has been published, separates the Acheulian's point of emergence (ca. 1.5 mya) from its peak (ca. 1 mya). The earliest evidence of the use of large flakes in tool production is probably provided by the Karari scrapers of Koobi Fora, East Turkana Lake, Kenya (Harris 1978; Isaac 1997). These crude steep scrapers, unifacially shaped on large flakes, were found in the lower part of the Okote Member and dated to 1.5–1.6 mya. However, since no bifacial tools were fashioned from similar large flakes, the identification of the Karari scrapers as tools rather than as a source of flakes has been questioned (Isaac 1986). No assemblages parallel to the Karari industry have been reported from any other site, rendering us unable to discuss further their significance as Acheulian large flakes.

Somewhat in contradiction to Isaac and Leakey, intensive use of large-flake technology does not feature in early Acheulian site data. The earliest reported Acheulian site (1.6 mya) is in West Turkana, Kenya (Roche 1995). Apart from the fact that an Acheulian industry was identified there, very little information has been made available. At Konso Gardula, Ethiopia, an Acheulian industry was reported (Asfaw et al. 1992) in association with tuff that was dated to 1.34–1.38 mya, resulting in a suggested age of 1.4 mya for the assemblage. Most of the tools in this instance are large (sometimes very large – up to 27 cm) handaxes and trihedrals, shaped on cobbles, with a cortical butt and deep flake scars. Cleavers are very rare and no spheroids are present. The tools are made of basalt, quartz, quartzite and volcanic rocks, and no use of large flakes has been reported. The Early Acheulian at Koobi Fora has been dated between 1.5 and 1.2 mya at only three sites: FxJj 63, 33, and 37. At these sites, the Early Acheulian knappers produced flakes larger than 12 cm from large cores, predominantly utilizing them as blanks for the production of large picks. Handaxes are rare and the assemblages from all three sites are atypical (Isaac 1997). Other East African sites that are reported to be very early, or to present very early features of the Acheulian industry, are Peninj, Tanzania (Dominguez-Rodrigo et al. 2001; Isaac 1967; Isaac and Curtis 1974), Gadeb in the high plateau of Ethiopia (Clark 1987), and such localities in Melka Kunture, Ethiopia (Chavaillon and Piperno 2004) as Simbiro III and Garba XIII. In South Africa, the assemblage from Sterkfontein Caves Member 5 has been attributed to either Developed Oldowan (Leakey 1970) or Early Acheulian. Renewed excavation at the same site (Kuman and Clarke 2000) has yielded a date of 1.7–1.4 mya for the layer's lithic assemblage, and its categorical classification as Early Acheulian. The finds in the site included relatively numerous handaxes; a shift from quartz, the primary raw material source, to quartzite; and, most importantly, the appearance of a small but significant number of large flakes (n=7) in the assemblage (Kuman and Clarke 2000, 835). In North Africa, the site of Thomas 1 Quarry, Casablanca, is probably the earliest Acheulian site. It has been determined that it is older than 1 mya, due to the presence of *Kolpochoerus* (an ancient suid) in its faunal assemblage (Raynal et al. 2001; Raynal and

Texier 1989). The site's lithic assemblage consists of rough bifaces, with no cleavers or large flakes being reported.

Through her research at Olduvai Gorge, M. D. Leakey concluded that a site can be attributed to the African Acheulian if over 40% of its tool assemblage comprises bifacial tools (Leakey 1971). In a later publication, Leakey (1975) emphasized that LCT technology is the crucial element in classifying a site's assemblage. Taking this factor into consideration, she transferred some of the early Olduvai Gorge sites (MNK and TK Lower Floor), which had initially been categorized as Developed Oldowan in their lithic tradition, to the Acheulian category, regardless of the fact that the percentage of bifacial tools in these sites was lower than 40%. In this context, it is worth noting that some sites that are contemporary with the Acheulian lack bifacial tools in their lithic assemblage, although several scholars have supported their classification as Acheulian (Clark 1998; Heinzelin et al. 2000; see also discussion and references in Tryon 2003). I mention these only as a reminder that the overall picture of the Acheulian techno-complex is very intricate.

The first recorded Acheulian site in Olduvai Gorge, EF-HR, in the upper part of Middle Bed II, has been dated to about 1.4 mya (Klein 1999). The site's Acheulian assemblage is contemporary with the Developed Oldowan. The LCTs are crude with only a few flake scars, and the shapes are not uniform. Cleavers appear together with large picks, and the assemblage is dominated by irregular ovate handaxes (Leakey 1975). Apart from Olduvai Gorge, the only well-documented Acheulian site older than 1 mya whose lithic assemblage has been fully published is 'Ubeidiya, Northern Jordan Rift, Israel (Bar-Yosef and Goren-Inbar 1993). The site was dated to 1.4 mya and contains many rich archaeological layers. Where sample size in these layers permitted analysis, results showed a significant number of bifacial tools. Hence, all layers were assigned to the Acheulian. The LCTs from 'Ubeidiya are generally large, crude handaxes and picks made on basalt cobbles. Shape standardization is very low and LCT technology is not advanced. No definite cleavers are present and, although large flakes are in evidence (Stekelis 1966, Pl. XIII), they are rare and did not serve as LCT blanks.

By one million years ago, the Acheulian in East Africa had reached a point where it demonstrated its full range of tools, technology, and other characteristics. At Kilombe, Gowlett (1991) noted that all of the assemblage's morpho-typological indications render it Late Acheulian. Nevertheless, inverse magnetism indicates that the Acheulian of Kilombe is of Early Pleistocene age. A similar situation was observed at Olorgesailie, where early layers containing Acheulian artifacts were dated in the order of 1 mya (Noll 2000; Potts

1989; Potts et al. 2000). This led Isaac (Isaac 1968, VIII-70) to suggest that the only distinguishable stages of the Acheulian in Africa are “Lower Acheulian”, “Late Acheulian” and “Post Acheulian” (Sangoan). Isaac maintained that there are no strictly morphological grounds for demarcating a “Middle Acheulian” phase in Africa. The same view was expressed by Clark (1994), who divided the African Acheulian techno-complex into the “Lower Acheulian”, “Late Acheulian” and “Terminal Acheulian” phases. Along similar lines, Kleindienst attributed all of the assemblages that she studied, and which formed the basis for her typological scheme (Isimila, Kalambo Falls, Kariandusi), to the Late Acheulian. Also noteworthy in this context are the very early dates proposed for the Vaal River Acheulian and the evolved Victoria West core method. Acheulian layers bearing Victoria West Type I cores have been compared in age to Olduvai Gorge, Bed IV, placing this highly sophisticated core method in the Early Pleistocene (Sharon and Beaumont 2006).

The LFB Acheulian: Geographical Distribution

As has been mentioned above, from the initial stages of Acheulian research the use of large flakes as blanks for LCTs was noted outside the borders of Europe, where it was associated with the presence of cleavers that are, by definition, made on large flakes (see below). Large flakes as a central technological trait typifying the lithic industry of a site, along with a high frequency of cleavers, have been reported in African Acheulian assemblages (excluding the very early sites, as noted above) in many regions, ranging from South Africa through East Africa to North Africa’s Mediterranean coast. Unusual in this sense are the Acheulian sites of the Nile Valley and the Eastern Sahara oases, where many handaxes were made on cobble blanks and cleavers are almost totally absent (Caton-Thompson 1952). Despite this, recent years have yielded reports of LFB Acheulian finds in the Eastern Desert of Egypt (Haynes et al. 1997, 2001).

The Acheulian of Europe is primarily known from the western part of the continent and, within this distribution, only the Iberian Peninsula and the Garonne and Tarn Rivers of the South of France exemplify a rich LFB Acheulian industry (Santonja 1996; Santonja and Villa 1990, 2006 and references therein).

In the Levant, only the site of Gesher Benot Ya‘aqov is reported to have an LFB industry with cleavers as a significant component of its assemblage (Bar-Yosef 1998; Gilead 1970a; Goren-Inbar 1992, 1995; Goren-Inbar and Saragusti 1996; Stekelis 1960).

Farther to the northeast, the presence of large flakes and cleavers was noted in several sites in the Caucasus (Lioubine 1998; Lyubin and Belyaeva 2006), and it would seem that large flakes were regularly produced in such Acheulian sites as Persati II, Eastern Georgia (Z. Kikodza, personal communication).

The Arabian Peninsula, Turkey and South-Central Asia still represent a void in our knowledge of the Acheulian (see, however, Petraglia 2003). It is clear that the Acheulian of India had a very rich industry of large flakes and cleaver-dominated assemblages (Corvinus 1983b; De Lumley and Sonakia 1985; Misra 1985; Paddayya 1982, 2001; Paddayya et al. 2006; Pappu and Akhilesh 2006, to mention only a few; see also overviews in Chauhan 2004; Petraglia 2006). The impact of the Indian sub-continent on the global Acheulian techno-complex has certainly been overlooked until recent years (Petraglia 1998).

Although the Movius Line has traditionally been perceived as the boundary of Acheulian expansion into Northeast Asia (Corvinus 2004; Movius 1948; Schick 1994), new arguments supporting the presence of large flakes and Acheulian handaxes in China have been put forward (Yamei et al. 2000). An alternate view of the Southeast Asian Acheulian has also been suggested (Corvinus 2004).

To sum up the distribution of LFB industries, sites are dispersed throughout Africa (apart from the tropical rain forest regions of West-Central Africa) and in the Iberian Peninsula, the Levant (a single site), and the Caucasus, extending into India. It is only in Europe north of the Pyrenees that a substantial Acheulian presence not accompanied by LFB industries is present.

It has often been suggested that the type of available raw material played a determining role in the geographical distribution of LFB Acheulian industries. J. D. Clark expressed this view in a straightforward manner:

> "… it has now become much more apparent that it is the nature of the raw material that was largely responsible for dictating the primary technique used to produce the bifaces characteristic of the Acheulian. It is my contention that raw material has been all important in producing the variability to be seen in the handaxes, cleavers, and picks in Acheulian assemblages" (Clark 2001b, 1).

It has been argued that the makers of Acheulian LCTs exploited large blocks of raw material where these were available, resulting in the production of large flakes and the presence of cleavers. In regions where the primary raw material (i.e. flint) was available only in the form of small cobbles and nodules, as was the case in Europe to the north of the Pyrenees and in Egypt, large flakes could not have been obtained, and handaxe production relied on these cobbles and nodules for a different type of blank (Clark 1980, 1994; Clark 2001b; Santonja 1996; Santonja and Villa 2006; see, however, Rolland 1995 for an alternative view). This line of argument, which points to the size and shape of raw material as a leading cause of the development of LCT technology, will be examined in the current study.

Acheulian Large-Flake Production Technology and the Giant Core Phenomenon

Experimental studies of Acheulian large-flake production began during the 1980s, the work of P. Jones (1994) and N. Toth (2001) being the most significant. In recent years, Acheulian core technology has been the subject of an increasing number of studies (DeBono and Goren-Inbar 2001; McNabb 2001; White and Ashton 2003), with Madsen and Goren-Inbar presenting a comprehensive overview of large-flake production from giant cores (Madsen and Goren-Inbar 2004; see also the detailed discussion in Chapter 4 below). In the early years of research, however, many scholars described the process of producing Acheulian large flakes without addressing the core methods used in this process. The reason for this was twofold: it is rare to find large cores used for flake blank production in an archaeological context and it is difficult to produce such flakes experimentally. As Kleindienst and Keller (1976, note 4) pointed out, "it is possible that large flakes can be produced by direct (hand-held) percussion... although L. S. B. Leakey, J. D. Clark, G. H. Cole, and C. M. Keller have never been able to accomplish this satisfactorily with the difficult materials found on East African Acheulian sites".

Nevertheless, some scholars did conduct pioneering studies of large cores at various sites. South African sites, particularly in the region of the Vaal River, revealed a technology that was termed "the Victoria West industry" (Goodwin 1953; Goodwin and van Riet Lowe 1929; Jansen 1926; van Riet Lowe 1935, 1945, 1952). Between the 1950s and the 1970s, the rich Acheulian of the Western Sahara Desert, the North African Mediterranean and the Atlantic shores of Africa inspired much research on Acheulian core technology (Alimen 1978; Balout et al. 1967; Biberson 1961). This facilitated the identification of such large-core technologies as the Tabelbala-Tachenghit (Tixier 1957) and the Kerzaz (Alimen 1978), and also enhanced our understanding of the Kombewa technique (Dauvois 1981; Newcomer and Hivernel-Guerre 1974; Owen 1938). At Koobi Fora, Kenya, large cores are reported from the Acheulian sites of FxJj 33, 16, and 37 (Isaac 1997). At FxJj 33, large cores and related artifacts were almost the only finds, apart from a very few flakes (n=8).

The 65 cores average 129 mm in maximal dimension, the largest measuring 196 mm. They are described as discoid in shape and technology and bear a mean number of 13 scars, with the largest scars measuring 165 mm. Many of these cores have two or more striking surfaces. At the site of FxJj 37, six large cores and eight bifacial tools were reported, with three large cores coming from FxJj 16. Most of the Acheulian large cores from Koobi Fora fall on the small side of the size range of Acheulian large flakes (see Chapter 4 below).

Other references have sporadically been made to the large cores used in large-flake production in the context of many regions and sites. Isaac (1977, Pl. 23) illustrated one large core from Olorgesailie, a surface find. Heinzelin and others (Heinzelin et al. 2000, Fig. 5.2) illustrated a similar find and reported what they termed "giant cores with a preference for plain striking platforms", along with the presence of the rare Kombewa method, in the Middle Awash region (Heinzelin et al. 2000, 67). At Olduvai Gorge, only one large core was reported to derive from an archaeological context at the site of WK (Jones 1994). Large prepared Acheulian cores were reported from Baringo Lake (Leakey et al. 1969) and compared to the Victoria West cores of South Africa. Kleindienst reported the presence of minimally prepared large cores, up to 60 cm in size, in the site of Isimila (Kleindienst 1962). Clark (2001b) pointed out that the site of Arba, at the southern end of the Afar Rift, contained many "Proto-Levallois" cores and flakes. In the Levant, large cores were reported from the site of Gesher Benot Ya'aqov (Goren-Inbar et al. 1994; Madsen and Goren-Inbar 2004), and Clark (1966, 1967) noted the presence of large limestone blocks, which could have served as a source of raw material, in the site of Latamne, Syria. The study of the Indian site of Chirki-on-Pravara reached fruition in a detailed description of the core method applied in the production of cleavers (Corvinus 1983b). Corvinus reported ten large cores (Corvinus 1983b, 60), arranging them in two groups: a) irregular large cores without preparation of striking platforms on which every suitable platform was used for flake removal; and b) large prepared polygonal cores that were compared to the Victoria West Type II cores and named "Chirki Cleaver Cores" (Chapter 4 below). Due to the presence of Kombewa flakes in the lithic assemblage, the Kombewa core method was also noted. Large cores were also reported from the Bhimbetka rockshelter complex, Madhya Pradesh (Petraglia 2006) and other Indian Acheulian localities.

In recent years, publications dealing with Acheulian quarry sites have also reported large cores. A well-excavated and well-documented quarry site is Isampur, Hunsgi Valley, Central India (Paddayya et al. 1999, 2000; Paddayya et al. 2006; Paddayya and Petraglia 1997; Petraglia et al. 1999). Acheulian quarry sites have been reported in South Africa

(Kuman 2001; McNabb 2001; Sampson 2006), East Africa (Stiles 1998) and most recently the Levant (Barkai et al. 2006), but data on such sites are still fragmentary. The method that was used by Acheulian knappers in the production of large-flake blanks for LCTs will be discussed in Chapter 4.

Dating the Acheulian Techno-complex

Establishing a reliable chronological frame for the Acheulian is still a major challenge in the study of this long-enduring cultural entity. As has already been discussed, the first appearance of Acheulian LCTs in East Africa has been dated to ca. 1.6 mya, and the first well-reported Acheulian assemblages in East African sites (Asfaw et al. 1992; Isaac 1997; Leakey and Roe 1994) and those of the Levant (Bar-Yosef and Goren-Inbar 1993; Shea 1999) have been dated to around 1.4 mya. The Acheulian of East-Central Asia is very poorly dated. ESR dating of three bovid teeth from the site of Isampur has yielded an average date of 1.2 mya (Paddayya et al. 2002; Paddayya et al. 2006). In principal, all other Acheulian dating in these regions has been based on typological comparisons. In Europe, the Acheulian made its first significant appearance ca. 0.6 mya in sites like Notarchirico and Boxgrove, UK (see Roebroeks and Kolfschoten 1995 for an overview). In the Iberian Peninsula, the geological formations containing Acheulian industries date from the time range of Oxygen Isotope Stages 11 to 6, starting at ca. 0.4 mya (Santonja and Villa 2006), a very late date if we employ other European early Acheulian reports as a point of reference (see also an overview in Santonja and Villa 2006).

Throughout its geographical distribution, the Acheulian disappeared some 300–250 thousand years ago (kya), when it was replaced by later stone traditions. In Africa, Sangoan lithic assemblages, which overlie Acheulian layers in such sites as Kalambo Falls (Clark 2001a) and the Kapturin Formation near Lake Baringo (Tryon 2003; Tryon and McBrearty 2006), range in date from 300 to 250 kya (see Clark 2001 and Tryon 2003 for an overview of African Acheulian dating and the closing stages of the Acheulian in Africa). Again, no reliable dates are available for the end of the Acheulian in India and Central Asia. The Acheulo-Yabrudian culture of the Levant is considered part of the Lower Paleolithic (Goren-Inbar 1995), although new dates show that its emergence occurred as early as 400 kya (Barkai et al. 2003), thus probably indicating the end of the Acheulian. At any rate, by 250 kya the Middle Paleolithic Mousterian industries were well established in the Levant (Bar-Yosef 1998). In Europe, although the Acheulian was replaced by a variety of

Mousterian entities at ca. 200 kya, the production of handaxes persisted until the very end of the Middle Paleolithic (Jöris 2006).

Despite their low reliability, the chronological data available for each of the sites under study here are summarized in Chapter 3. Only one site, Gesher Benot Ya'aqov, is well dated through the presence of the paleomagnetic chron boundary in its layers. The inadequate chronology hinders some of our attempts to draw conclusions from the data under discussion.

The Makers of Acheulian LCTs

Several hominin taxa have been associated with the story of human evolution over the entire interval of the Acheulian techno-complex. In Africa, the emergence of *Homo erectus*/*Homo ergaster* at ca. 1.8 mya has sometimes been linked to the appearance of the Acheulian, which occurred at approximately the same time. Later-stage African Acheulian assemblages have been associated with the appearance of Archaic *Homo sapiens*, considered to be the successor of *H. ergaster* (Clark et al. 2003; White et al. 2003). In Europe, *Homo heidelbergensis* is believed to have evolved from *H. erectus* and has been reported in association with Acheulian assemblages of ca. 0.5 mya (Klein 1999).

The study of hominin evolution during the Pleistocene is an ever-changing field of research. In our context, it is important to stress the likelihood that the emergence of the Acheulian was linked to the appearance of a hominin taxon that shared with modern humans such attributes as body size and limb proportions, and possessed a much larger brain than the hominin taxa that preceded it (Klein 1999; see, however, Potts et al. 2004). The makers of Acheulian stone tools distributed their material culture over a very large geographical expanse, their culture coming to an end with the appearance of new hominin taxa very similar to modern humans (Klein 1999).

A Source of Research Questions – Gesher Benot Ya'aqov

The Levant Acheulian represents a unique picture in comparison to the Acheulian of other regions. Its cultural sequence comprises the following entities:

The earliest stage of the Acheulian in the Levant is represented by the lithic assemblage of 'Ubeidiya (Bar-Yosef and Goren-Inbar 1993). Here, the Acheulian is characterized by the presence of large, crude LCTs, such as handaxes, picks, trihedrals, and quadrihedrals. While large flakes are present in small numbers, their production method cannot be labeled a significant technological praxis, and cleavers are absent. Clear correlation is observable between raw material and tool types: the toolmakers of ‘Ubeidiya showed a preference for basalt in the production of their LCTs, while they used limestone primarily in the production of spheroids and flint for chopping tools and small flake tools. There has been some attempt to compare the lithic assemblage of ‘Ubeidiya with those of other Levantine sites, such as Abbasia near Cairo or the Evron Quarry in the northern coastal plain of Israel, but these assemblages have never been studied on a large scale (Bar-Yosef 1998; Gilead 1970a). Recently, Ginat and others (Ginat et al. 2003) reported a small LCT assemblage in Nahal Zihor, the southern Negev, Israel, whose tools closely resemble the bifacial tools of ‘Ubeidiya. These tools were collected from the surface and dated to the Early Pleistocene. Nonetheless, at a date of 1.4 mya ‘Ubeidiya remains the sole example of the earliest Acheulian in the Levant.

Next in the chronological sequence is the site of Gesher Benot Ya‘aqov (GBY), the northern Dead Sea Rift, Israel. Recent excavations at GBY (Goren-Inbar et al. 2000; Goren-Inbar et al. 2002) have exposed 34 m of a stratigraphic sequence comprising more ten Acheulian occupation layers. The site has been assigned to Oxygen Isotope Stages 18–20 by the presence of the paleomagnetic Matuyama-Brunhes chron boundary in the sequence (Goren-Inbar et al. 2000; and see Chapter 3 below). The finds in the site comprise a very rich assemblage of basalt handaxes and cleavers, a much smaller number of flint and limestone handaxes and very large basalt cores from the same occupation layers. This lithic assemblage is unique among Levantine Acheulian sites, for the following reasons: a) basalt served as the primary raw material for LCT production; b) large flakes were a major technology in preparing blanks for LCT production; and c) cleavers are present in significant numbers (Gilead 1968, 1970a, 1970b, 1973; Goren-Inbar and Saragusti 1996; Stekelis 1960). The assemblage also contains a large collection of other tools, waste and hammerstones, many of which are related to the reduction sequence of LCT production (Goren-Inbar et al. 2000; Goren-Inbar and Saragusti 1996; Sharon 2000). These unique features, particularly the presence of very large cores, motivated a large-scale experimental knapping project to reconstruct the *chaîne opératoire* (see below) of LCTs at GBY (Madsen and Goren-Inbar 2004; Sharon 2000). The meticulous excavation methodology at GBY, the richness of its in-situ LCT assemblage, the presence of very large cores alongside their waste and hammers, and the extensive experimental work carried out at the site all render the GBY lithic assemblage a type-site for the study of LFB Acheulian industries.

The hundreds of other Acheulian sites in the Levant differ greatly from both ‘Ubeidiya and GBY. In these sites the LCTs were made only of flint, cleavers were either very rare or completely absent, and large flakes were not usually a factor in blank production technology (Bar-Yosef 1998; Gilead 1970a; 1970b; Goren-Inbar 1995). The only known equivalent to the GBY lithic assemblage (i.e., one containing many cleavers produced from large flakes) has been reported in the Western Desert of Egypt (Haynes et al. 1997; Haynes et al. 2001).

It has been argued that the presence of GBY in its particular temporal (the Lower/Middle Pleistocene boundary) and spatial (the northern section of the Great African Rift) contexts can only be interpreted as evidence that we have yet to uncover comparable sites elsewhere. In addition, in the very early stages of research (Stekelis 1960) the GBY assemblage’s African affinity was noted, and its implications for the study of the Acheulian have been discussed several times since then (Bar-Yosef 1998; Goren-Inbar 1992; Goren-Inbar and Saragusti 1996; Saragusti and Goren-Inbar 2001), scholars marking it as a milestone on the Early/Middle Pleistocene hominin route “Out of Africa” (Goren-Inbar et al. 2000). It is indeed possible that the very fortunate geological circumstances that exposed the sediments of the Benot Ya‘akov Formation (Belitzky 2002) and their rich Acheulian assemblages simply did not occur in other regions, where similar cultural relics remain deeply buried. Nevertheless, both the uniqueness of the GBY lithic assemblage and its affinity to assemblages of other regions justify an investigation of its merits as representing a distinctive cultural phase. GBY is therefore a major source of the research questions addressed in this study.

Research Questions and Goals

The production of large flakes for LCT blanks is a technological hallmark of the Acheulian in East Africa and elsewhere. It has been reported across most of the geographical distribution of this techno-complex and, in some regions, seems to have lasted until the latter stages of the Acheulian. The tool that typifies LFB assemblages is the cleaver, appearing at differing frequencies. In order to gain greater understanding of the large-flake phenomenon and its bearing on the study of hominin behavior during the Acheulian, it is my intention to explore the following questions:

1. Was the production of large flakes for LCTs an episodic technological praxis, applied by some knappers who had access to suitable raw material at certain sites, or can it be defined as a central global aspect of hominin behavior?
2. Is there a set of defined technologies and tool types, common to LFB assemblages, that can serve to identify a "stage" or a facet within the Acheulian techno-complex?
3. Are LFB assemblages from different sites indeed similar to one another in terms of core and blank shaping technology, raw material strategies, tool types and sizes, and other techno-typological aspects, or is this "similarity" simply in the eye of the modern beholder?
4. If such a similarity is found to be undeniable, how is it to be interpreted? Does it indicate a common survival strategy applied by different groups in the face of similar circumstances? Do certain chronological barriers and geographical borders restrict it? Does it constitute a "lithic tradition"?

A comparison between the GBY "prototype" site and other Acheulian assemblages will assist in defining the technological and typological attributes of LFB Acheulian assemblages, and thus in answering these questions. Firstly, it is my aim to identify the archaeological attributes of the LFB Acheulian industry of GBY, including its technological features, the typological composition of LCTs in its assemblage, its raw material strategies, and additional idiosyncrasies that might serve to characterize it as a cultural stage in the Acheulian entity. A study of these features will entail determining the frequency of such LCT types as cleavers, quantifying the intensity of large-flake utilization, identifying such technological attributes as the direction of the blow and the nature of the striking platforms, observing a preference for specific raw materials, etc. The well-excavated and rich GBY assemblage may enable us to suggest a comprehensive answer to these questions.

Once this has been achieved, further exploration of the LFB industry of GBY will involve a comparative study with other assemblages that may qualify as members of the LFB stage of the Acheulian. An apparent similarity between the LCTs of GBY and other LFB industries has repeatedly been pointed out in the literature, and the LCTs illustrated in these publications do seem to resemble one another. Such assemblages have been reported across most of the geographical distribution of the Acheulian techno-complex, emphasizing the necessity for a detailed study of their archaeological attributes to test the working hypothesis that this apparent similarity does indeed exist. The data emerging from these assemblages must then be compared to data derived from other, non-LFB assemblages, in an attempt to determine the differences between them and note their significance. If it becomes evident that the LFB Acheulian stage can be classified on a wide geographical (and possibly chronological) scale, a possible explanation for such a phenomenon will be suggested. This discussion will culminate in an assessment of the popular hypothesis that the distribution of LFB Acheulian industries was influenced by the shape and form of the available raw material. Alternative hypotheses, emphasizing functional features and cultural lithic tradition preferences, will be suggested and discussed.

Many key issues in the study of Acheulian hominin behavior will be affected by a definition of the LFB industries. These include the cognitive abilities of the Acheulian hominins as reflected by their stone technology, the level of innovation versus traditionalism in stone tool production, the pace of technological change and evolution during the Lower Paleolithic, the interconnections between Acheulian groups over very large geographical distances, and the Acheulian toolmakers' degree of familiarity with their environment and relationship with it.

Acheulian Large Cutting Tools – Study Methods

A methodology must be established for achieving the goals set above. Several methodological approaches have been applied in previous lithic studies, and the principal ones are addressed below:

One common approach can be termed the "typological approach". The first to suggest a comprehensive and methodological typology for European handaxes was F. Bordes (Bordes 1961). The Bordesian typological system is still one of the most influential in the study of Acheulian (as well as Mousterian) lithic assemblages (for recent examples, see Goren-Inbar and Sharon 2006 a). However, given the fact that European-based typology has proved inadequate for depicting the Acheulian culture of other Old World regions, alternative typologies have been developed (Kleindienst 1962; Tixier 1957). Some of these typological systems are based on shape frequency, as demonstrated by fixed metrical indexes of tools, while others are based on blank manufacture technology. Generally speaking, all LCT classification systems depend upon named types (classes). A comparison between several sites, or between levels within a given site, can be achieved by measuring the frequency of each different type in the assemblages under study.

In the late 1960s, Roe developed an alternate method for describing the shape of UK handaxes (Roe 1964, 1968). Rather than classifying LCTs into types, this method was based on indexes calculated from standardized measurements of tools, and aimed at the graphic representation of the shape distribution of all LCTs in an assemblage. This method later evolved to include African Acheulian LCT types, namely cleavers (Roe 1994, 2001).

In his study of the site of Olorgesailie, Isaac (1968, 1977) was the first to apply a comprehensive approach to the study of an assemblage's LCTs, combining Kleindienst's typological approach, the Roe method and statistical tests with the examination of many other technological and morphological attributes of LCTs.

With the advancement of technology and the introduction of computers into prehistoric research, additional approaches to the study of LCTs have been forthcoming. In attempts to quantify the variability observed in handaxe shapes, sophisticated statistical tools, requiring a broad knowledge of mathematics and computers, are being applied to the growing databases of Acheulian LCTs. These new tools are described in the works of Cahen and Martin (1972), who developed an algorithm for measuring the disparity between forms; Saragusti (2003; Saragusti et al. 2005), who quantified handaxe symmetry and refinement in four Levantine Acheulian sites; and others (Callow 1986, 1994; Vaughan 2000; Wynn 2002).

Gowlett and others (Crompton and Gowlett 1993; Gowlett 2006; Gowlett et al. 2001) have used the study of tool allometry in their LCT studies, describing the different tool shapes in terms of their geometric attributes. In an effort to explain handaxe variability rather than to describe it, McPherron (1999, 2000, 2003, 2006) has suggested that variability depends on the stage within the reduction sequence at which a particular handaxe was discarded.

In recent years, a comprehensive approach, commonly known by the French term *chaîne opératoire*, has been developed for the study of lithic assemblages. This method explains the lithic artifacts of an archaeological assemblage in terms of their full reduction sequence, starting with raw material acquisition and ranging through knapping, use and discard. This approach, which is applicable to all prehistoric technologies, will be discussed here as it relates to the study of Acheulian LCTs (Roche and Texier 1995; Texier and Roche 1992). Data collection in the *chaîne opératoire* method entails a multi-attribute lithic analysis of each artifact, combined with experimental knapping (Callahan 1979; Jones 1980, 1981, 1994; Madsen and Goren-Inbar 2004; Newcomer 1971; Toth 2001). This is the approach that has been adopted for this study, as will be detailed in Chapter 2. The specific *chaîne opératoire* method that is explored here was developed by N. Goren-Inbar for the study of the GBY assemblage (Goren-Inbar and Saragusti 1996). Other *chaîne opératoire* methods can be found in the studies of McNabb (McNabb et al. 2004) and

Pappu (Pappu and Akhilesh 2006), and in the "Method of Residuals" approach defined by Isaac (1986) and applied by Noll (2000) in his study of the LCTs of Olorgesailie.

Objects of Study – Handaxes and Cleavers

Most scholars involved in the study of Acheulian lithic assemblages agree that the LCT group comprises a few major artifact types that are morphologically distinct. As a result, specific attributes characterize each type and guide its study and analysis (cf. McNabb et al. 2004). "Handaxes" and "cleavers" are the usual categories that appear in LCT studies, with occasional mention of such additional tool types as "knives", "picks" and "core axes" (Balout et al. 1967; Balout and Tixier 1957; Clark 2001b; Corvinus 1983b; Goren-Inbar and Saragusti 1996; Isaac 1972b; Kleindienst 1962; Leakey 1951).

In his study of the LCT assemblage of Olorgesailie, Isaac (1972c; 1977) applied a detailed statistical analysis to biface morphology in order to:

> "determine whether groups of similar forms exist that are isolated from other distinctive forms (a) by relative rarity of intermediates (poly-modality), or (b) by showing a standardized combination of measured attribute values that are improbable in relation to the overall frequency distribution of the variables" (Isaac 1977, 117).

The results of this analysis led him to conclude:

> "…it appears that among the large tools of the Olorgesailie Acheulean series only two categories, handaxes and cleavers, are both numerous and well standardized" (Isaac 1977, 124).

Isaac's approach has provided the basis for the present study: handaxes and cleavers can, and should, be studied as two distinctive tool categories. Nevertheless, as has been pointed out by many scholars, when it is only the *form* of a tool that determines the type to which it is ascribed, difficulties in defining a clear-cut borderline between the various individual tools may arise. The presence of "cleaver-edged", "chisel-edged" or "square-ended" forms (e.g. Kleindienst 1962) in many assemblages makes definite identification problematic. These problems will be addressed below.

Handaxe Definition

In nineteenth-century Western Europe, "handaxes" were the first objects to be recognized as tools that had been produced by prehistoric peoples. Since then, the definition and terminology of the Acheulian "handaxe" have progressed along the lines described by Isaac

(1968, Chapter VII) in his comprehensive overview of the history of Acheulian research. As opposed to the term "cleaver", which has proven somewhat problematic to define (see below), the Acheulian "handaxe" has been uniformly defined by most researchers (e.g. Debénath and Dibble 1994, 130; Deacon and Deacon 1999; Noll 2000), a representative definition being that of Kleindienst:

> "Hand-axes (bifacial) and pointed flakes (unifacial). Characterized by a cutting edge around the entire circumference of the tool, or more rarely around the entire circumference with the exception of the butt. The emphasis in the manufacture, if distinguishable, seems to have been upon the point and both edges. Usually bilaterally symmetrical, and more or less biconvex in major and minor sections (i.e., along the major and minor axes). Points range from exceedingly acuate to linguate. There is large variation in size, degree and quality of workmanship, and plan-view, primarily according to the curvature of the edges, the length: width ratio, and the placement of the greatest width relative to the length of the tool" (Kleindienst 1962, 85).

Cleaver Definition

The term "cleaver" (*hachereau* in French) is the subject of a long and ongoing debate. In his comprehensive study of Acheulian cleavers, Mourre (2003) rightly pointed out that the debate derived from disagreement between Francophone prehistorians who support a minimalist definition for "cleavers" (see below) and English-speaking scholars who favor a more inclusive classification that identifies all bifacially knapped tools with a transverse cutting edge as "cleavers" (i.e. the "bifacial cleavers" of Bordes 1961).

The cleaver has been documented in Spain, the Levant, and most particularly in India, where it was as prevalent as the handaxe. Nevertheless, the region most abundant in Acheulian cleavers is Africa, the source of the tool's identification. Burkitt (1928) was the first to apply the term "cleaver" to South African Acheulian implements. His definition, as quoted by Isaac, was:

> "…The working edge is straight or only slightly curved and is more or less at a right angle to the length of the tool, being formed by the inter-section of two large flake scars slightly inclined to each other. This edge is at what in a normal coup-de-poing [the old French term for "handaxe", G.S.] will be at the butt of the tool; the more pointed end is left blunt and sometimes some of the crust of the original pebble

…remains. The whole gives one the impression that it …is undoubtedly a near relative of the coup-de-poing" (Isaac 1968, VII, 4–5).

Clark's definition is based on the study of many East African sites:

"Usually made on a large flake (*hachereau sur éclat*), cleavers are generally worked down the side edges and butt, and have a cutting end formed by the intersection of one large flake scar on the dorsal face with the main flake, or ventral surface. This cutting end may be straight (approximately at right angle) or oblique to the long axis of the tool (guillotine)... The butts or proximal ends of cleavers are classified as round, square or pointed. Special forms of parallel and divergent edged cleavers have splayed ends and some convergent cleavers may be shouldered and ultra-convergent. As with handaxes, cleavers may be either symmetrical or asymmetric. In most examples the side edges are bifacially trimmed. Examples retouched only on the dorsal face are termed cleaver flake. The cross sections are commonly biconvex, trapezoid and parallelogram. Edge plans of cleavers bits may be straight, concave, convex or irregular" (Clark 2001, 49).

According to Tixier (1957), two elements define a cleaver. First, cleavers are exclusively flake tools. Hence, LCTs with a transverse cutting edge that were made on non-flake blanks (such as a cobble or a flat slab) are not cleavers. Second, a cleaver's cutting edge was never shaped through secondary retouch, but was always formed by the joint between the ventral and dorsal faces of the cleaver flake. This edge can be either cortical or margin of the scar formed on the original large core at the start of the blank extraction process. Tixier (1957) outlined a typological framework for North African cleavers, basing it largely on the technology used in their manufacture, which he believed to lack chronological significance. Six cleaver types (numbered 0–5) were identified. A seventh type (6 – a cleaver fashioned on a Kombewa flake) was added later as a result of a study of cleavers from Ternifine (Balout et al. 1967). This particular approach gave rise to what may be labeled the "minimalist cleaver definition tradition" (e.g. Roche and Texier 1995, 162):

"… a flake tool whose terminal beveled cutting edge (the French word biseau sums up all these characteristics) results from the intersection of the lower face of the blank with the negative of the predetermining removal."

The presence of cleavers in Western Europe, particularly in the UK, has added to the controversy (for a recent overview, see White 2006). The equivocal nature of the general discussion has resulted in much confusion in describing, analyzing, interpreting and comparing Acheulian assemblages, especially with regard to "bifacial cleavers". The phrase "transverse cutting edge", for example, has often been applied to cleavers, but it has also been used to describe the convex edge of a round handaxe. This has led to the classification of the same tool as both an oval handaxe and a cleaver (e.g. Matskevich 2006; Rollefson 1978; Rollefson et al. 2005), causing some to describe an assemblage as very rich in cleavers, while others refer to the assemblage's abundant oval handaxes. In the current study, I will follow Roe's definition for the cleavers of Olduvai Gorge:

> "Generally speaking, a cleaver is defined by its possession of a characteristic transverse or oblique cutting edge at the tip end, having distinct points of junction with the implement's sides (which may be blunt or have working edges of their own)... There can be some overlap between cleavers and square-ended handaxes... The only point of metrical definition that needs to be reported here is if an implement is to qualify as a cleaver, the length of the distinctive transverse or oblique edge or 'bit' must be greater than half the implement's breadth. If not, the implement counts as a square-ended handaxe" (Roe 1994, 151–153)

In various relevant sections below, I shall also present data supporting Tixier's (1957) definition of cleavers as flake tools with an unretouched cutting edge.

Acheulian Lithic Study – Proviso

Any study of the lower Paleolithic era, a substantial part of which was occupied by the Acheulian entity, needs to consider the following difficulties, which were put forth by Isaac (1972b):

a. We are attempting to explore and understand the behavior of hominins whose neuro-physiological features (chiefly the size and structure of the brain) differed from our own. Our study involves an enormous span of time, both in terms of the Acheulian period's duration (ca. 1.5 million years), and the chronological gap (over 0.25 million years) separating us from the makers and users of Acheulian tools.

b. The archaeological record is low in density, in terms of both time and space; i.e., in comparison to later archaeological periods, Acheulian sites and the finds within them are sparse.

Additional general views and principles that have guided my research approach are enumerated under various subheadings below.

Large Cutting Tools are Indeed Tools

Most researchers agree that the main function of the handaxe was the slaughter of large game (Isaac 1986; Jones 1980, 1994; Potts et al. 1999). Nevertheless, it should be borne in mind that the exact function of LCTs is still largely unknown, a fact that constitutes one of the main difficulties in any study of Acheulian bifaces. Some scholars have suggested that handaxes (most explanations seem to ignore cleavers) were multipurpose tools that were used for cutting, digging, scraping and other tasks (Isaac 1977; Wymer 1968). Others have conjectured that they served as woodworking tools (Dominguez-Rodrigo et al. 2001). Subsequent to finds made in Isimila, Kleindienst and Keller (1976) suggested that the ground or a foot were used to stabilize handaxes in a vertical position, so they could serve as a stationary cutting edge, reminiscent of the fixed knives employed in many South Indian kitchens today. An additional proposal was that handaxes were used as missiles in hunting (see, however, discussion, references and refutation in Whittaker and McCall 2001). The "handaxe enigma" (Wynn 1995) of assemblages in which thousands of large, symmetrical objects of indeterminate function are found together has led some researchers to suggest non-functional explanations. Some scholars have speculated that handaxes were in fact cores for the production of flakes (Davidson 2002). Others have maintained that handaxes were employed in sexual selection (Kohn and Mithen 1999), arguing that the production of a well-made handaxe involved a massive investment of time and energy, a fact that could be rationalized if the handaxe is viewed as analogous to a peacock's tail, as explained by Zahavi's handicap principle (Zahavi and Zahavi 1997). Scholars have gone so far as to claim that handaxes were part of the "social-technology" versus "functional-technology" phenomenon that finds reflection in the small tools and cores of the Acheulian. Any definitive conclusion, however, would depend on use-wear analyses, as has been pointed out by Roe (2001; 2006).

In this study, I have adopted a functional approach to LCTs, which perceives handaxes and cleavers as functional artifacts, made in accordance with certain specifications and designed to suit specific needs (Deacon and Deacon 1999; Jones 1994). Their *raison d'être* was the long sharp cutting edge that was obtained by their makers.

Handaxes Were Not Made by Machines

The statement that forms the title of the previous section is of course common knowledge among those who study and describe Acheulian LCTs. Nevertheless, it would seem that many scholars overlook this fact in their analyses. Acheulian knappers did not produce LCTs for museum exhibitions. While the esthetic value of some of the tools cannot be denied, and symmetry was very probably a desirable goal (more than anything else, for such functional reasons as tool balance, etc.), the Acheulians made functional tools for their own use. Archaeological bifaces were in many cases fashioned to such an extent as to maximize their functionality, without rendering them the "perfect" handaxe. As stated by Roe:

> "Stone handaxes, cleaver, knives and core axes were individually made, not cast in a set of moulds for each tool class. The makers were committed to achieving functional effectiveness; it is the archaeologists who demand typological exclusiveness" (Roe 2001a, 497).

This strategy both preserved energy and "safeguarded" the tool against its maker. Modern experimental knapping has demonstrated that while attempting to produce a perfectly shaped tool, one persists in chipping away at it, very often overworking it to the point of breakage.

It cannot be overstressed that Acheulian tool morphological variability very often stems from the faults, mistakes, and accidents of its knappers. Together with problems of dexterity, cracks and other irregularities in the raw material are crucial factors in the morphological variability of LCTs. Corvinus demonstrated this with regard to cleaver flakes from the site of Chirki-on-Pravara in India:

> "…The idea of the finished cleaver was in the mind of the maker, but the result depended on the more or less prepared core. Thus, apart from a certain preparation of the platform, which had to conform to the idea, and apart from the envisaged cutting edge at the left, the cleaver flakes turned out often rather unlike each other and had to undergo secondary trimming till the shape was more or less as it has been desired... This renders understandable the fact that there are considerable varieties in the shape of the cleavers, for example, in the thickness of the flakes, or in the pattern on the dorsal faces, or in the fact that the cleaver edges are sometimes unsuccessful etc." (Corvinus 1983b, 41).

The Frame of Study

Chapter 2 presents the methodological tools that were applied in the current study, along with some of the definitions, nomenclature and terminology that are used.

Chapter 3 offers a summary of the available data regarding each of the sites that have provided LCT samples for the present study. The data are summarized in a standard format, imparting the nature of each site and central archaeological points relating to it.

Chapter 4 is the first of three central chapters whose purpose is to explore different aspects of Acheulian LCT production on large flakes, and to synthesize it into a comprehensive description of the phenomenon. The data in these chapters were collected through lithic attribute analysis of LCTs, in addition to that of other stone artifacts, namely large flakes and giant cores, which were part of the same *chaîne opératoire*.

Chapter 4 presents an overview of a variety of core methods used in the technology of large-flake blank production from giant cores. In some cases, descriptions rely solely on the available literature, while in other instances they are supplemented by new data acquired in the process of this study. Some new core methods are defined and depicted for the first time. The efficacy of Acheulian large-flake production is evaluated against the use of river cobbles and natural slabs on the one hand, and ethnographic evidence as well as experimental large-flake production by modern knappers on the other.

Chapter 5 explores and discusses the technological features that were involved in shaping a completed handaxe from a selected blank. The frequency of use of different types of raw materials and their implications for tool size and knapping technology are discussed first. The sizes of all LCT samples are compared and the technology of tool shaping is expounded and tested in light of the investment of work, location of retouch, number of flake scars, and more. The chapter concludes with a discussion of specific technological and morphological assemblage compositions indicating that the tools originated in LCT production workshops.

Chapter 6 explores LCT morphology and shape. Typological considerations are presented and shape variability of handaxes and cleavers is assessed and discussed. The chapter concludes with a suggested model that explains the presence or absence of cleavers and ovate handaxes in different assemblages.

Chapter 7 attempts to synthesize the data and results into a comprehensive picture of the current state of research into LFB Acheulian industries. The implications and significance of this picture for the study of human behavior and evolution during the Early and Middle Pleistocene are then explored.

Chapter 2: Methodology

The Assemblages

Sample Selection

The assemblages studied here originated in varied collections. Some are the result of surface collections, while others are finds from the most meticulous of excavations. Some encompass many hundreds (and sometimes thousands) of bifaces, while others number only a few tools. In some sites, all LCT types were represented in large numbers, while in others, certain tool types (in most cases cleavers) were almost entirely absent. Specific assemblages were chosen according to the following principles:

a. An assemblage had to contain an LCT sample (handaxes and cleavers alike) of adequate size. The guideline was to sample at least 50 handaxes and 50 cleavers from each assemblage. Where only a few LCTs were present, all of them were analyzed. Where one type of tool (either handaxes or cleavers) was dominant (e.g. cleavers in the Vaal River Acheulian sites of South Africa), an attempt was made to analyze at least 100 tools of the more common type, and as many as possible of the less frequent type.

b. When available, sites excavated by modern, accurate methods were preferred over older excavations and surface collections.

c. There was a need for a control group not based on large flakes in comparison to which the technology and typology of LCTs based on large flakes could be evaluated. A sample from the site of Ma‘ayan Barukh, Upper Hula Valley, Northern Israel, was selected for this purpose. The curator of the site’s local museum, A. Asaf, maintains that as many as 8000 handaxes have been collected there (see also Ronen et al. 1980 and Chapter 3 below), although only a small number were produced on flake blanks. Stekelis and Gilead (1966) studied 2500 of the handaxes and identified 2.2% of them as cleavers, although Chapter 6 below demonstrates that 1.6% of these “cleavers” are ovate handaxes with a tranchet blow. Nevertheless, the presence of a few true cleavers made on large flakes is undeniable (Fig. 1). Due to these circumstances, and because of Ma‘ayan Barukh’s proximity to GBY, it is tempting to classify the former together with the LFB cleaver Acheulian of GBY. This postulation might be supported by findings from the Italian site of Rosaneto, where on the basis of two sandstone flake cleavers

Santonja and Villa (2006) concluded that: "…flake cleavers were a part of the technical repertory of Acheulian craftsmen in Italy, yet they were not commonly used" (see also similar considerations and arguments pertaining to the Caucasus region in Lyubin and Belyaeva 2006). We could have made a similar assumption with regard to the vicinity of GBY/Ma'ayan Barukh. However, these sites differ in many technological and typological aspects and the current study follows a different approach, according to which a lithic assemblage should be identified by the frequencies of different tool types and technologies within it, in addition to any other aspect of the assemblage. In other words, almost every Acheulian assemblage will have very low frequencies of almost any type of handaxe and some cleavers (Gilead 1970; Roe 1968). There will also be minimal presence of very large or very small LCTs, which deviate dramatically from the typical size range, in the assemblage. The presence of a few end-scrapers and burins in the assemblage of GBY does not render the assemblage Upper Paleolithic in nature. The same holds true for the cleavers of Ma'ayan Barukh, whose assemblage cannot be labeled an LFB Acheulian one.

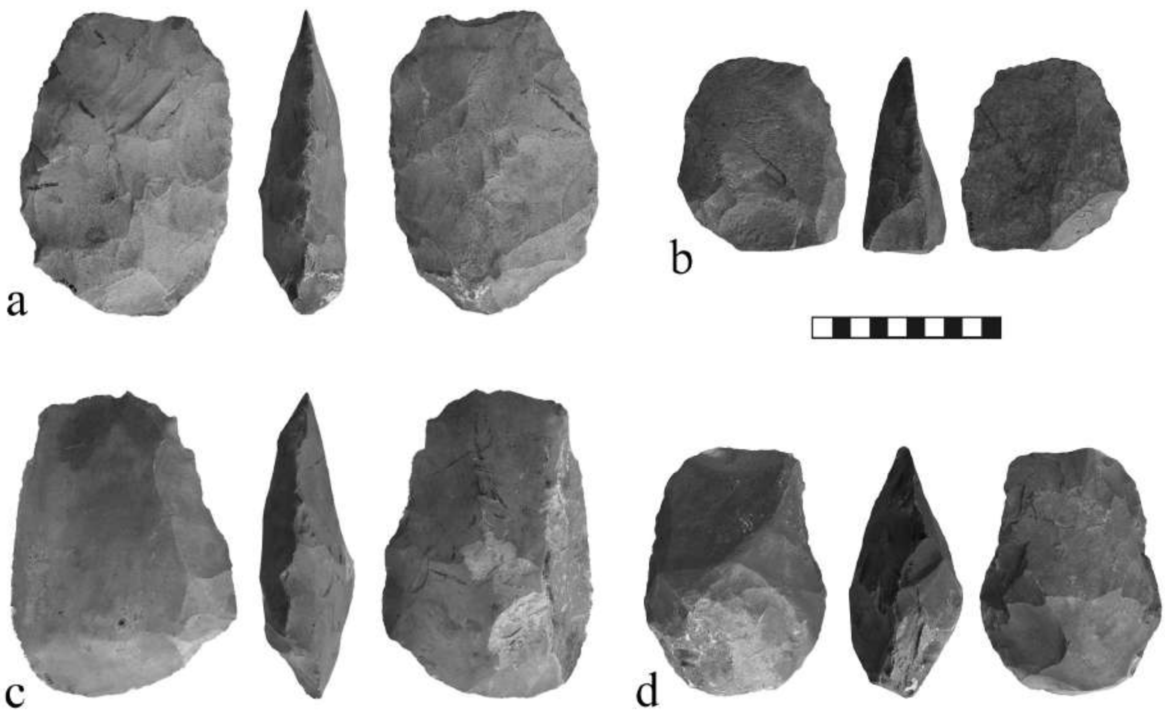

Figure 1. Cleavers from Ma'ayan Barukh in the Ma'ayan Barukh Museum collection. a and d are bifacial cleavers, while b and c are clearly flake cleavers.

In working with sample assemblages, I also used data that have been made available through the efforts of many Acheulian LCT researchers. In the framework of the GBY archaeological project, N. Goren-Inbar and I. Saragusti analyzed the biface assemblage of the main GBY Acheulian site (Goren-Inbar et al. 2000; Goren-Inbar and Saragusti 1996). N. Alperson and T. Goldman analyzed the handaxe assemblage from Ma'ayan Barukh. Although I have examined LCT samples from both GBY and Ma'ayan Barukh and have added my own observations to the database, these scholars have achieved the main body of work. The website of Marshall and others (Marshall et al. 2002) contains a comprehensive database of Acheulian LCTs and has made an important contribution to this study. I have used these data for the sites of Amanzi Springs and Elandsfontein in South Africa, Olduvai Gorge in Tanzania, Tabun Cave in Israel (the collection housed in the British Museum) and Boxgrove, Cuxton and Broom in the UK (for details and references, see Marshall et al. 2002). Many of these sites yielded non-LFB assemblages that acted as a control group for the LFB samples. Essentially, I used the data provided by Marshall and others for general issues relating to the Acheulian techno-complex (e.g. global LCT sizes and blank selection strategies). For other, more subjective and measuring-method-sensitive attributes, such as the nature of retouch or scar counts, I did not use these data, as they may reflect different recording strategies and approaches rather than objective variability. Additional significant data were retrieved from a large sample of Tabun Cave layer E handaxes housed in the Rockefeller Museum, Jerusalem, which was analyzed by Z. Matskevich (Matskevich 2006; Matskevich et al. 2002). The Tabun Cave assemblages preserve the final stages of the Lower Paleolithic in the Levant (Goren-Inbar 1995) and their study was conducted by the methods used here. The Tabun handaxes are important as a comparative body of data, both because they do not technologically represent an LFB industry and because they differ from many other Acheulian LCT assemblages in the Levant (Gilead 1970; Gisis and Ronen 2006; Saragusti 2003). A Ph.D. dissertation by P. Noll (Noll 2000) provided data from the DE 89B site of Olorgesailie, facilitating the integration of a key East African site into parts of the comparison presented here.

Stratigraphic Context of Selected Artifacts

When sampling LCTs for the purpose of analysis, their stratigraphic context must be considered. Some assemblages may have accumulated over long-term occupation of a specific locality, while others did so during a single, relatively short hominin habitation (lasting days, weeks or months). Using their archaeological context as a guideline, the origins of the assemblages under study can be divided into three groups:

a. Unexcavated context – Assemblages amassed through surface collection. Those of the Vaal River sites of South Africa are an obvious example, but the assemblages of other sites, such as Tachenghit, Ma'ayan Barukh and the North of Bridge Acheulian site at GBY, all come from archaeologically disturbed contexts. They were selected for study because no alternative excavated material is available for these key sites.

b. Short-occupation context – The assemblages of the North Western African sites of STIC Quarry and Grotte des Ours, the Indian sites of Hunsgi, Chirki and Yediyapur, and the Isimila localities are all good examples. In these sites, only a few archaeological levels (usually no more than two), representing a relatively short occupation, were identified by excavators and attributed to the same lithic culture. It should be noted that several assemblages, like those of Isimila and Chirki, are primarily composed of artifacts that originated in unclear stratigraphic locations and were found on the surface. Because these sites comprise a single Acheulian occupation, it would seem safe to suggest that such tools had eroded from the sites' occupation layers.

c. Multi-layered excavated sites – GBY and Olorgesailie belong to a third group of sites in which long sequences of Acheulian occupation were unearthed. Many layers, in sub-sites that can be stratigraphically and geographically some distance apart, represent this type of occupation (Goren-Inbar et al. 2000; Goren-Inbar and Saragusti 1996; Isaac 1977). The GBY and Olorgesailie excavations are high in resolution, a fact that is advantageous to our purpose of fully and accurately representing the LCT assemblage of a multi-layered Acheulian site. In the case of Olorgesailie, for example, it was argued that no clear patterns of cultural change can been discerned between its various assemblages (Isaac 1977). It is therefore possible to select one layer, rich in finds, to represent each site's entire assemblage. At Olorgesailie, horizon B of site DE89 was selected due to the large number of LCTs excavated there. At GBY, layer II-6 was chosen. This layer was subdivided on a stratigraphic basis into seven sub-levels, each representing a different stage of the site's occupation during a relatively short period (Goren-Inbar et al. 2000, 2002). In this study, the LCTs of GBY II-6 were for the most part combined into a single sample (see discussion in Chapter 5). A detailed comparative study of the differences between the sub-level assemblages and their significance will be undertaken elsewhere.

Generally speaking, well-excavated assemblages and their recorded data are of greater descriptive and explanatory value than are assemblages resulting from surface collection or originating in unclear stratigraphic contexts. The former sample type is relatively well founded, while data based on the latter should always be qualified. Nevertheless, a consideration of all available data is crucial to the enhancement of our understanding. For instance, many surface collections (e.g. the sites of Ma‘ayan Barukh and the Vaal River) represent “unbiased” collections comprising all bifaces, regardless of their size and state of preservation. These conserve the only data available for many key sites, valuable data that cannot be retrieved from any other source at present.

Artifact Typology and Detailed Sampling Considerations

The artifacts that were selected for analysis were subdivided into four general categories, in accordance with the GBY lithic analysis scheme. These categories include two tool categories (handaxes and cleavers) and two waste categories (flakes and cores), each analyzed in conformity with a specific attribute list (see Appendix 1). In most cases, special emphasis was placed on handaxes and cleavers, as they are the focal point of this study. Large flakes and large cores were analyzed when present in significant numbers, although both categories proved rare in most of the sites. In choosing specific artifacts for analysis, the following guidelines were followed:

a. The shape and workmanship of artifacts did not favorably influence their selection; in other words, classically shaped, esthetic artifacts were not preferred over atypical forms, classified as such by many typological systems.
b. Tools that were abraded or encrusted in such a way as to interfere with technological observation (e.g. scar counts and direction) were not included in the sample. Broken tools whose fractures occupied more than 10% of their original size (roughly estimated) were also excluded.
c. When present, untrimmed large flakes were also studied, in an attempt to understand the technology of their manufacture. As noted above, untrimmed large flakes are rare in most assemblages. Their frequent presence in a site was deemed to indicate an assemblage that was unique in nature, perhaps one oriented toward a specific activity locale such as a workshop (see Chapter 5).
d. In the production of Acheulian LCTs, large-flake blanks were detached from large or giant cores (Madsen and Goren-Inbar 2004), a rarity in most Acheulian assemblages. Hence, all such samples were analyzed, regardless of their number.

Table 1. General typology of artifacts by site.

Site	Handaxes	Cleavers	Large Flakes	Large Cores
South Africa				
Power's Site	50	118	-	-
Pniel 6a	41	102	-	-
Riverview	47	76	-	5
Pniel 7b	40	100	-	-
Doornlaagte	17	14	-	15
Canteen Koppie	-	-	-	18
Northwest Africa				
STIC	83	5	10	9
Ternifine	57	47	41	8
Grotte des Ours	81	10	35	
Tachenghit	29	16	3	6
Sidi Zin	-	10	-	-
East Africa				
Olorgesailie DE89 Horizon B	330	88	-	-
Isimila K6	185	28	-	-
Isimila K14	25	56	-	-
Isimila K19	24	40	-	-
India				
Hunsgi	47	49	52	-
Yediyapur	5	12	8	-
Chirki	41	48	15	-
Levant				
Ma'ayan Barukh	125	-	-	-
GBY NBA	171	93	-	-
GBY Layer II-6*	325	136	-	13
GBY Area C*	7	10	-	-

* The data from GBY are preliminary, as the lithic analysis of the assemblage is not yet complete.

Typological Classification: Handaxes and Cleavers

> "My analysis suggests that the sets of pieces classified into the named forms constitute a recurrent improbable combination of attribute states and that the field of morphological variation is consequently not random. However, the analysis also suggested that, in general, the form categories are not modes, but arbitrary zones within a structured continuum" (Isaac 1977, 120).

As defined and explained in Chapter 1, handaxes and cleavers are Acheulian mega-types. The typological-morphological borderline between cleavers and cleaver-edged handaxes was established by Roe, who defined cleavers as tools whose cutting edge measures more than half the maximal width of the tool (Roe 1994). Yet, strict definitions notwithstanding, in some cases it is still difficult to distinguish between Acheulian handaxes and cleavers, whose contours can be confused. Some of these classification dilemmas are demonstrated in Fig. 2, using tools from the site of Tachenghit.

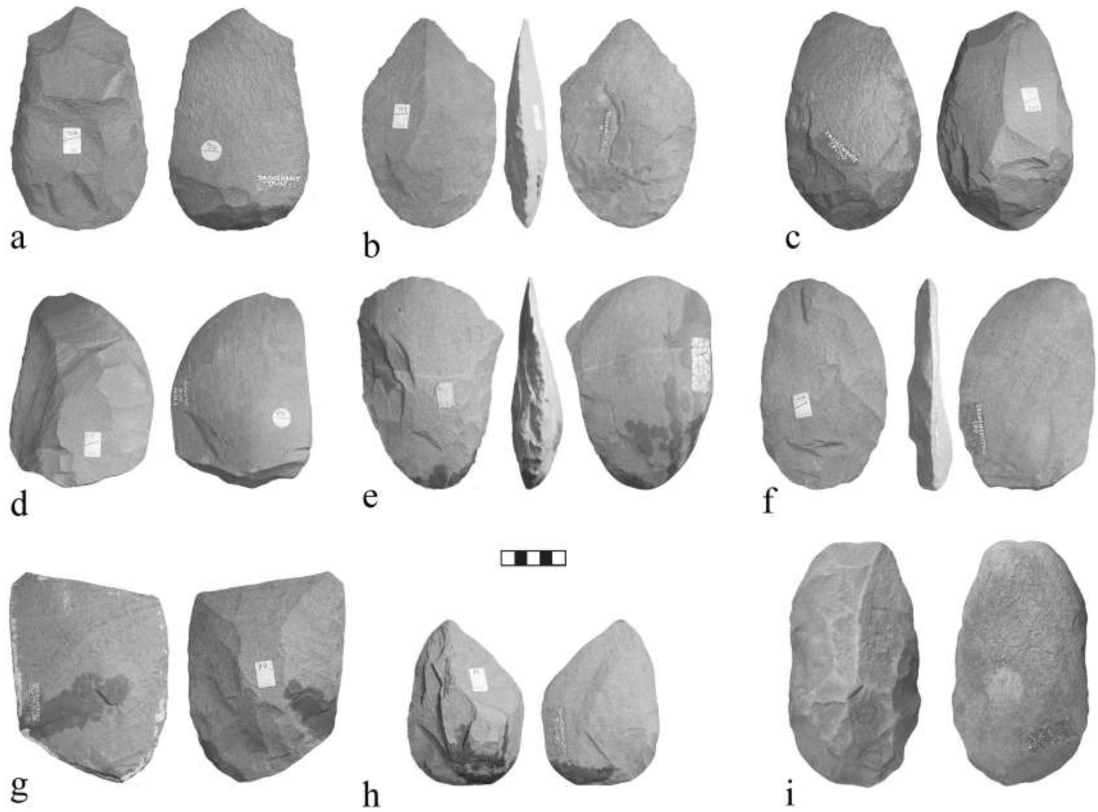

Figure 2. Cleaver/handaxe examples from Tachenghit.

Tools **a**–**c** are cleavers with a pointed tip. The cutting edge was formed by two scars, resulting from the removal of flakes from the giant core prior to the detachment of the flake itself (unlike the more frequent cases, in which only one such scar exists). They are considered to be cleavers, due to their technology of manufacture and the nature of their cutting edge. The main factor dictating their overall shape is the morphology of the blank selected for their manufacture (see below). They are tools made on large flakes, with an unretouched distal cutting edge and a clear separation between the edge and the lateral margins (Chapter 1). The cutting edge combines two straight edges. In his account of the LCTs from Kalambo Falls, Roe named these tools “double cleavers” (Roe 2001a, 501). He maintained that they were deliberately designed to have a pointed tip, although they proved to be somewhat problematic for Roe’s measurements of the edge angle and length and could not be included in his cleaver shape diagrams.

Tools **d**–**f** were made on large flakes and show very convex distal cutting edges. Of the three tools presented here, only **e** (made on a Kombewa flake) would have been traditionally classified as a cleaver, due to the visible meeting points between the distal edge and the lateral edges. Tool **d** is simply a large flake, because no secondary retouch is visible, and **f** should probably be classified as a handaxe.

Tool **h** represents an additional difficulty in definition. The tool has a clearly identifiable marginal cutting edge, unshaped by secondary retouch, which is tilted drastically to the side of the tool, forming a pointed tip. This is an extreme case of the "ultra-convergent" angle-edged cleaver that led Roe to base his shape diagrams on the measurement of edge angles (Roe 1994). These tools are also known as "guillotine-type", chisels or bevels (Clark and Kleindienst 2001, 49). Tool **g** is undoubtedly a cleaver, although it too has a slanting edge.

Tool **i** is a large biface with a transverse cutting edge, representing another borderline case between handaxes and cleavers. It is also relatively weathered, rendering all observation difficult. It is unclear whether it has "distinct points of junction with the implement's sides", to use Roe's definition (Roe 1994). It is also hard to determine a point from which to begin measuring the length of the tool's cutting edge.

Despite the occasional quandary, as exemplified above, it should be noted that it is relatively easy to assign most Acheulian tools to their appropriate class (handaxes or cleavers). In this study, I have followed the definitions of cleavers and handaxes given in Chapter 1. Where these were found to be inadequate, I judged the relevant tool individually, usually basing my classification on such technological observations as the determination that the tool was produced on a large flake, and the treatment of minimal retouch on the ventral face of the tool as an indication that it is a cleaver.

Principles of Studying Lithic Assemblages

The concept of *chaîne opératoire* (Inizan et al. 1999; Roche and Texier 1995) has been adopted as this study's approach. The *chaîne opératoire* is a way to "reconstruct and organize all the events having modified a block of raw material, from its selection to the ultimate discarding of all the elements coming from it" (Julien 1992, as quoted by Roche and Texier 1995). The concept combines such technological considerations as data retrieved from experimental knapping, raw material properties, refitting and an analysis of all the artifacts in a given assemblage, in an attempt to gain as full an understanding as possible of the entire lithic technological process. The life history" of a stone tool is termed a "project", which is composed of four successive sequences: raw material acquisition, tool production, tool utilization and tool discard. As this study deals with LCTs, constituting a restricted part of the Acheulian tool kit, it is self-evident that it cannot reconstruct the full *chaîne opératoire* typifying the Acheulian. Moreover, even when given the opportunity to study an Acheulian site's full assemblage, the best one can hope to achieve is a partial reconstruction of the *chaîne opératoire* (usually the first two sequences), due to the antiquity of the finds and the fragmented nature of the data (Roche and Texier 1995). In order to describe and interpret the *chaîne opératoire* of the Acheulian LCT assemblages, I shall use the multi-attribute analysis developed for the study of the GBY lithic assemblages. This method will be described below.

Nomenclature and Definition of Technological Terms

Acheulian LCTs and their technology of manufacture have been the subject of research for a hundred and fifty years. Over that time, many names, terms and definitions have come into use. The abbreviation "LCT" is itself quite new, replacing, albeit not completely, such terms as "bifaces". To add to the confusion, much of the terminology was developed in more than one language (usually English or French).

In this study, I have used those terms I deemed most suitable and explained my choices. Many of the terms follow the definitions of Inizan and others (1999). For a wider view on applying the *chaîne opératoire* method to the study of Acheulian LCTs, I followed Roche and Texier (1995) and Texier and Roche (1992). Clark and Kleindienst (1974, 2001) served as an additional source in defining many terms and tool types. Below is a list of key terms and their definitions as used here, while other, more specific terms will be defined in the appropriate chapters.

Large Cutting Tool (LCT): A single heading for unifacially and bifacially knapped Acheulian tools of all types (i.e. handaxes, cleavers, knives, picks, core axes, trihedrals and more), which emphasizes the importance of the cutting edge as the tools' main *raison d'être*. Some scholars prefer the terms "bifaces" or "bifacial tools", as they make no assumptions about the use of the tools. However, "bifaces" are sometimes perceived as being synonymous with handaxes, to the exclusion of cleavers and other tool types.

Pre-form: "… a subjective term used to distinguish between well-made artifact forms and less well-made tools" (Clark and Kleindienst 2001, 35), which is interchangeable with the terms "unrefined" and "unfinished". The term refers to Acheulian LCTs, unfinished in edge and shape, which bear a relatively low number of deep and unorganized scars. These tools were brought to their locale of discovery in an unfinished state for completion of their production process on-site, a task that was never accomplished. Thus, their crudeness indicates an incomplete technological sequence, rather than "primitive" technology.

Knapping Technique: This term takes into consideration both the tools used by the knapper during the tool-production process (e.g. hammers, anvils, etc.) and their function (Roche and Texier 1995). The main knapping techniques were percussion (either direct or indirect) and pressure flaking. During the Acheulian, direct percussion was probably the only technique applied, although different types of hammers (soft or hard) and anvils were in use. These will be discussed in connection with the term "technique".

Block: Raw material in its natural form prior to knapping. This general term groups together cobbles, boulders, nodules and any other natural form of raw material that was available to the Acheulian knapper (Roche and Texier 1995). Some scholars have used the term "chunk" for the same purpose (see, however, Clark and Kleindienst 2001, 62).

Core Method: A sequence of actions that reflects a specific concept of handling and manipulation, applied to a block of raw material during knapping for the purpose of detaching a desired flake (e.g. Levallois, Kombewa, Victoria West etc.). The definition is that of Roche and Texier (1995). Other scholars have used such terms as "core technology", or "core technique", but those are used in this study to describe other aspects of the knapping process (see below).

Blank: "Any element from which an object is knapped, shaped, flaked or retouched [see below]. It can be a nodule, a slab, a cobble, a debitage product (flake) etc." (Inizan et al. 1999). In this study, a "blank" represents a piece of raw material that has been worked to the stage just preceding shaping. Gamble and Marshall (2002) have suggested that large-flake blanks should be classified under the heading "debitage" and worked nodules (and any other natural block) under the heading "*façonnage*". I use the term "blank" as a general name for all implements at this production stage, with "flake blank", "slab blank" or "cobble blank" etc. serving in more specific contexts.

Shaping, Flaking (debitage) and Retouching: All of these terms denote stages in tool manufacture (Inizan et al. 1999; Roche and Texier 1995; Texier and Roche 1992). In the prevalent Acheulian LCT terminology, "shaping" usually refers to the main stage of production, prior to blank obtainment. "Flaking" normally refers to the detachment of a flake or a blade from a core. "Retouch(ing)", sometimes called "secondary retouch(ing)", is largely applied to a flake or a blade to modify its cutting edge. I use the general term "shaping" for all knapping activities that take place after a blank has been extracted. Newcomer (Newcomer 1971) distinguished between three stages in Acheulian handaxe shaping: “rough-out”, “shaping” and “finishing”. These have proven very useful in describing the bifacial tool-knapping sequence (Sharon and Goren-Inbar 1999; Sharon and Goring-Morris 2004 for definition, discussion and references), and are used here when applicable. Of course, the shaping of LCTs is only one stage in the *chaîne opératoire* sequence. Many other factors could have affected a tool’s flaking process: resharpening (McPherron 1999; McPherron 2006 for references), the tool’s history of use and such post-depositional occurrences as trampling. However, these elements are very hard to distinguish from scars that derived from shaping (see Chapter 5 for further discussion).

The Lithic Analysis Method

In order to ensure reliability in comparing widely separated Acheulian sites, the current study had to formulate a database of LCT samples that were documented in a uniform manner. This was achieved through the methodology of the attribute analysis developed for the GBY lithic assemblage (Goren-Inbar and Saragusti 1996; Goren-Inbar et al. 1992; Sharon 2000), combining a record of quantitative and qualitative attributes with typological observations (see below for detailed description). This method adopts the approach that understanding the cultural aspects of an Acheulian lithic assemblage depends upon studying as many stages of its tools’ *chaîne opératoire* as possible. The GBY attribute analysis method was selected for the following reasons:

a. The method was developed and adapted specifically for analyzing large-flake-based LCT technology, which is prominent in GBY.
b. The method is flexible, enabling one to add observations and attributes (e.g. a new type of raw material or retouch) into the system during the procedures of analysis.
c. The GBY lithic attribute analysis incorporates earlier approaches to lithic analysis into the examination. The measurements of the handaxes follow the method presented by Roe (1968, 1994, 2001). F. Bordes’ typological definition was also used (Bordes 1961).

General Typological Classification

At the base of the GBY classification system lies the one developed for the lithic assemblage of ‘Ubeidiya (Bar-Yosef and Goren-Inbar 1993). The latter, in turn, was based on M. D. Leakey’s Olduvai Gorge lithic artifact classification (Leakey 1971). The lithic artifacts can be classified into the following general categories:

1. **Natural Pieces:** All pieces of stone (of any size) that bear **no clear evidence** of human modification or use (e.g. flake scars, battering marks, etc.). The fact that they lack any sign of utilization does not mean that their archaeological presence in a layer is due to a natural agent. In fact, a geomorphologic study of the GBY sediments has indicated that the water energy, involved in the accumulation of most of GBY Layer II-6 (Chapter 3), was insufficient for shifting lithic pieces larger in diameter than about 10 cm. This group includes manuports, potential hammer stones and anvils that due to insufficient evidence could not be assigned to any other tool category. From the technological perspective, these lithic artifacts preserve important information about raw material use strategies and other features.
2. **Flakes and Flake Tools:** All artifacts, tools as well as waste, that possess the morphological characters of a flake. Some of these artifacts display all of the characteristic flake attributes, including striking platform, ventral face with percussion bulb and conchoidal features. On others only a ventral face is identifiable, which is sufficient for ascribing an artifact to the “flake and flake tool” category.
3. **Cores and Core Tools:** All artifacts from which flakes have been removed by human agency. These include true cores as well as tools shaped on non-flake lithics, like chunks or natural cobbles (chopping tools, spheroids, etc.). The giant cores from which large flakes were produced for Acheulian LCT blanks are members of this group. Hammer stones, defined as cobbles and pebbles that show clear markings of battering, are also included in this group.
4. **Bifaces:** a) *Cleavers*: All knapped bifacial tools that fall under Roe’s definition of “cleaver” (Roe 1994; see also above). b) *Handaxes*: All bifacially knapped tools that are not cleavers are grouped into this category, encompassing handaxes of all types and such tools as picks and knives, which are very rare among GBY LCTs. In order to qualify for the handaxe category, a tool must have significant retouch on both faces. Retouch on only one face (unifacial) categorizes a tool as a flake rather than a handaxe, even though it may be similar in its morphology and flaking technology.

Attribute Analysis

Each of the above-mentioned typological groups (handaxes, cleavers, cores and core tools, flake and flake tools) was analyzed using a particular list of attributes, applicable to its specific character. These attributes include metric measurements, based largely on the methodology of Roe (1994, 2001), weight, circumference and the length of the cutting edge in handaxes. The qualitative attributes include such descriptive information as the raw material, state of weathering, patination and location and nature of any breakage. Other attributes refer to such technological features and observations as the type of blank used, the number and location of flake scars on a tool's face, the amount of residual cortex, the direction of the blows, the type and location of retouch, and more. The full version of the attribute lists is detailed in the Appendix.

Defining a Tool's Face

Many lithic analysis attributes (e.g. number and location of scars, location and nature of the striking platform, residual cortex, etc.) are usually recorded separately for each face of the LCT. In order to facilitate comparison with other tools and assemblages, a consistent method of identifying each face was selected. Of the methods suggested by Goren-Inbar and Saragusti (1996) and Roberts and others (1997), Goren-Inbar and Saragusti's method was adopted in this study. The faces of a biface flake blank can be defined as dorsal (face 1) or ventral (face 2), depending upon the presence of a striking platform and other features, such as a percussion bulb or conchoidal waves. In those (rare) cases where two striking platforms are present on the same flake (Kombewa flakes), the definition of one of the faces as "ventral" is arbitrary. Problems arise when both tool faces are fully covered in flake scars, obstructing the identification of any of the blank's features. In such cases, the flatter of the two faces of the tool is treated as an equivalent of the ventral face (face 2).

Raw Material Identification

The type of raw material, used for LCT production in each assemblage was established through visual observation. When available, published data, or a site's excavator, provided additional assistance. Visual observation proved to be problematic in the following types of sites:

a. Sites whose different rock types are visually indistinguishable. An example is Ternifine, where quartzite and sandstone were used. The sand-rich quartzite made visual identification of the rock type impossible in many cases, forcing me to use the hybrid term "quartzite/sandstone" (see also similar discussion in Asensio 1996).
b. Sites at which various raw materials were in use, many of which require mineralogical testing for identification. A case in point is the East African sites, where a large variety

of metamorphic and volcanic rocks were used alongside quartz, chert and others. It is fortunate that meticulous observations on these sites are available. With regard to Olorgesailie, Noll (2000) provided a detailed study of each artifact's raw material. In Isimila, several researchers studied the lithic assemblage, and the results of this work appear in a digital database at the Field Museum, Chicago. I have used these identifications when available.

Flake Scar Count

Flake scars, created by the knapper in the process of shaping a bifacial tool, are a key technological mark, attesting to a tool's production sequence. The number of scars and their morphology can tell us about the knapping method used, the time invested in production, and even the quality of workmanship. In analyzing LCTs, prehistorians contend with two main difficulties related to counting and interpreting flake scars:

1. Experimental studies have long demonstrated that the production of large cutting tools (particularly handaxes) generates many more flakes than the scars left on the finished tool (Madsen and Goren-Inbar 2004; Newcomer 1971). What, then, is the validity of counting scars on a finished and discarded biface?
2. The scars left on a biface are the result of different stages in the tool manufacturing process. Large, deep scars could have stemmed from giant core shaping prior to the removal of the large flake that was used as a blank for the tool. Other large scars could be the consequence of the "rough-out" stage of production. Long, shallow scars are attributable to the "thinning and shaping" stage, and small scars, adjacent to a tool's edge, are probably the result of the "finishing" stage, in which the knapper prepared the cutting edge for use (all stages after Newcomer 1971). In addition, one cannot rule out the possibility that some scarring is the result of post-production tool use or post-depositional processes. The problem is distinguishing between the different types of scars, and the stages at which they were made. In many cases, it is not even possible to decide whether a specific scar was produced before or after blank production. This problem becomes even more crucial when dealing with coarse-grained and very old and weathered LCTs, similar to many of the tools depicted in this study.

These are problems that cannot be solved. Nonetheless, scar counts can teach us a great deal about the technology used in tool shaping and about the effort and dexterity involved in tool production. The method adopted here is a complete count of all scars, regardless of their stage of origin. Goren-Inbar and Saragusti (1996) defined the minimal length of a scar as 5 mm, but I have counted all of the tool scars I could identify, including the smallest ones. The rationale behind this approach is that according to many modern knappers (Goren-Inbar and Sharon 2006; Madsen and Goren-Inbar 2004; Newcomer 1971), finishing the edge by removing numerous micro-flakes and creating miniature scars on a biface's surface is an essential part of the knapping procedure. Since these tiny scars are virtually indistinguishable from those caused by tool resharpening, or use, I have counted all visible scars as a part of biface reduction. Studies that use the sequence of scars as an instrument for reconstructing technology and reduction strategy are very promising (Jöris 2006) in themselves, but are unsuitable for most of the tools under study here.

Metric Measurement

The following diagrams demonstrate the method of artifact placement during analysis, and the general measurements recorded for each artifact type-group (i.e. flakes and flake tools, cores and core tools, handaxes and cleavers). I have followed the methods of Roe (2001), both in tool grip and placement in the "Virtual Box" for measurement, and the measurement itself (with some exceptions, e.g. in measuring the length of a cleaver's edge).

Flake and Flake Tools

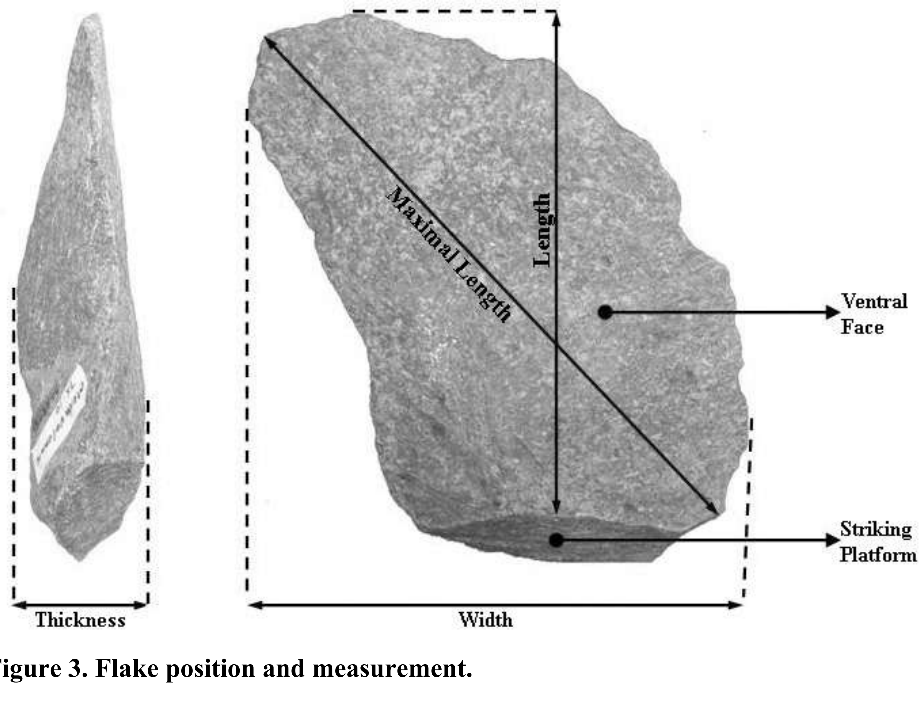

Figure 3. Flake position and measurement.

Cores and Core Tools

In cores bearing a scar that seems to have resulted from predetermined flake removal (in the sense of Boëda 1995), the scar's dimensions were recorded according to the axis of removal (Fig. 4). The weight of the core and its circumference were also measured.

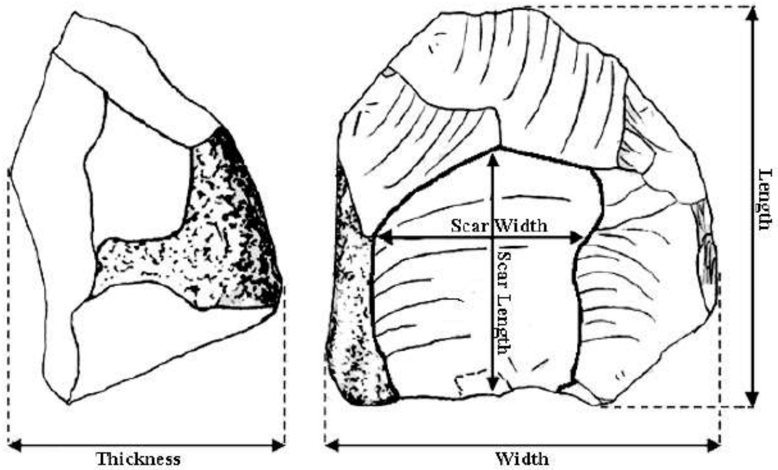

Figure 4. Core position and measurement.

Handaxes

In addition to the measurements specified in Fig. 5, the circumference of the handaxe was measured along its cutting edge perimeter, and the handaxe was weighed.

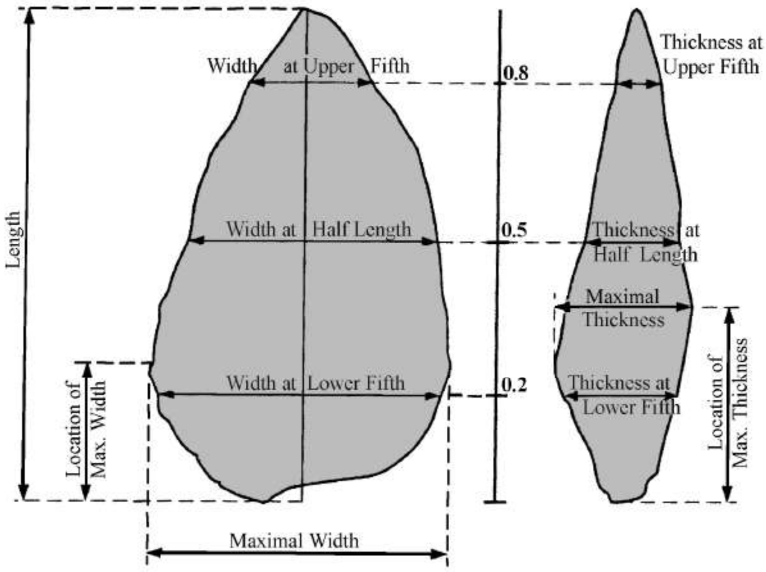

Figure 5. Handaxe position and measurement (after Goren-Inbar and Saragusti 1996).

Fig. 6 demonstrates possible handaxe cutting edge locations. The edge and its significance are discussed in detail in Chapter 5.

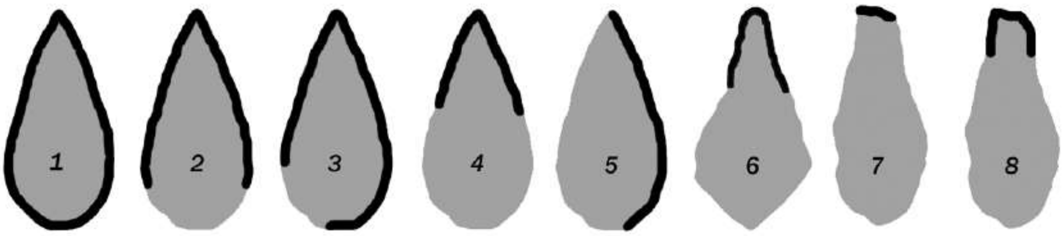

Figure 6. Locations of handaxe edges.

Cleavers

The circumference of the cleaver was measured along its maximal perimeter and its weight was recorded.

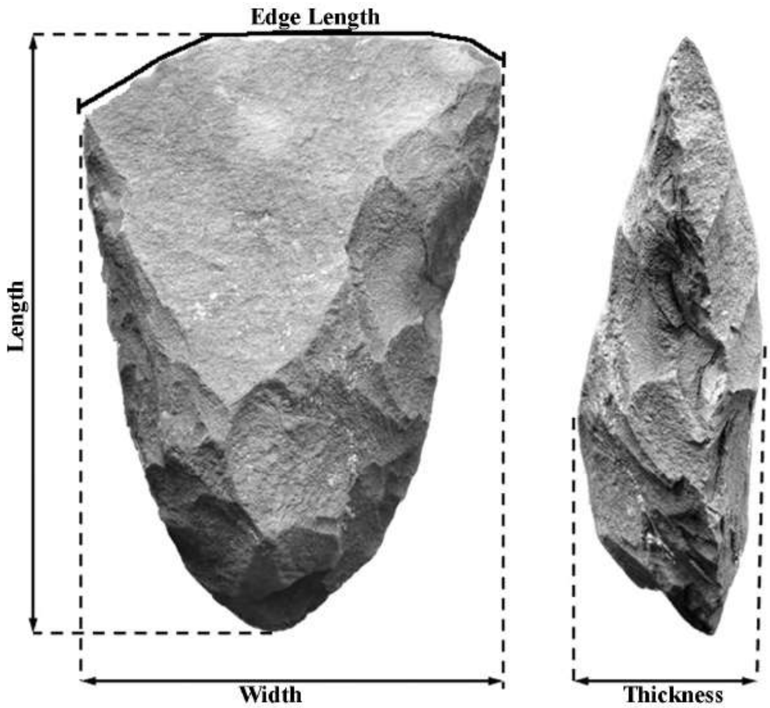

Figure 7. Cleaver position and measurement.

Data Analysis and Graphic Presentation

The data retrieved from the lithic attribute analysis of the artifacts was documented using the Microsoft Access database program, and the statistical study was carried out using

SPSS 10 software, with metric attributes being graphically presented through boxplot diagrams (Fig. 8). The advantages of using boxplots are that they present the full range of available data and its distribution, while eliminating the biased effect of extreme values on the median, without excluding or ignoring them. The boxplot diagram is essentially a "summary plot based on the median, quartiles, and extreme values. The box represents the interquartile range, which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median" (SPSS 10 software help). The outlier values comprise two categories:

1. **Extremes**, marked by asterisks (*****) and representing cases with distal values of more than 3 box lengths (box length = interquartile range) from the upper or lower edge of the box.
2. **Outliers**, marked by circles (○) and representing cases with distal values of between 1.5 and 3 box lengths (box length = interquartile range) from the upper or lower edge of the box.

Sample sizes are indicated in the bottom row. Gray boxes mark samples originating in excavated sites, while white boxes represent samples from surface collections and uncertain stratigraphic contexts. When metric data are presented, only unbroken artifacts are included in the statistical analysis.

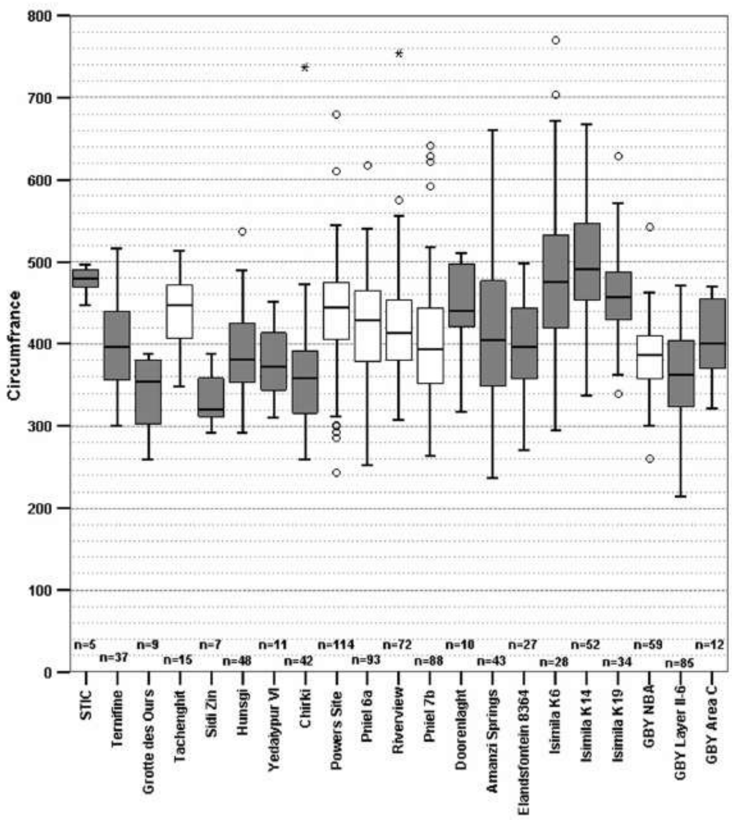

Figure 8. Example of boxplot diagram.

On Statistical Tests of Significance

Statistical significance tests have come to be regarded as indispensable when comparing stone tool assemblages. Yet, in many cases these statistical tools have proven inadequate for the task at hand (Thomas 1978). Statistical significance tests (such as the T-test) posit that sampling should be carried out randomly in a single population, thus leading one to the inevitable probability that any observed variation can be explained away by sampling error alone. Furthermore, statistical significance tests can only test differences between samples, not their similarity. If the result of a particular test is "insignificance", this only serves to indicate that, given total population variability, any deviation from a tested attribute's average value may be random. This by no means indicates that the tested samples share any kind of similarity. It most certainly does not *prove* that the objects being tested are random samples from the same population, but merely that this possibility cannot be discounted (Gutman 1977; Sharon 1992).

The main problem with applying such tests to archaeological samples is that samples usually come from different populations at the outset. A sample of handaxes from India and another from South Africa do not, by definition, belong to the same population, and differences are apparent in raw material, technology, chronology and craftsmanship. One might claim that both sub-populations belong to a diffuse parent population (e.g. "all the Acheulian handaxes ever manufactured in the world"), but then sampling was by no means random in this study (I consistently sampled South Africa as one batch, India as another, and failed to sample other segments of the "population", e.g. France). Statistical testing in such cases becomes no more than an elaborate way of stating the obvious, because it is designed to detect the sheer *existence* of differences between two or more sub-populations, not the *degree* of those differences. Given a large enough sample, even tiny and archaeologically inconsequential differences will stand out as statistically significant (see further discussion and details in Gutman 1977; Sharon 1992; Thomas 1978). For these reasons, I did not use tests of significance, or any other highly sophisticated statistical analyses in this study (Thomas 1978). I preferred to present a basic descriptive statistical comparison between the samples, making many observations by eye.

Digital Archive of Artifacts

Unless otherwise specified, I digitally photographed all the artifacts included in this study in both a frontal plan-view and a sectional view. In cases that seemed of special illustrative value for their technological aspects, the opposite cross-section was also photographed, in addition to the tip and any other aspect of interest. All photographs were taken with a Pentax Optio 330GS digital camera supported by a tripod, using no special lightning. The scale is always in centimeters, with exceptions noted in the figure captions. My own line drawings are also sometimes included. During data processing, the digital image archive was used as a reference source for examining questions and hypotheses. The digital images were processed by means of Adobe Photoshop 7 software, enabling me to demonstrate many of my observations graphically, and to produce and present shape diagrams of the full range of LCT shapes in a given sample. These diagrams served as an important tool in discussing the significance of Acheulian LCT shape variability (Chapter 5).

Experimental Data

It has long been known that experimental replication of lithic artifacts is an essential tool for understanding and interpreting archaeological lithic assemblages (Callahan 1979; Crabtree 1967; Jones 1981, 1994; Toth 2001). The study of the lithic artifacts from GBY was accompanied by an extensive experimental program, designed to replicate the main aspects of stone-working at the site by focusing on its knapping reduction sequence, i.e. the production of LCTs from large flakes that were detached from giant cores (Dag and Goren-Inbar 2001; Goren-Inbar and Sharon 2006; Madsen and Goren-Inbar 2004; Sharon 2000; Sharon and Goren-Inbar 1999; Sharon and Goring-Morris 2004). Madsen and Goren-Inbar (2004) recently discussed this experimental study in detail, including its implications for the GBY archaeological data.

Most of the archaeological data presented in this study were compared to B. Madsen's data (Madsen and Goren-Inbar 2004; Sharon 2000), obtained by controlled knapping experiments on basalt giant cores. The boulders collected in the vicinity of GBY that were used as blocks of raw material for giant core production were measured and described prior to the knapping process, as well as during and after the procedure. The flakes resulting from some of these cores were collected and analyzed, using the lithic attribute analysis applied to the GBY archaeological flakes. An additional set of data was provided by B. Madsen's study (Madsen and Goren-Inbar 2004) of experimentally manufactured basalt and flint LCTs. All flakes from all stages of knapping were kept and, in some cases, later measured and analyzed using the GBY methodology. Specific experimental cases, selected to illustrate different aspects of the lithic assemblages under study, are presented in the relevant places below.

Chapter 3: The Sites

This study is based on a comparative analysis of LCTs sampled from most regions in which the Acheulian techno-complex is documented, excluding the Iberian Peninsula. The sites that were sampled in the current study, their regional location and their main published resources are presented in Table 2. Based on the available literature, uniform outline summaries of the current state of archaeological research were compiled, stressing a site's lithic assemblage and its sampled LCTs.

South Africa – Acheulian Sites of the Vaal River

Background – The main South African archaeological remains bearing Quaternary sediments that predate the Middle Pleistocene are Australopithecine cave fills and the Vaal River terraces. Such deposits are most abundant along the lower 300 km of the Vaal River (Cooke 1949; Helgren 1978, 1979). The discovery of diamonds in these sediments in 1869 led to massive and still ongoing mining operations along their entire length. Piles of discarded deposits and sections of unfilled digger pits are very often the sole source of extant archaeological information.

Excavation – For over a hundred and fifty years, both professional and amateur archaeologists have been collecting stone tools from the abovementioned piles (Beaumont and Morris 1990; Helgren 1978; and references therein). In his pioneering work, van Riet Lowe (Söhnge et al. 1937) surveyed more than 500 miles along the Vaal River. His results remain the most comprehensive archaeological description of this region. The wealth of prehistoric artifacts in the Vaal River deposits permitted the establishment of the first prehistoric cultural sequence in Africa (Goodwin and van Riet Lowe 1929). This scheme has since been disputed and is no longer considered valid, although no alternative scheme has been provided. Moreover, the ever-dwindling intact archaeological deposits have very seldom been explored through modern excavation methods.

Table 2. Sites chosen for sampling.

Site	Region	Key Publication
South Africa		
Power's Site	Lower Vaal River, South Africa	Helgren 1978
Pniel 6 (locality a)	Lower Vaal River, South Africa	Helgren 1978
Pniel 7 (pile b)	Lower Vaal River, South Africa	Sharon and Beaumont 2006
Riverview Estate	Lower Vaal River, South Africa	Helgren 1978
Doornlaagte	West of Kimberley, South Africa	Mason 1988
Canteen Koppie	Lower Vaal River, South Africa	Beaumont and McNabb 2001
East Africa		
Isimila K6	Southern Highlands, Tanzania	Howell et al. 1962
Isimila K14	Southern Highlands, Tanzania	Howell et al. 1962
Isimila K19	Southern Highlands, Tanzania	Howell et al. 1962
Olorgesailie Main Site – DE/89 horizon B	Southern Gregory Rift Valley, Central Kenya	Isaac 1977
India		
Hunsgi	Hunsgi Valley, Karnataka State, South India.	Paddayya 1982
Yediyapur Locality IV	Hunsgi Valley, Karnataka State, South India.	Paddayya 1987
Chirki-on-Pravara	Maharashtra State, India	Corvinus 1983b
North Africa		
Sidi Abderrahman – Grotte des Ours	Casablanca, Morocco	Biberson 1961
STIC Quarry	Casablanca, Morocco	Biberson 1961
Ternifine	Algeria	Geraads et al. 1986
Tachenghit	West Sahara Desert, Morocco	Alimen 1978
Sidi Zin	Algeria	Gobert 1950
Levant		
Gesher Benot Ya'aqov (GBY)	Northern Rift Valley, Israel	Goren-Inbar et al. 2002
GBY North of Bridge Acheulian (NBA)	Northern Rift Valley, Israel	Sharon et al. 2002
Ma'ayan Barukh	Northern Rift Valley, Israel	Stekelis and Gilead 1966

Stratigraphy – The general stratigraphy of the Vaal River was established in the 1930s, when three major units of the Vaal sedimentary sequence were defined. These are the "Older," "Younger" and "Youngest" Gravels (Söhnge et al. 1937), which are in turn divided into sub-stages. This stratigraphy has since been revised and the old definitions are no longer accepted as an accurate description of the Vaal River geology and sedimentology (Helgren 1978). Nevertheless, the terminology "Older" and "Younger" Gravels is still in use, and is essential to our understanding of the stratigraphic locations of the stone tool collections along the Vaal River. A view of the Vaal River's alluvial history, and a summary of current research is given by Butzer (1984, Table 4).

Date of the Vaal River Deposits – The Older Gravels were roughly dated to the Early Pliocene and are perhaps even as early as the Miocene, based on the presence of a few large mammal fossils of uncertain origin. The Younger Gravels contain over 1000 specimens of fossil animals, all coming from surface collection and very likely covering a long time span. However, within this span 70% of the fossil bones originate in "Younger Gravels C", dating this stage to the Middle Pleistocene. Stages A and B of the Younger Gravels are thought to be Early Pleistocene. Acheulian artifacts were found in all Younger Gravel deposits (Helgren 1978, 45–46). The cores and large cutting tools discussed here are a part of the Acheulian assemblages housed at the McGregor Museum in Kimberley, South Africa. The LCT assemblages that were sampled come from the following major Acheulian localities in the lower Vaal River Basin (Fig. 9):

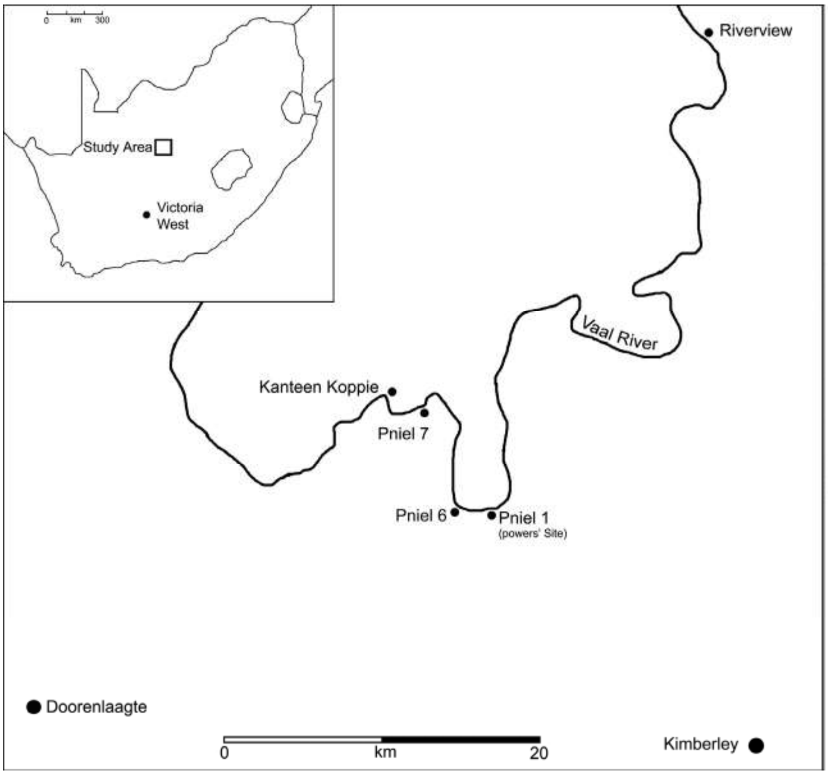

Figure 9. Location map of Vaal River Acheulian sites (after Sharon and Beaumont 2006).

Power’s Site

Previous/Alternative Names – Pniel 1.

Location – Coordinates 28°35"45'S and 24°36"30'E (Beaumont and Morris 1990, 7). Power’s Site is located about 22 km northwest of Kimberley, on the southern bank of the Vaal River (Fig. 9; Beaumont 1990c).

History of Research – Power’s Site is named after J. H. Power, who after discovering it collected its artifacts and bones for over twenty years. Massive quarrying by diamond diggers, primarily during the 1930s to the 1950s, exposed large quantities of Acheulian artifacts along the banks of the Vaal River. Most of the material was collected from dumps that had resulted from mining activity. During the years 1984–5, Beaumont collected additional artifacts (Fig. 10; Beaumont 1990c).

Excavated Area – The artifacts sampled here originated in a large unselected sample of fresh to lightly abraded tools that were collected at two neighboring digger dumps in 1984. The material could be divided into a Fauresmith group with ferricrete adhesions and an Acheulian group lacking this trait (Beaumont, personal communication).

Figure 10. Collecting LCTs from Power’s Site during the 1980s (from Beaumont and Morris 1990).

Stratigraphy – In 1954, an exposure occurred about 7 meters from the water’s edge. This enabled Power to describe the site’s stratigraphy (from top to bottom, Beaumont’s stratum numbers) as follows (Beaumont 1990c; Power 1955):

Stratum 1 – 2.5 m of compact superficial alluvium, archaeologically sterile.

Stratum 2 – 1.3 m of fine gravel containing Middle Stone Age (MSA) artifacts, alternating with levels of sandy clay.

Stratum 3 – 0.5 m of hard ferruginized sand and cobbles. The contact surface between strata 3 and 4 contains Acheulian material, with some Fauresmith handaxes.

Stratum 4 – 2 m of "gravel" fining upward, overlying uneven bedrock. This stratum contains Early Stone Age (ESA) artifacts. Stratum 4 was defined by most scholars as belonging to the "Younger Gravels" (also known as Reitputs C; Helgren 1978). Alternatively, Beaumont (Beaumont 1990c) termed this layer "colluvial rubble". The archaeological levels of the site are currently under water.

Environment and Fauna – The deposits below river level indicate a high-energy fluvial Vaal environment, fed by a precipitation higher than the present one (Klein 1988). The fauna collected by Power was taphonomically biased, comprising almost exclusively teeth. Two of the taxa, *Elephas recki* and the suid *Metridiochoerus andrewsi*, are of an advanced evolutionary stage and are unfamiliar in post-Acheulian contexts in South Africa.

Date – The elephant and suid teeth have aided in attributing the site to the "same Middle Pleistocene interval" as the Acheulian sites of Kathu Pan and Elandsfontein (Klein 1988, 18).

Human Remains – None.

The Lithic Assemblage

Raw materials – As at other Vaal River sites, large exposed blocks of andesite, the site's primary raw material, are situated adjacent to the river (Helgren 1978; Söhnge et al. 1937).

General description by the excavator – Beaumont has suggested that all andesite artifacts without ferricrete adhesions belong to Stratum 4, while those with ferricrete adhesions originate in Stratum 3. Chert and hornfels artifacts can be attributed to Stratum 2. Furthermore, Beaumont noted that the MSA admixture is minor, indicating that the Acheulian tradition at Power's Site is composed of two entities. The lower (early) one mainly contains lightly abraded artifacts, with cleavers being dominant among the group. Occasionally, a large prepared core is present. The upper (younger) phase is characterized by a higher percentage of variously sized handaxes and blades. Power's Site is probably the densest site among the Vaal River Acheulian Sites (Fig. 10). Power "counted 65 specimens (cleavers only) within a radius of a couple of yards… on one gravel heap" (Helgren 1978, 55). That heap had been a collection source on previous visits.

The Collection Sampled

Location – McGregor Museum, Kimberley, South Africa.

State of preservation – The tools from Power's Site are rather more abraded than the other Vaal River Acheulian samples under study here. While 32.2% of the cleavers and 36% of the handaxes are slightly abraded, 61% of the cleavers and 50% of the handaxes were classified as abraded.

Reconstruction of the stratigraphic location of artifacts – Since the artifacts are from surface collection, no layer is noted. The name of the site is well marked on the artifacts.

The sample – 116 cleavers and 50 handaxes were analyzed as a part of the current study.

Additional data – An additional 153 cleavers and 26 handaxes were counted in the boxes at the McGregor Museum. The assemblage is characterized by cleaver dominance.

Pniel 6

Previous/Alternative Names – The Bend (Beaumont 1990d).

Location – Coordinates 28°36"25'S and 24°34"40'E (Beaumont 1990d). Pniel 6 encompasses a Vaal River channel and its southern bank. It is located on Pniel's farm, about 23 km northwest of Kimberley (Fig. 9). As is the case for most Vaal River sites, it has largely been destroyed by diamond mining activity.

History of Research – The site was brought to the attention of archaeologists by the work of van Hoepen (see Beaumont 1990d for references). Beaumont's systematic survey and fieldwork enabled him to establish a basic stratigraphy and chronology for the site. During the summer of 2000, an excavation covering 5 m^2 was directed by McNabb (2001).

Excavated Area – The tools in this study originate in a large unselected sample of fresh to lightly abraded Acheulian tools, collected in 1983 from a 15 m^2 "island" of gravel in midstream Vaal River. This "island" is the downstream end of an old cofferdam built from riverbed deposits by diamond diggers in the 1920s and 1930s (Beaumont, personal communication).

Stratigraphy – Beaumont's observations at Pniel 6 led him to reconstruct the following stratigraphy for the site (from top to bottom):

Stratum 1 – 5 m of gray over-bank silts, or alternatively heavily weathered Holocene alluvium.

Stratum 2 – Up to 11 m of beige over-bank silts.

Stratum 3 – 0.5 m of down-slope fining andesite clasts in a matrix of sand-grit.

Stratum 4 – A similar unit that lenses in below Stratum 3, lying on bedrock (Beaumont 1990d).

A recent excavation by McNabb (2002) has confirmed the sterile nature of both Strata 1 and 2, and Beaumont's observations on the nature of Stratum 3 and its distinction from Stratum

4. However, the lithic assemblage originating in the contact surface between Strata 3 and 4 is MSA (laminar and convergent Levallois artifacts), dominated by hornfels as its raw material. These features, coupled with the near-absence of bifaces (only two heavily rolled handaxes were excavated in this layer), mark a significant divergence from the Pniel 6 Acheulian assemblages that had been collected earlier (McNabb 2002).

Environment and Fauna – The bones are well preserved. A collection of fossil bones from the diggers' piles is dominated by large ungulates, typical of an open environment. Some cut-marks and signs of hammer-cracked bone were noted (Beaumont 1990d, 11).

Date – Stratum 1 was dated to the Holocene. On the basis of its lithology, which is similar to that of the neighboring site of Nooitgedacht, Stratum 2 was dated to OIS 5e (Beaumont and Morris 1990). Stratum 3 has yielded a Fauresmith assemblage resembling that of the site of Florisbad, dated to OIS 8. The larger and cruder andesite bifaces, collected from piles of material dredged from the Vaal channel, have been assigned to Stratum 4. Beaumont has suggested that based on their size, shape and material, the tools at the site represent two different Acheulian entities. He noted, however, that both had originated in the same technological system, which he defines as "Proto-Levallois" cores. Given the typological similarity of the Stratum 4 early Acheulian assemblage to the bifaces of Power's Site, and based upon the presence of *Elephas recki* at Power's Site, Beaumont dated this stratum to the later Early Pleistocene (Beaumont 1990d; McNabb 2002).

Human Remains – None.

The Lithic Assemblage

Raw materials – As in other Vaal River sites, andesite is the dominant raw material in the Acheulian layers. A shift to hornfels, chert and quartzite is noted in the site's later MSA assemblages (McNabb 2002). In the immediate vicinity of the site, large angular blocks of andesite are widely available in outcrops (Fig. 11:c).

General description by the excavator – Subsequent to Goodwin and van Riet Lowe (1929), Beaumont has suggested that while Acheulian bifaces from lower Layer 4 (found in material obtained from deep within the present Vaal River channel) are large and made almost entirely of andesite, the younger assemblage (found closer to the present-day bank) comprises tools smaller in size and shows use of other raw materials, primarily hornfels (Beaumont 1990d).

Figure 11. Pniel 6, June 2003. a. General view looking south. b. General view looking northeast, showing piles of gravel in the river. c. Looking west: an andesite outcrop in the immediate vicinity of the site. d. Large cores and a cleaver collected from a pile at Pniel 6.

Size of excavated assemblage – A very large assemblage was collected from the piles in and near the river channel.

The Collection Sampled

Location – McGregor Museum, Kimberley, South Africa.

State of preservation – As in other Vaal River assemblages, the preservation of the large cutting tool assemblage is relatively good. 69.6% of the cleavers and 41.5% of the handaxes are only slightly abraded and heavily rolled tools are almost entirely absent.

Reconstruction of the stratigraphic location of artifacts – All artifacts are marked with the site's catalog number, 6755.

The sample – The site's assemblage represents its earlier Acheulian phase (Beaumont, personal communication). The collector sorted the tools according to their state of weathering. Naturally, fresh artifacts received priority in sampling. 102 cleavers and 41 handaxes from Pniel 6a were analyzed.

Additional data – All of the artifacts in the collection were tallied and typologically classified. In addition to the tools that were sampled, 83 cleavers and 62 handaxes were counted, although most are rolled.

Pniel 7b

Previous/Alternative Names – None.
Location – This site is located 2 km ESE of Canteen Koppie and a few hundred meters from the southern bank of the Vaal. No publications are available for the site.
History of Research – Diamond diggers exposed the site in 1990. Beaumont collected the archaeological material from three sediment piles (a–c) in 1990 (Beaumont, personal communication).
Excavated Area – The tool sample in this study derives from a large unselected sample of mainly fresh Acheulian artifacts, originating in a single gravel pile (pile b) (Beaumont, personal communication).
Geology – The site was dug from sediments along a small trench, flanked by an andesite outcrop. The sequence comprised calcified beige silt, up to 4 m thick, overlying about 3 m of calcified sub-angular rubble. A large number of artifacts were spread throughout the latter stratum, which had probably derived from the nearby ridge (Beaumont, personal communication).
Environment and Fauna – None.
Human Remains – None.
The Lithic Assemblage
Raw materials – No information is available on the form of the raw material in the vicinity of Pniel 7. However, the closeness of the site to other Vaal River sites suggests similarity to them in this aspect. The dominant raw material is andesite (92.5% of the handaxes and 99% of the cleavers). One chert cleaver is present. Two handaxes and one cleaver were made on quartzite.
General description by the excavator – The full range of Acheulian typological forms occurs in the assemblage. This contrasts with the Pniel 6 collection, where handaxes and cleavers made up >90 % of the sample. Distinctive to the Pniel 7 material is a small number of very small cleavers, which do not occur at Canteen Koppie or Pniel 6. In light of his observation of the Pniel 7b collection, Beaumont has suggested that the Acheulian

represented at the site is somewhat younger than that of other Vaal River Acheulian sites (Beaumont, personal communication).

Size of excavated assemblage – As at other Vaal River sites, hundreds of bifaces and other artifacts were collected from digger piles.

The Collection Sampled

Location – McGregor Museum, Kimberley, South Africa.

State of preservation – The artifacts vary from fresh to slightly abraded (Beaumont, personal communication). The artifacts in the sample are well preserved, with 62.2% of the cleavers and 50% of the handaxes classified as only slightly abraded.

Reconstruction of the stratigraphic location of artifacts – Museum number 6950.

The sample – All artifacts are from Pniel 7b, "b" signifying a specific pile (Beaumont, personal communication). 100 cleavers and 40 handaxes were analyzed.

Riverview Estate

Previous/Alternative Names – Several localities have been classified as Acheulian sites on the property of the Riverview Estate Farm**.** Each has a specific name, and those that have been studied and briefly described are Homestead, Larsen, Riverview VI and Newman's Pont (Cole 1961; Helgren 1978; Söhnge et al. 1937).

Location – Coordinates 28^{o}20"S and 24^{o}44"E (van Riet Lowe 1935): "on the property of Carrig Diamonds Ltd., at Riverview Estates on the left bank of the Vaal River immediately opposite Windsorton" (van Riet Lowe 1935, 53).

History of Research – F. W. Webber (Director of Carrig Diamonds Ltd.) collected the first artifacts in 1935 and brought the site to the attention of archaeologists. C. van Riet Lowe and S. H. Haughton carried out a detailed survey and study of the site. The tool sample used in this study originates in a collection assembled in 1971 by V. V. Halliwell, a digger who spent his entire life at Riverview. The collection of Acheulian tools came from a diamond-mining pit known locally as Halliwell Pothole (Beaumont, personal communication).

Geology and Stratigraphy – Extensive diamond digging activity has rendered Riverview Estate sediments the most exposed along the Lower Vaal River (Söhnge et al. 1937, 73). Van Riet Lowe (1935) described the stratigraphy of a number of archaeological localities (mainly mining pits), portraying the area as a sequence of sands and silts topping a layer of river gravels. He suggested a general reconstruction, in which Fauresmith artifacts (small handaxes on durated shale) were present within the sand/silt layers and Acheulian

(Stellenbosch) artifacts rested in the underlying gravels (van Riet Lowe 1935). Van Riet Lowe's interpretation is no longer considered valid, making it difficult to link the archaeological finds with his sequence. Helgren's (1978) work revised the earlier stratigraphic description, detailing the sites much more fully.

Environment and Fauna – The well-preserved fossil bones include the remains of horse, buffalo, antelope, large carnivore, hippopotamus and others (van Riet Lowe 1935).

Date – In his report on Larsen's Site, van Riet Lowe considered the origin of its Acheulian tools. Helgren (1978, 50) interpreted this pertaining to the surface of Gravel A and the lower part of Gravel B. Gravel C is dated to the Middle Pleistocene, possibly indicating that our assemblage should be assigned to the Early Pleistocene (a less hypothetical date has not been suggested).

Human Remains – None.

The Lithic Assemblage

Raw materials – Van Riet Lowe noted that at Riverview Estate, varieties of Ventersdorp lava and quartzite were the preferred raw material. Like all other Vaal River Acheulian sites, andesite was predominant in the production of Acheulian LCTs. It is important to note that, unlike any other Acheulian site in this study, 12 of the Riverview handaxes were made on hornfels. The handaxes made on this fine-grained material showed extremely high scar counts (maximal number: 80 scars per face; average: 40 scars per face). The raw material and the style of production may suggest that these tools are younger in age and therefore that the entire assemblage represents more than one cultural stage.

General description by the excavator – Van Riet Lowe assigned the Vaal River lower terrace assemblage to the Upper Stellenbosch culture, which was defined as Acheulian plus Proto-Levallois in type. The site was identified as a factory site on the basis of the presence of numerous hammerstones, knapping debris and many Victoria West cores. Fauresmith assemblages were also described in some of the Riverview localities (van Riet Lowe 1935).

The Collection Sampled

Location – McGregor Museum, Kimberley, South Africa**.**

State of preservation – The Riverview assemblage is the least abraded of the Vaal River assemblages included in this study. 76.0% of the cleavers and 68.1% of the handaxes are only slightly abraded.

Reconstruction of the stratigraphic location of artifacts – Museum number 7043. Halliwell collected this assemblage from Riverview Estate and most of the stones are marked "Mr. V. V. Halliwell 1971."

The sample – 76 cleavers and 47 handaxes were analyzed. In addition, one Victoria West core and 4 unstruck Victoria West pre-forms were studied.

Canteen Koppie

Previous/Alternative Names – Canteen Kop (Goodwin and van Riet Lowe 1929), Canteen Kopje, Klipdrif (Beaumont 1990a).

Location – Coordinates 28°32"30'S and 24°31"50'E (Beaumont 1990a). The site is located just over a kilometer southeast of the town of Barkley West.

History of Research – The quantity of stone debris at the site, estimated in the millions of items, is astonishing. Abbé Breuil was quoted as saying, "…not only are there enough specimens to fill a museum to overflowing, but to build it of them also". In 1869, the first alluvial diamond of South Africa was discovered here. This fact, rather than the richness of the prehistoric site, is the reason that it was declared a South African national monument in 1948. Between these two dates, extensive diamond digging changed the face of the whole area (Beaumont 1990a). Recently, further digging has taken place in the vicinity of the site, causing massive damage to the archaeological layers (Beaumont and McNabb 2001).

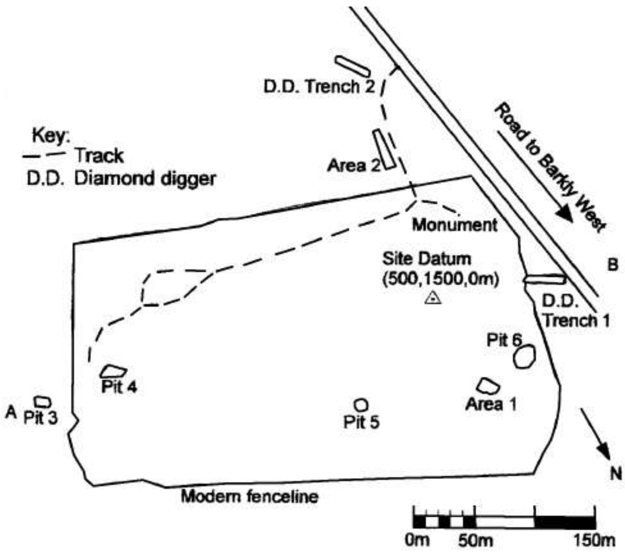

Figure 12. Canteen Koppie excavation map (after McNabb 2003).

Excavated Area – A few pits and one excavation area were dug at Canteen Koppie (Fig. 12). No exact location is given.

Geology and Stratigraphy – The main geological units, as summarized by Beaumont, are (from top to bottom):

Stratum 1 – Between 0.2 and 5 m of yellowish red sand and silty sand.

Stratum 2 – Up to 11 m of mainly angular andesite clasts, with some heavily rolled exotic pebbles. This is the Younger Gravels II. Bedrock of shale and andesite (Beaumont 1990a; Helgren 1978; Söhnge et al. 1937). Beaumont's interpretation of the nature of the deposit (Beaumont 1990a) was that it had shifted a short distance, due to gravitation from the surrounding low ridges (koppies).

Stratum 1 has yielded some Late and Middle Stone Age artifacts. Two Acheulian entities have been identified in the upper few meters of Stratum 2, one fresh and the other lightly to heavily abraded. Both contain prepared cores of the Victoria West II type. They differ from one another in that irregular cortical flakes are up to three times more numerous in the more abraded group. In the lower part of the gravels (Stratum 2) there is another, earlier assemblage, lacking Levallois (prepared) cores. However, the sample size of this stage is too small to permit any further definition (Beaumont 1990a and references therein).

Recent work at Canteen Koppie has enabled Beaumont to refine the site's stratigraphy (McNabb 2001, Table 4.2). Upper Stratum 1 is known locally as Hutton Sands, and in it Beaumont was able to distinguish four separate stages of development. This layer contains MSA artifacts and Fauresmith material. Layer 2 was divided into 3 sub-layers: **Stratum 2a** is matrix-supported gravel in which clasts, ranging from pebbles to boulders in size, are dominated by andesite. **Stratum 2b upper unit** is a matrix-supported sandy gravel. The nature of this unit was not clarified, as it did not appear in all parts of the excavated area's section. **Stratum 2b lower unit** is a matrix-supported sandy gravel (similar to that of Stratum 2a) resting on andesite bedrock (McNabb 2001).

Environment and Fauna – No bones are preserved**.**

Date – Stone artifact typology is the only criterion for dating the site. Beaumont has suggested dating Stratum 2a to the Early Pleistocene.

Human Remains – None in the Acheulian layers, although a San-type skull of unknown origin was found.

The Lithic Assemblage

Raw materials – Canteen Koppie was identified by excavators as a factory site for the production of Acheulian large flakes. The site contains abundant fresh exposures of andesite cobbles and boulders (Beaumont and McNabb 2001), the latter serving as the main raw material.

Specific description by the excavator – The frequency of LCTs is very low. Two giant handaxes (pre-forms?) probably originated in the base of Stratum 2a. Levallois prepared cores were noted in both Strata 2a and 2b. Victoria West cores, documented for the first time in a stratified context, were confined to Stratum 2a (Beaumont and McNabb 2001).

The Collection Sampled

Location – McGregor Museum, Kimberley, South Africa.

State of preservation – The great majority of artifacts (88.9%) are only slightly abraded.

The sample – In an effort to answer specific questions concerning the nature of the Victoria West core technology, a sample of 18 Victoria West cores was analyzed (Sharon and Beaumont 2006). These cores form a part of a small sample of bifaces and cores that were collected from dump surfaces next to section S of the Canteen Koppie site (Beaumont, personal communication).

Doornlaagte

Previous/Alternative Names – Doornlaagte 1

Location – Coordinates 28°43"20'S and 24°21"10'E (Beaumont 1990b). The site is located on the farm of Doornlaagte about 41 km due west of Kimberley, beside the road to Schmidtsdrif.

History of Research – A grader operator found the site in 1962 while initiating a quarry for road construction. Consequent to the operator's report, a small portion of the site was set aside for the archaeological excavation of R. Mason, G. Fock, H. J. Deacon and J. Deacon in early 1963 (Mason 1988).

Excavated Area – A living floor was exposed in an area measuring 20x50 ft (6x15.2 m), a segment of a much larger surface that had been removed by quarrying activity (Mason 1988). A pit located some 100 ft (30.5 m) south of the main area yielded no archaeological material.

Geology – Doornlaagte is a Calc-Pan site, in Butzer's terminology (Butzer 1974). The site was embedded in nearly 6 m of sedimentary deposits from a shallow paleo-lake (Pan). Butzer (1974) detailed the geology of the area and the sedimentation of the Doornlaagte strata.

Stratigraphy – Beaumont (1990b) summarized the stratigraphy as follows :

Stratum 1 – About 0.3 m of reddish-brown sand.

Stratum 2 – About 1.7 m of laminated calcrete.

Stratum 3 – About 0.7 m of southward-dipping greenish silty sand.

Stratum 4 – About 1 m of pebble-rich calcrete.

Stratum 5 – Over 2 m of massive white calcrete. The base of this layer was not reached. Test pits near the main excavation area indicated that Acheulian stone artifacts could be found 2–3 ft below the exposed living floor – essentially to the full extent of Stratum 3, interpreted to be the sandy margins of a seasonal shallow lake. Some of the handaxes were found tipped downward or sideways. This is the only site in the Vaal River basin in which a living floor, preserved in a colluvial deposit ("near-primary" context), was excavated and its artifact distribution recorded.

Environment and Fauna – Organic material is totally absent from the site.

Date – The excavator assigned the artifacts to the Late Acheulian. In summarizing the chronological evidence, Butzer concluded that the Doornlaagte Acheulian should be dated to the Middle Pleistocene (Butzer 1974, 1984).

Human Remains – None.

The Lithic Assemblage

Raw materials – Andesite was used almost exclusively.

Table 3. Doornlaagte typology (after Mason 1988, 625).

Type	Sub-type	N
Handaxes	Elliptical	6
	Opposed arc	3
	Oval	18
	Irregular	22
	Hemilemniscate	40
Picks		102
Large Flakes		162
Anvils		9
Manuports		31
Knives	Large	46
	Small	49
Waste		166
Choppers		4
Cleavers	Irregular	18
	Trapezoid	25
	Parallelogrammatic	34
	Oval	38
Small Flakes	Parallel	4
	Convergent	4
	Quadrilateral	5
	Irregular	168
Cores		144
Irregular Bifaces		55

General description by the excavator – The tools were classified as Late Acheulian in accordance with their typology, and the site itself was described as an "immense cache of artifacts abandoned by previous occupants of the site" (Mason 1988, 624).

Size of excavated assemblage – 1920 artifacts were excavated from the living floor.

The Collection Sampled

Location – McGregor Museum, Kimberley, South Africa.

State of preservation – The sample tools are relatively fresh, with 71.4% of the cleavers and 82.4% of the handaxes in a state of slight abrasion. However, the artifacts are covered in soft limestone (calcrete), making observation difficult.

Reconstruction of the stratigraphic location of artifacts – The artifacts come from the main excavation at Doornlaagte.

The sample – Only a small sample of tools and cores (14 cleavers, 17 handaxes, 12 cores and 3 hammerstones) was studied.

East Africa

Isimila

Previous/Alternative Names – Maclennan's Donga (Howell et al. 1962).

Location – Coordinates of the main excavation area in the northern branch of the Isimila Korongo are 7°53"48'S and 35°36"12'E (Howell et al. 1962, 45). The East African Archaeological Grid reference is Hx Jg (Cole and Kleindienst 1974). The site is situated 21 km (13 miles) from the town of Iringa in the southern highlands of Tanzania.

Elevation above Sea Level – About 1631 m **(**Howell et al. 1962).

History of Research – D. A. Maclennan (South Africa) discovered the site in 1951 during a car journey from Nairobi to Johannesburg. F. C. Howell, M. R. Kleindienst and G. C. Cole excavated the site for a total of 7 months during 1957–58 (Howell et al. 1962, 44). An additional season of excavation, directed by Hansen and Keller, took place in 1969 (Hansen and Keller 1971), and a small-scale excavation was undertaken by Kleindienst in 1970.

Excavated Area – The exact surface area of the excavation in 1957–58, encompassing all its numerous excavation spots, trenches and sounding pits, has not been published. During the 1969 excavation, an area of 620 m^2 was opened in grid unit K13 (Hansen and Keller 1971). The 1970 small-scale excavation was conducted in the Sand 4 layers (Fig. 13).

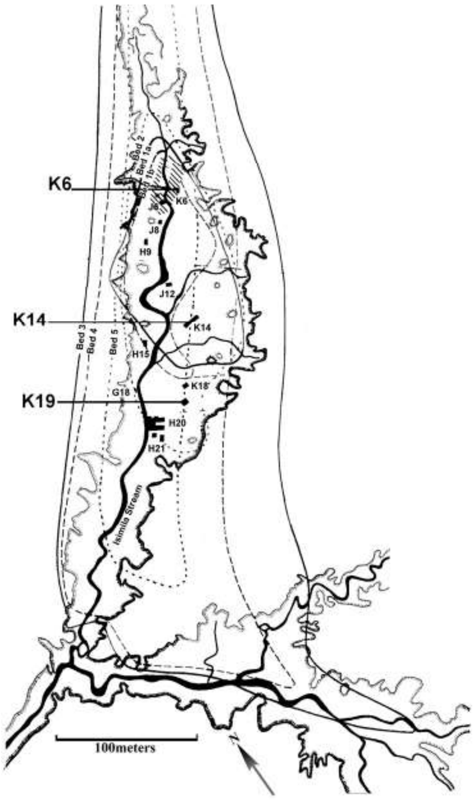

Figure 13. Isimila Korongo map and location of sites under study (after Howell 1961).

Geology – E. G. Holdemann and R. Pickering conducted a geological study of Isimila (Howell et al. 1962, 45). Precambrian crystalline rocks, covered by Quaternary sediments of variable thickness, cover the area. The Isimila stream runs through a small valley that was created by tectonic movement. During the Pleistocene the outlet of the basin was partially blocked, creating an elongated body of water. This body comprised a combination of marshes and small ponds, sometimes with an overflow. The basin was filled by alternating bands of fine, level-bedded gray-green clay and coarser sandy sediments, which Pickering named "Isimila beds" (Howell et al. 1962). The depth of the sediments is more than 18 m (60 ft), and the excavators estimated them to have accumulated over a "few thousand years at most" (Howell 1961; Howell et al. 1962).

Stratigraphy – Five distinct beds of coarser sands were identified in the Isimila beds, separated by layers of finer silty clay sediments (see Howell and Clark 1963 for details). The lower three sandy layers are thicker (up to a meter or more). Due to erosion, the upper sands feature only in the northern sector of the northern branch of the Isimila Korongo (Howell et al. 1962). Sand 1, the uppermost sand, has been subdivided into three levels: 1a, 1b and 1c. The main living floors and the largest quantities of artifacts originate in these upper layers. Sand 2 is only 30 cm thick and has only two occupation areas. Sand 3 starts the thicker, lower stratigraphic unit and contains some significant sites. Sand 4 yielded fewer artifacts, primarily small-flake tools and some large cutting tools (Cole and Kleindienst 1974). However, bone preservation is much better here. Very few tools were excavated in Sand 5 (Howell 1961). In several places, the colluvial sediments topping the Isimila beds contained Sangoan artifacts (Cole 1961; Howell and Clark 1963).

The sites sampled for this study include: K6 from the base of Sand 1 (Sand 1b), K14, excavated within 20 cm of the basal contact of this layer (Sand 1a; Howell *et al*. 1962, 61), and K19, located in Sand 3. Site K19 artifacts were distributed within 50–100 cm of the sand. This site (along with K18 and Upper J6/J7) was originally defined as "diffused", due to its artifacts, which were horizontally concentrated and vertically diffused. However, it was later concluded that the abovementioned sites comprise inter-digitating separate aggregates, situated on slightly differing stratigraphic levels (Cole and Kleindienst 1974, 351). K6 and K14 are "occupation floors", with the implements restricted vertically as well as horizontally. This type of site is found along the whole sequence of the Isimila stratigraphy, nearly always in the lower portion of the sand beds. As most artifacts are in mint condition and no evidence of water or other means of transport has been observed, it has been suggested that differences in artifact distribution within the sediments of the various sites should be attributed to human activity. The K6 occupation floor "was perhaps half preserved and this part was fully excavated; the surface-exposed implements also were collected" (Howell et al. 1962, 62).

Environment and Fauna – The upper three sands of Isimila are acidic in nature, and no bones (apart from a single hippopotamus tooth from the K14 occupation floor) were recovered from these layers. In Sand 4, on the other hand, many bones were excavated (mainly at H20 and H21), including a hippopotamus skeleton (H20, Trenches 3 and 6) that was probably butchered (Howell 1961). This entity was later reassigned to Sand 5 (Cole and Kleindienst 1974, 350). Other remains are of an alcelaphine antelope (a half skull with horn core) and fragmentary bones of rhinoceros, equids, hares, elephant and pig (Howell *et al*. 1962, 67; Coryndon et al. 1972).

Date – The short duration of the Isimila bed's sedimentation process, estimated to be a few thousand years, should be emphasized (Howell et al. 1962), although Hansen and Keller (1971) have questioned this interpretation. More study is required before a definitive answer can be reached. Typological comparisons with the Late Acheulian assemblages of Olorgesailie and Kalambo Falls have led Kliendienst to define Isimila as being younger than both (Howell and Clark 1963). Uranium series dating of bones from Sand 4 have yielded a date of 260,000 (+40–70 kya; Cole and Kleindienst 1974; Howell et al. 1972), but these dates are only a rough estimate.

Human Remains – None.

The Lithic Assemblage

Raw materials – Granite vein quartz, quartzite and mylonite were the main rock types used in the production of LCTs, while quartz was the primary raw material used for the production of small implements at the site (Howell et al. 1962, 47). Mylonite is a cataclastic microcrystalline rock with a finely divided quartz groundmass of various types and colors (Howell et al. 1962, 64). The Isimila mylonite has good knapping qualities. The best outcrops of this acidic-volcanic-metamorphic rock are found 4–5 miles west of Isimila, but the formation itself can be traced closer to the site. Since several cores larger than 60 cm were reported, mylonite was probably available in the form of large nodules or chunks. There is also evidence that this raw material occurred in the area as seams in the granite.

Some Isimila occupation floors were covered with stony rubble in addition to artifacts, showing varied raw material dominance in tools and rubble alike (Howell et al. 1962). For example, gray-green mylonite dominated both the LCTs and the rubble at K6, which was the most densely packed surface in Isimila and yielded large granite and mylonite chunks (over 10 cm) and artifacts. Since no typical waste products were present, this site was not identified as a quarry (Howell et al. 1962, 65). K14, excavated in the same layer (Sand 1), is an example of a living floor with very small quantities of rubble (Howell et al. 1962, 63).

General description by the excavator – The Acheulian sites of Isimila demonstrate great variety in the shape, type and finishing of the artifacts, as well as in their spatial distribution in the same stratigraphic horizon, which can be best seen in the material from Sand 1 (Cole and Kleindienst 1974).

K19 is one of the three living floors identified in the Sand 3 stratigraphic unit (together with K18 and H15). This locality contains the highest frequency of cleavers in the entire Isimila site (50%, n=44). “The cleavers are largely parallel-sided, with a third as many convergent types and extremely rare divergent ” (Howell et al. 1962, 69).

K6 is from the base of Sand 1. “In the K6 floor large cutting-edge implements formed about 80% of the shaped implements. The frequency of hand-axes (54%) was the highest recorded at the site and the frequencies of certain types of hand-axes were also distinctive with particular respect to the lanceolate (including narrow lanceolate) and ovate-acuminate categories... The percentage of cleavers (10%) was essentially as low as the lowest recorded at the site (in K18)... Knives (8%) are quite numerous and the pointed and end/side varieties are especially common on this floor" (Howell et al. 1962, 70–71).

K14 is in the upper part of Sand 1 (together with the other two assemblages excavated in this layer, H9-J8 and Upper J6-J7). The workmanship of the large cutting edge tools is very high, and the tools are large and well finished. "… Cutting edge implements are regularly shaped and symmetrical. Most pieces have careful secondary edge trimming, straight edges and lenticular minor sections (only 3 hand-axes have plano-convex sections)" (Howell et al. 1962, 71). Small flake tools make up 17% of the tool assemblage. The only struck (Levallois) core and the only Levallois flake at Isimila come from K14 (Howell et al. 1962).

Size of excavated assemblage – See Table 4.

The Collection Sampled

Location – The Field Museum, Chicago, USA.

State of preservation – The Isimila artifacts are generally very fresh; one can still cut one's hand when handling some of the quartz handaxes. Some tools have sustained recent damage, perhaps as a result of excavation or previous storage conditions.

Reconstruction of the stratigraphic location of artifacts – All artifacts have a museum serial number and can be traced in the Field Museum database. Very useful data are available, including stratigraphic location, raw material, typology as established by the excavator, and more. These data were integrated into the database of this study.

Table 4. **Isimila site typology** (after Howell et al. 1962, Table 2).

Type	K14		K6		K19	
	N	%	N	%	N	%
Handaxe	42	17.3	281	54.0	6	6.8
Cleavers	93	38.3	53	10.2	44	50.0
Knives	4	1.6	40	7.7	5	5.7
Picks	2	0.8	9	1.7	-	-
Flake scrapers	-	-	10	1.9	5	5.7
Core scrapers	9	3.7	15	2.9	1	1.1
Push-plans	1	0.4	4	0.8	-	-
Other Large Tools	1	0.4	8	1.5	-	-
Discs	2	0.8	-	-	-	-
Choppers	23	9.5	28	5.4	6	6.8
Spheroids–Polyhedral Stones	12	4.9	7	1.3	-	-
Small Flake Tools	41	16.9	10	1.9	21	23.8
% Large shaped tools	202	83.1	510	98.0	67	75.0
% All shaped tools	243	80.1	520	91.2	88	80.0
Trimmed Pieces	60	-	50	-	22	-
% Shaped & modified pieces	303	41.6	570	63.9	110	20.9
Other Used Pieces	28	-	26	-	38	-
Cores	24	-	30	-	5	-
Waste	373	-	269	-	371	-

The sample – Three Isimila localities were sampled: two are from the Sand 1 complex (K6 and K14) and one is of Sand 3 origin (K19). From K6, 185 handaxes, 28 cleavers and 3 large flakes were sampled. From K14, 25 handaxes and 56 cleavers, representing most of the available tools, were selected for study. From K19, 24 handaxes, 40 cleavers and 21 large flakes were studied.

Northwest Africa

The Casablanca Quarry Sites

Background – “It was a stroke of luck for Archaeologists that Sultan Moulay Abdelaziz decided to build a modern harbor at Casablanca” (Raynal et al. 2001). From 1907 onward, stones for building the harbor were quarried near Casablanca. In these quarries, a large number of Acheulian sites were discovered and excavated (see Raynal et al. 2001 for a summary and references). Although most of the work was carried out in the 1940s and 1950s, research at some of the sites has continued (Raynal and Texier 1989; Raynal et al. 1995; Raynal et al. 2001). In his monumental work on the Early Paleolithic in Morocco, Biberson (1961) published the data from the early excavations.

Chronology – The area of Casablanca was formed by a series of barrier systems, beginning at an elevation of 180 m above sea level and reaching present-day sea level. This is the great Moroccan sequence, geologically exemplifying the marine history of the Atlantic since the end of the Late Miocene (Raynal et al. 2001 for references). Several methods have been used in establishing dates for this geological sequence, but the dating still “needs refining, and could indeed be improved, in particular for the Lower Pleistocene” (Raynal et al. 2001, 66). New dates for the sites of Casablanca are in the process of being established by a joint French-Moroccan project that began in 1978 (Raynal et al. 1995; Raynal et al. 2001). Lower Pleistocene deposits in the Casablanca area have yielded no archaeological evidence. The earliest known archaeological site in the Moroccan Atlantic area is the site of Thomas Quarry 1, unit L, appearing in a late Lower Pleistocene context. The age of this site is estimated at 1 mya, based primarily on bio-stratigraphical evidence such as the presence of the ancient pig *Kolpochoerus* and various micro-mammals. The assemblage is Acheulian in nature and consists of a few cleavers, handaxes, trihedrals and chopping tools. According to the excavators, the tools were made on flakes struck from discoidal cores (Raynal et al.

2001). The site of Ternifine belongs to the same chronological stage, judging by the fauna. In addition, questions have recently arisen regarding the early date assigned to the site of Ain Hanech in Algeria (Geraads et al. 2004; Sahnouni, et al. 2004).

Sidi Abderrahman – Grotte des Ours

Previous/Alternative Names – None.

Location – Coordinates 33°25"N and 7°40"W (Howell and Clark 1963). Grotte des Ours ("The Cave of the Bears", named for its many bear fossil remains) is a part of a large complex of karstic caves that occur in the sandstone and limestone of the Amirien Formation. These were exposed during work at the Sidi Abderrahman Quarry (Fig. 14).

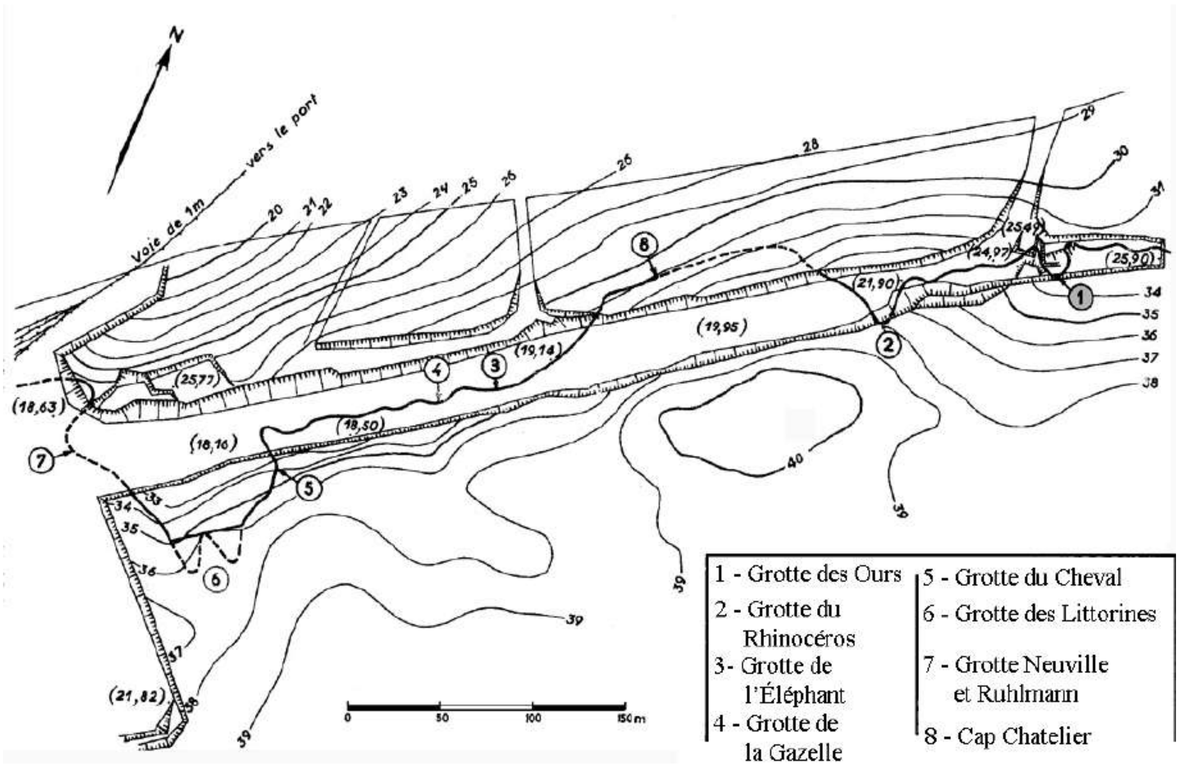

Figure 14. Sidi Abderrahman archaeological sites (after Biberson 1961, Fig. 9).

History of Research – P. Biberson discovered the site in 1952 and excavated it in the following year.

Excavated Area – 90 m^2 (Biberson 1961).

Stratigraphy – Three archaeological layers were identified in the cave, situated in the lower part of the main Sidi Abderrahman general section (Fig. 15). The archaeological layers correspond to the three stages of rise in sea level during the Anfatienne Phase

(Biberson terminology). The layers were designated (from bottom to top) G0, G1 and G2. The richest in fauna and artifacts was G0 (Fig. 15). G2 was very poor in finds, with most of the artifacts emerging from the inner part of the cave. Evidence of knapping, as well as of bone and meat processing, was found. Biberson has the preference of this part of the cave was due to its greater proximity closer to a freshwater spring as well as to quartzite cobbles, a major source of raw material. An alternate explanation for the richness of the inner part of the cave is that a flood possibly shifted artifacts from their in-situ position during an elevation in sea level in the climatic stage following their deposition, also causing some tool loss.

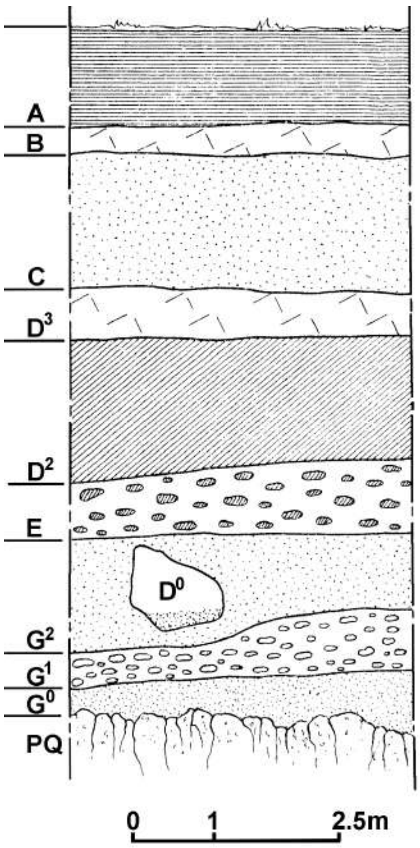

Figure 15. Sidi Abderrahman, general section (after Biberson 1954, Planche LXXXIX).

Environment and Fauna – Many bear bones were found, two of which were identified as bone tools.

Date – The estimated date for Grotte des Ours is ca. 0.4 mya (Raynal et al. 2001, Table 5), based on bio-chronology and typological considerations.

Human Remains – None.

The Lithic Assemblage

Raw materials – All of the LCTs at Grotte des Ours are made of quartzite. It would seem that this raw material was available in the vicinity of the site in the shape of large rounded cobbles (Biberson 1961). However, no detailed description is available.

General description by the excavator – Grotte des Ours was noted by Biberson as a site typical of Middle Acheulian Stage V in the cultural sequence of Morocco (Biberson 1961).

The Collection Sampled

Location – Musée de l'Homme, Paris

State of preservation – 75% of the handaxes are slightly abraded, 21% are abraded.

Reconstruction of the stratigraphic location of artifacts – The catalogue numbers on the artifacts conform to the following pattern: 57.25.1191. The first two sets of digits indicate that the artifact comes from Biberson's collection (Series 57.25). The additional number refers to the layer in the following manner: numbers 786–1196 have no stratigraphic attribution; 1197–1777 originated in layer G0; and 1778–1801 came from layer G1 (Musée de l'Homme catalogue, Paris 2002). Although not all artifacts bear numbers, the reconstruction of their stratigraphic location is possible in most cases.

The sample – The artifacts analyzed as a part of this study comprise 10 cleavers, 81 handaxes, 8 cores and 35 large flakes.

STIC Quarry

Name – Abbreviation for ***S****ociété de* ***T****ransformation* ***I****ndustrielle et de* ***C****onstruction*.

Location – The site is a quarry, located on the road between Casablanca and Azemmour (Biberson 1961).

History of Research – Biberson discovered the site in 1951, and his study was executed concomitantly with quarry work.

Excavated Area – 6 m^2 were opened during the first stage. No additional data are available.

Stratigraphy – Biberson noted that the stratigraphy is straightforward (Fig. 16). The top Layer A is superficial red silt; Layer B is thin limestone; Layer C is a fossilized dune of Amirien age; and Layer D is white limestone dating from the beginning of the Amirien. It is comprised of terrestrial limestone, 2.5 meters thick and sloping toward the sea. Layer D was formed during a drop in sea level, when a large quantity of fresh spring water flowed through it and possibly disturbed its material. The layer was exposed for a long period before the next layer was formed. Biberson reported that the sediments at the time of occupation were loose and that the artifacts did not lie horizontally (Biberson 1961). Layer F is a thin layer consisting of regressive beach gravel rich in mollusks (named Maarifian in Biberson's terminology, Biberson 1961).

Environment and Fauna – The fauna consist entirely of terrestrial mammals and, like all other Lower Paleolithic sites in the Maghreb thus far, there is no evidence that marine fauna were part of the human diet (Clark 1992).

Date – In common with most other Northern African Acheulian sites, the chronology of the STIC Quarry Acheulian is vague. The climatic correlations that were previously considered to tie the different geological formations and paleo-beaches to the glacial sequence of Western Europe have been rejected by recent research. In bio-chronological terms, the fauna from STIC has been described as somewhat younger than the Ternifine fauna (Clark 1992).

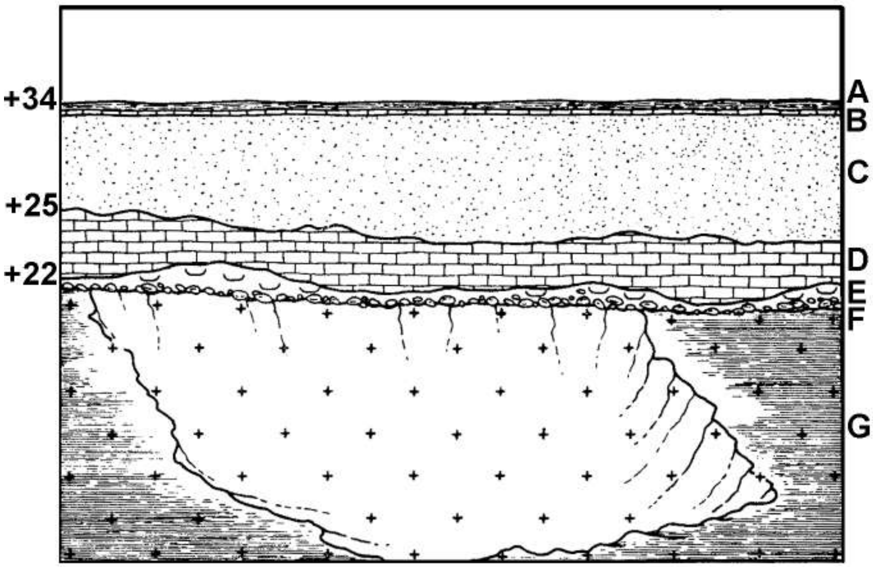

Figure 16. Stratigraphy of STIC Quarry (after Biberson 1961, Fig. 6).

The Lithic Assemblage

Raw materials – All of the tools from STIC Quarry are made of quartzite. The blanks were detached from large flat cobbles or flat slabs.

General description by the excavator – STIC is a site typical of Early Acheulian Stage III, as defined by Biberson (1961). He reported a concentration of "bolas" (spheroids) next to the inner water channel. This was the only pattern of artifacts identified at the site. No cores were found, and a few modified and whole blocks of raw material were brought to the site. Most of the flaking was done elsewhere. Cleavers comprise only 1.5% of the assemblage.

Specific description by the excavator – The handaxes in the assemblage are usually long and pointed. The soft hammer technique was reported to have been used to a certain extent. The tools in the assemblage most resemble the assemblage from Ternifine (Balout et al. 1967; Balout and Tixier 1957). Most of the tools are thick, usually differing in the shape of their tip, although a few are oval in shape. They are very well made in terms of both shape and workmanship, although they were predominantly knapped with a hard hammer (Biberson 1961).

Table 5. STIC typology (after Biberson 1961, 161–162).

Type	N
Pebble tools (total)	**97**
Pebble tools classic	37
Spheroids and "bolas"	40
Discs	19
Hammers	1
Bifaces (total)	**418**
Handaxes	298
Trihedral	104
Cleavers	16
Waste	
Large (?) flakes	84
Biface preparation flakes	274
Unclassified artifacts	145
Total	**1018**

The Collection Sampled

Location – Musée de l'Homme, Paris

State of preservation – Most of the tools from the site are relatively well preserved. 83% of the handaxes are slightly abraded. Many tools have a coating of sand, sometimes with mollusks attached, making observation difficult.

Reconstruction of the stratigraphic location of artifacts – The numbers on the artifacts are taken from the museum catalogue, which designates them according to stratigraphic location. In the STIC Quarry, all the tools originated in Layer D.

The sample – The sample analyzed encompasses 83 handaxes, 5 cleavers, 9 cores and 10 large flakes.

Ternifine

Previous/Alternative Names – Tighenif, Palikao (after the nearest city).

Location – Coordinates: 35°24"N and 0°20"E. The site is located about 20 km east of Mascara, Algeria.

History of Research – The site is a quarry for building materials, in use from 1872. Pummel and Tommasini conducted the first excavation at the site in 1882, and Arambourg and Hoffstetter directed the main excavation, which has provided the sample for this study, in 1954 and 1956 (Arambourg and Hoffstetter 1963). The LCTs from this excavation were described in some detail by Balout and Tixier (Balout et al. 1967). The high water level at the excavation site necessitated continuous pumping, eventually bringing the excavation to a halt. A significant lowering of the water level was later achieved, enabling renewed excavation between 1981 and 1983 (Geraads et al. 1986, for references).

Excavated Area – The new excavations exposed some 30 m^2 north of the main excavation area.

Geology – The site is located next to a small paleo-lake, which had formed in a clayey basin fed by artesian springs. The lake was swampy and even dried up from time to time. The artesian springs brought up some fine-grained sands from the underlying Miocene beds, creating a deposit. The deposit was then promptly covered by sand from the shore of the paleo-lake (Arambourg and Hoffstetter 1963).

Stratigraphy – The quarry's stratigraphic sequence constitutes about 7 m of sands and clays. In the upper part, under the modern topsoil, a layer of sandstone protected the lower layers from erosion. At the bottom of the sequence, a layer of varicolored clay is topped by grayish clay, with carbonate nodules up to 1.5 m thick. Above this are very fine sand layers with ferruginous lenses. The thickness of the layers varies throughout the site, and in some places the sands reach a thickness of 5 m. In the center of the site, the abovementioned artesian spring activity has strongly disturbed the horizontal lie of the layers, which sometimes tilt upward at an angle of 8°. The main fossil-bearing layers are the nodular clay and the lower levels of sand (Geraads et al. 1986).

Environment and Fauna – The site is rich in fauna of all sizes (Geraads et al. 1986, Table 1), and systematic wet sieving was practiced at the site. Open-country faunal species, such as gazelles, provide up to 93% of the bovid remains. This fact, combined with the presence of eolian sands in the site's layers, has enabled the site's environment to be identified as a relatively dry savanna (Geraads et al. 1986). It is suggested that a change in the environment to drier conditions occurred after the deposition of layer 4, since changes are apparent in the frequencies of micro-faunal species (Geraads et al. 1986).

Date – The site was defined as problematic for paleomagnetic study. Those samples that were successfully tested yielded normal polarity. There is a clear faunal demarcation between Ternifine and the older site of Ein Hanech. Garaads and others (1986) have suggested an age of around 700,000 kya, which is close to the borderline dividing the Lower Pleistocene from the Middle Pleistocene. In a newer publication, Raynal and others (2001) point out a similarity between the sites of Ternifine and the Thomas 1 Quarry in Casablanca, dating the latter site to 1 mya on bio-chronological considerations. The presence of most of the faunal species throughout the site's entire archaeological sequence suggests a relatively short duration of occupation (Geraads et al. 1986).

Human Remains – In 1954, two hominin lower jaws were found in the clay of the lower part of the section. They are still considered the oldest human remains from North Africa. Identified as *Homo erectus* (Arambourg and Hoffstetter 1963), both are very robust.

The Lithic Assemblage

Raw materials – The lithic industry includes pebble tools, handaxes and cleavers made on sandstone, quartzite and some limestone. In addition, small flint flakes are present (Geraads et al. 1986). No cleavers were made on flint, and rare use of mudstone was observed in the production of handaxes (Balout et al. 1967). Raw material was probably available in the form of large cobbles or slabs (Balout et al. 1967).

General description by the excavator – The excavators observed no living floors. The density of artifacts was very low: the 1954–6 excavation yielded only 2200 artifacts per estimated volume of 5000 m^3. In the new excavation, the density of artifacts never exceeded 0.8 artifacts per m^3 (Geraads et al. 1986). The assemblage was attributed to the late Lower Acheulian. Rare use of a soft hammer and the Kombewa technique were reported. There was no evidence of the Levallois technique, usually demonstrated by giant cores prepared for the production of large flake blanks (Balout et al. 1967). Some of the lithic artifacts, mainly those made of sandstone, show heavy weathering, and it is possible that many small flakes of sandstone were not preserved due to post-depositional processes (Geraads et al. 1986). Balout suggested that the large number of pebble tools and the use of pebbles, together with the presence of trihedrals, are due to the primitive nature of the assemblage (Balout 1955). There is evidence of tools shaped from bone (Geraads et al. 1986).

Typology established by the excavator – Balout, Biberson and Tixier (Balout et al. 1967) attempted to apply the European handaxe typology to the Ternifine assemblage. Their main conclusion was that, while the assemblage is very homogenous in terms of technology, it is very heterogeneous typologically. None of the types stand out as a preferred shape among the 110 handaxes studied by Balout**.** Cleaver type 6 (a cleaver on a Kombewa flake) was defined on the basis of the study of the Ternifine cleaver assemblage. The dominant type here is type 0, a cleaver with no distal dorsal scar.

The Collection Sampled

Location – Institut de Paléontologie Humaine (IPH), Paris

State of preservation – As observed by the excavators, some of the artifacts are heavily weathered and others are crumbling. On the other hand, some of the tools are in mint condition.

The sample – Due to the relatively small numbers of artifacts, an effort was made to sample all of the tools available from the collection. Artifacts that were too weathered or broken to enable full analysis were not included. The sample of artifacts from Ternifine contains 47 cleavers, 57 handaxes and 41 large flakes.

Acheulian Sites Adjacent to Tabelbala in the Tachenghit Formation

Previous/Alternative Names – Tachnrhit.

History of Research – French army officers posted in the area of the Tabelbala Oasis in the early twentieth century were the first to identify the Acheulian sites in the area. Lieutenant César collected a large sample of Acheulian tools during his stay in 1911–12 (Alimen 1978). His collection formed the basis for Breuil's definition (1930, 1931) of the Tabelbala Tachenghit technique. From 1948, Champault (1996) conducted a survey and excavations in the area, primarily in Feidj, located some 20 km north of the Tabelbala Oasis. During 1966–67, Alimen (1978) conducted two seasons of excavation, aimed to refine the stratigraphy and establish better control over the geology and cultural sequences. Both Champault (1966) and Alimen (1978) studied the collections of stone tools housed by different French institutions, providing a detailed description of them.

Geology – The limestone of the Tachenghit Formation was embedded in a shallow paleo-lake, created in the basin during the Pleistocene (Alimen 1978). Fig. 17 presents a typical section of the site of Feidj Tachenghit (Alimen 1978, Fig. 27). Layer 2b represents

Tachenghit white limestone, reported to bear Acheulian artifacts in in-situ context, embedded between layers of sandstone.

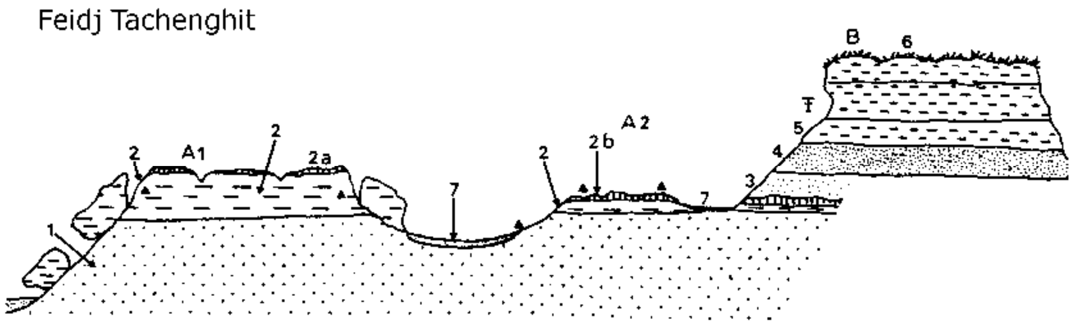

Figure 17. Section of Feidj Tachenghit (after Alimen 1978, Fig. 27).

Stratigraphy – All the sites or stations in the area are short-occupation sites. They are scattered unevenly in terms of area and find density on the surface of the Tachenghit limestone layers (Alimen 1978).

Date – Alimen (1978) assigned all of the sites to the Final Ougartian stage.

The Lithic Assemblage

Raw materials – Alimen (1978) described the sample as containing handaxes and cleavers, of which 90% are made of quartzite. There are a few bifaces made of rhyolite, and a smaller number made of *meulière* (a low quality flint-like rock).

Specific description by the excavator – Alimen (1978) noted the use of large flakes as blanks in bifacial tool production, identifying 82 such bifaces. Of these, 35 were detached from what she recognized as Levallois cores and 9 from Kombewa cores. In other words, large flakes detached from Levallois cores dominate the assemblage. The striking platforms are, in most cases, plain (only 3 are facetted). In many cases, the striking platform was removed to thin out the area of the bulb of percussion.

The Collection Sampled

Location – Musée de l'Homme, Paris.

State of preservation – 82.5% (n=12) of the cleavers and 86.2% (n=25) of the handaxes are slightly abraded. The rest are abraded. One handaxe is defined as fresh.

The sample – 16 cleavers and 29 handaxes were sampled.

India

Hunsgi – Localities V, VI

Location – Hunsgi Valley, Gulbarga district of Karnataka State, South India. Excavation took place at two localities on the left bank of the Hunsgi Stream.

History of Research – The site was discovered and excavated by K. Paddayya between 1975 and 1979 (Paddayya 1977a, b, 1979, 1981, 1982).

Excavated Area – At Locality V, an area of 22.75 m^2 and a trench (Trench 3) covering a total of 63 m^2 were excavated. At Locality VI, a trench (Trench I) measuring 8 m on a north-south axis by 6 m on an east-west axis was dug.

Geology – The area is located at the junction between three major geological features: Archaean granite, Precambrian shales and limestone, and Deccan Trap basalt. Large parts of the valley floor are covered by a conglomerate rich in silicified limestone slabs, the principal raw material during the Acheulian (Paddayya 1982).

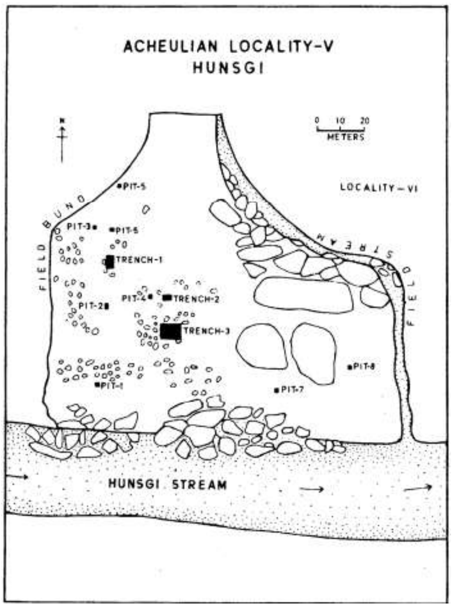

Figure 18. Hunsgi Locality V (after Paddayya 1982).

Stratigraphy – Various methods of geo-archaeological study have led to claims that the site is in situ (Paddayya 1982; Paddayya and Jhaldiyal 1998–99). See Fig. 19 for a detailed section.

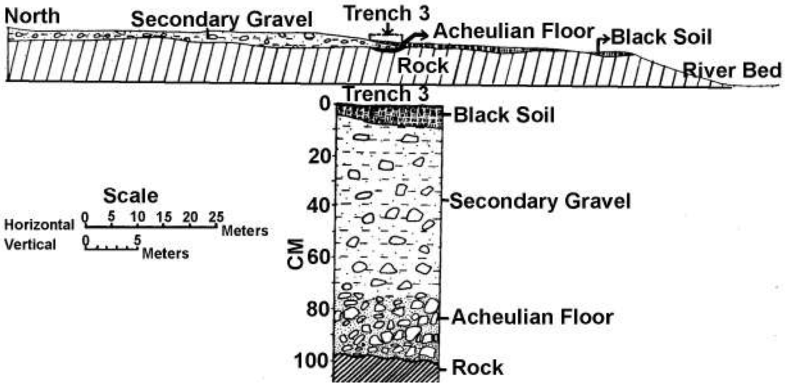

Figure 19. Stratigraphic section of Hunsgi V site (after Paddayya 1982).

Environment and Fauna – The Hunsgi Valley forms part of the semi-arid and drought-prone Deccan Plateau, with an annual rainfall of about 650 mm (Paddayya 1991). Using a settlement system approach, the excavator has reconstructed the environment on the basis of present-day conditions and ethnography (Paddayya 1982, 1987, 2001). Paddayya's chief premise was that the geological and geographical conditions (i.e. water sources, drainage system, food sources, etc.) have not changed substantially since Acheulian times (Paddayya 1991). As in other Acheulian sites in this region, bone preservation is very poor.

Date – No dating method could be applied to the Acheulian sites of Hunsgi. However, some indication of the sites' age can be gleaned from the nearby site of Isampur, which was identified as an Acheulian quarry (Paddayya et al. 2000; Paddayya and Petraglia 1997; Paddayya et al. 2006; Petraglia et al. 1999). At this site, limestone slabs were used to produce large-flake blanks for LCTs. These blanks are very reminiscent of those used in producing limestone LCTs at Hunsgi. Preliminary ESR dating performed on two teeth from Isampur has yielded an average date of 1.2 mya (Paddayya et al. 2002). While this may provide a chronological framework for the Hunsgi assemblage, it needs corroboration.

Human Remains – None.

Special Features – Surrounding the excavated areas at Localities V and VI were blocks of granite (the local bedrock). These were interpreted by the excavator as a natural wind shelter, improved and used by hominins.

The Lithic Assemblage

Raw materials – The main raw material used at Hunsgi was silicified limestone. The Hunsgi Valley is the only part of India where this raw material was used for the production of Acheulian tools. Technological observations show that many of the large flakes used as blanks for the production of LCTs at Hunsgi were detached from large flat slabs of limestone, similar in shape to those used at the quarry of Isampur (Petraglia et al. 1999).

General description by the excavator – The excavator has interpreted the finds from Hunsgi V as representing an Acheulian living floor. Most of the artifacts were concentrated in the central portion of the excavated area, together with a few large granite blocks. At Locality VI, two occupation layers were identified. The upper layer has been disturbed by agricultural activity, while the lower has remained in situ. Here too the excavator noted large tools (over 5 cm in size) in clusters.

Size of excavated assemblage – Locality V has yielded 918 artifacts, while Layers 1 and 2 at Locality VI have yielded 243 and 930 artifacts respectively.

Table 6. Hunsgi V typology (after Paddayya 1982, Table 3).

Tools	**N**
Cleavers	28
Handaxes	18
Knives	14
Chopping tools	9
Picks	8
Polyhedrons	10
Spheroids	10
Scrapers	15
Flakes with prepared butt	2
Backed tools	1
Utilized pieces	
Anvils	3
Hammers	5
Utilized flakes	15
Utilized tabular pieces	2
Debitage	
Cores	5
Modified	20
Flakes	5
Waste products	127
Total	**291**

The Collection Sampled

Location – Deccan College, Pune, India

State of preservation – In general the preservation of artifacts is good. While only 4 artifacts were defined as fresh, the majority of the tools (48.9% of the handaxes and 69.4% of the cleavers) were defined as slightly abraded.

Reconstruction of the stratigraphic location of artifacts – The artifacts are marked with their number and layer, facilitating reconstruction of their stratigraphic location.

The sample – This consists of 49 cleavers, 47 handaxes, and 52 large flakes (cleaver flakes, scrapers on large flakes, unretouched large flakes) from Hunsgi Locality V, Trench 3.

Yediyapur Locality IV

Location – Baichbal Valley, Gulbargai District of Karnataka, South India. Coordinates 16°36"N and 76°33"E (Paddayya, 1987).

Elevation above Sea Level – 443 m.

History of Research – An irrigation trench exposed a rich Acheulian site at this locality in 1985. Excavations were directed by K. Paddayya during January and February 1986.

Excavated Area – Trench I, measuring 10 m on an east-west axis by 5m on a north-south axis, were excavated. Additional test pits were dug at various locations around Trench I.

Geology of the vicinity – “The valley is enclosed by hills of Dharwar schist on the east and by low shale limestone tablelands on the remaining three sides. The valley floor itself is made up of granite gneiss” (Paddayya 1987, 611). The geological formations in the area constituted a diverse source of raw material for the Acheulian knapper. Large boulders of limestone, dyke dolerite, coarse-grained rocks like granite and schist, and even chert are all common in the region (Paddayya 1991, 113).

Stratigraphy – The site was estimated to extend over 100 m^2 (Paddayya 1987, 612). Its surface black “cotton soil”, which typifies the area, is suitable for agriculture. The upper layer comprises loose brownish topsoil, 10–15 cm thick. It covers a one-meter layer of clay. In this clay, a “*clear-cut Acheulian horizon”* was excavated in two digging levels (upper and lower). The Acheulian artifacts were embedded in “an extremely hard matrix of whitish/light brown gruss, derived from the disaggregation and weathering of granite gneiss” (Paddayya 1987, 612). There is every indication that the artifacts were found in situ.

Environment and Fauna – The present climate is similar to that of the neighboring site of Hunsgi. A few bones and a tooth belonging to *Bos* sp. were excavated.

Date – Judging by the relative crudeness of the tools, the excavator attributed them to the Lower Acheulian tradition (Paddayya 1987). By comparison, Yediyapur II, with its dominant limestone assemblage, was assigned to a more advanced stage of the Acheulian culture (see also the discussion of the site of Hunsgi above).

Human Remains – None.

The Lithic Assemblage

Raw materials – Coarse-grained rocks like dolerite, granite, gneiss and schistone are present at the site. Pegmatite, aplite and sandstone have also been noted as raw materials for tools (Paddayya 1989, 27). Both levels of the Acheulian horizon in Trench I have yielded a large number of slab-like pieces that were identified by the excavator as paving stones and/or food processing surfaces (Paddayya 1987, 216). In a later publication, however, these dolerite, limestone, schist, chert, pegmatite and aplite blocks are referred to as raw material (Paddayya 1989, 27). There are sixteen Acheulian localities along the 5 km stretch between the margins of the Baichbal Valley and the village of Yediyapur, which exhibit unusual variability in raw material exploitation (Paddayya 1989).

Typology established by the excavator – Large discoids, chopping tools, handaxes, cleavers and knives are the chief tool types. Hammerstones and anvils are also present.

Size of excavated assemblage – More than 500 artifacts from Trench I and more than 200 artifacts collected from the surface.

The Collection Sampled

Location – Deccan College, Pune, India.

State of preservation – The excavator noted the fresh condition in which the artifacts were found (Paddayya 1987, 1989).

Reconstruction of the stratigraphic location of artifacts – All artifacts came from the single Acheulian horizon at the site. The stones are marked with their number and layer.

The sample – A small sample of predominantly granite tools was studied, the sample's primary importance lying in its unique raw material. In total, 12 cleavers, 5 handaxes and 8 large flakes were sampled.

Chirki-on-Pravara

Location – The Chirki area is located in Maharashtra State, some 10 km southwest of the confluence of the Pravara and Godavari Rivers (Corvinus 1983b). The site is located 3 km east of the village of Navasa, on the right bank of the Pravara River at its confluence with the small Chirki Nullah (a small, usually dry stream). Coordinates: 19^{o}33"10'N and 74^{o}56"45'E.

Elevation above Sea Level – 510 m.

History of Research – The site was discovered in 1963 during the pioneering geo-archaeological survey of the Pravara River. Three seasons of excavation, directed by G. Corvinus, took place between 1967 and 1969.

Excavated Area – Twenty-five trenches (8 main trenches and 17 trial trenches) were excavated at Chirki, representing an area of 482 m^2 in total. The Acheulian layer was located in an area totaling 316 m^2 (Corvinus 1983b). Trench VII was the largest and richest of all the trenches and, together with Trenches A and E, comprised the principal excavated area (Fig. 21).

Geology – The Chirki area is a part of the large Deccan Trap volcanic region, situated on the Deccan Plateau. The Deccan Trap basalt is about 60 million years old. The Acheulian site of Chirki is embedded in alluvial deposits, 8–10 m thick, on the right bank of the Pravara River. The accumulation of Pleistocene sediments in this area occurred after a phase of massive erosion that removed almost all of the ancient sediments in this region.

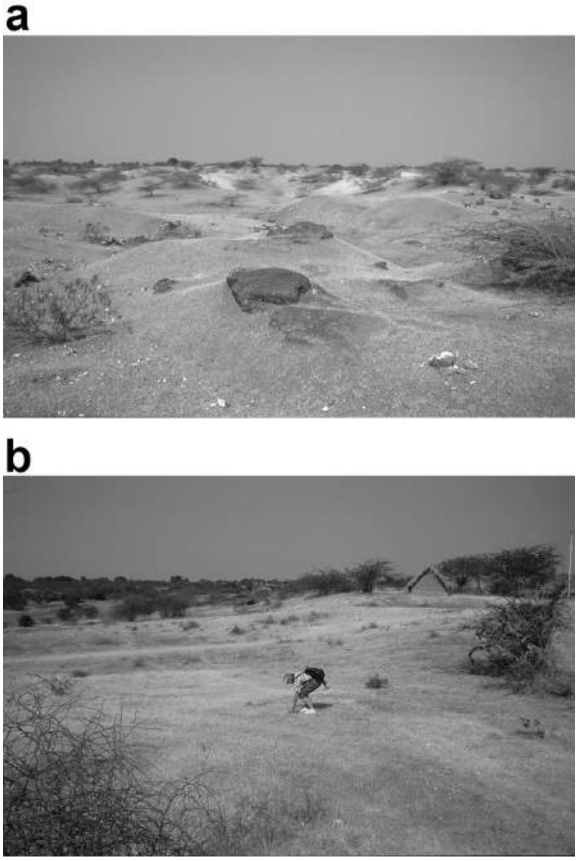

Figure 20. Chirki, January 2003. a. View of the Chirki Nullah; b. Dr. Corvinus in the excavation area.

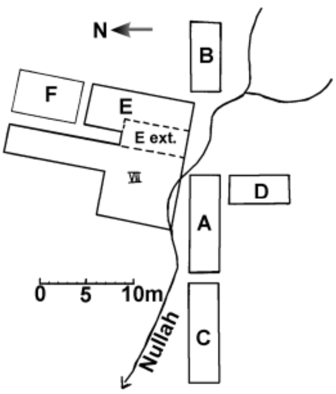

Figure 21. Excavation areas and test trenches at Chirki-on-Pravara (after Corvinus 1983b, Fig. 2).

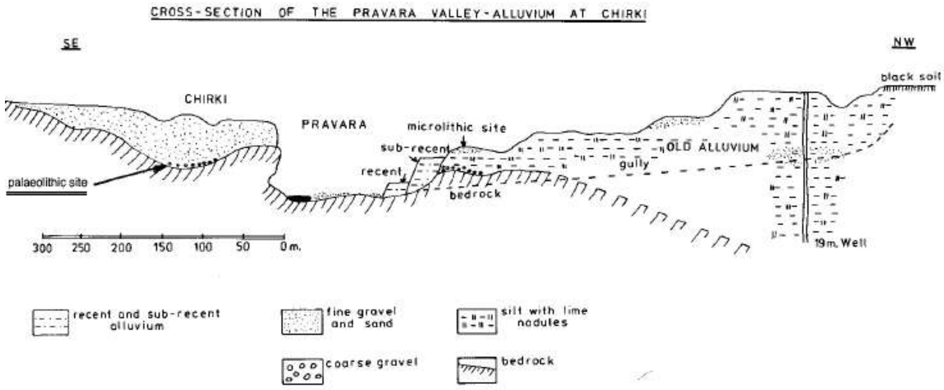

Figure 22. Cross-section of the Pravara River at Chirki (from Corvinus 1983b, Fig. 1).

Stratigraphy – The Acheulian horizon was found in layer 3. This is a cobble-boulder horizon, measuring 20–40 cm in thickness, which lay unevenly atop the basalt bedrock. The site's Acheulian occupation is of unknown duration, although it was evidently short. The layer comprises stones of various sizes, ranging from small pebbles to one-meter boulders. The great majority of artifacts were made on local gray basalt although some were made on red basalt and a very few were made on imported dolerite. In parts of the excavated area the artifacts and cobbles were cemented together, and many were broken during excavation (Corvinus 1983b).

Environment and Fauna – Chirki, which is situated at the confluence of three rivers, was probably richer in vegetation and wildlife than it is today. Although the area's sedimentation has preserved numerous bones in other localities, bone preservation at this particular site is poor. Of only 13 bone fragments that were excavated here, those that have been identified belong to bovids, including a single *Bos* horn core.

Date – An age of Middle Pleistocene was suggested by the excavator, based on the typological nature of the assemblage (Early Acheulian) and the presence of *Bos namadicus* (a Middle Pleistocene species) in a stratigraphically higher location than the Acheulian deposits (Corvinus 1983b, 77). However, no reliable date is available for the Acheulian deposits.

Human Remains – None.

The Lithic Assemblage

Raw materials – The Acheulian tool-makers at Chirki used many kinds of available rock types as raw material (Corvinus 1983b, 33). The excavator identified two different Deccan basalt flows in the Chirki bedrock cross-section, one of which is dense gray basalt. Dyke basalt is also present, the closest known source being 10 km away from Chirki. The dykes contained hard dolerite, which was used by the Chirki knappers for their finest tools. In addition, quartz and chalcedony cobbles were exploited.

General description by the excavator – The Acheulian assemblage from Chirki reflects a handaxe-cleaver industry. According to the excavator, the dominance of LCTs suggests that the functional nature of the site involved significant cutting activity (butchering?) (Corvinus 1983b, 70). Based on her analysis of the material, Corvinus describes the lithic industry of Chirki as a "not too advanced stage of technique" (Corvinus 1983b, 71). A detailed discussion of the typology and technology of the Chirki assemblage is provided by Corvinus (1983; see also below).

Typology established by the excavator – Cleavers (15%) are slightly more dominant than handaxes (13.4%) in the assemblage. Pebble tools comprise 12% of the assemblage.

Size of excavated assemblage – The assemblage was separated into three typological complexes: a) flake tools (1019 specimens, 47% of the assemblage); b) core tools (528 specimens, 24.5% of the assemblage); c) pebble-tools (617 specimens, 28.5% of the assemblage).

The Collection Sampled

Location – Deccan College, Pune, India.

State of preservation – As a natural result of weathering after exposure, the basalt artifacts are deteriorating. Steps to arrest this process were undertaken by the excavator in 2003.

Reconstruction of the stratigraphic location of artifacts – Although some ink marks have faded, the artifacts are marked with indications of their area of excavation, layer and, in many cases, elevation, usually facilitating good reconstruction of their stratigraphic location.

The sample – The main sample comprises artifacts from the close proximity of Trenches VII, E and A, and includes 48 cleavers, 41 handaxes and 15 large flakes.

Levant

Gesher Benot Ya‘aqov (GBY)

Previous/Alternative Names – Jisar Banāt Yaqūb (Arabic; Stekelis 1937, 1960)

Location – Coordinates of study area 33°00"28'N and 35°37"40'E (Goren-Inbar et al. 2000). Gesher Benot Ya‘aqov is located on the banks of the Jordan River and within its course, at its southbound outlet from the Hula Valley, in the northern Dead Sea Rift (Fig. 23).

History of research – After the site's discovery in the 1930s, many surveys and limited soundings were conducted. The most significant research was carried out by Stekelis in 1935–54 (Stekelis 1960) and Gilead following the war of 1967 (Gilead 1968, 1970). During 1989–97, N. Goren-Inbar conducted seven seasons of excavation in a new project at GBY (for a detailed history of research at the site, see Goren-Inbar et al. 2002). The following section relies on the data yielded by the Goren-Inbar excavation.

Elevation above sea level – About 60 m.

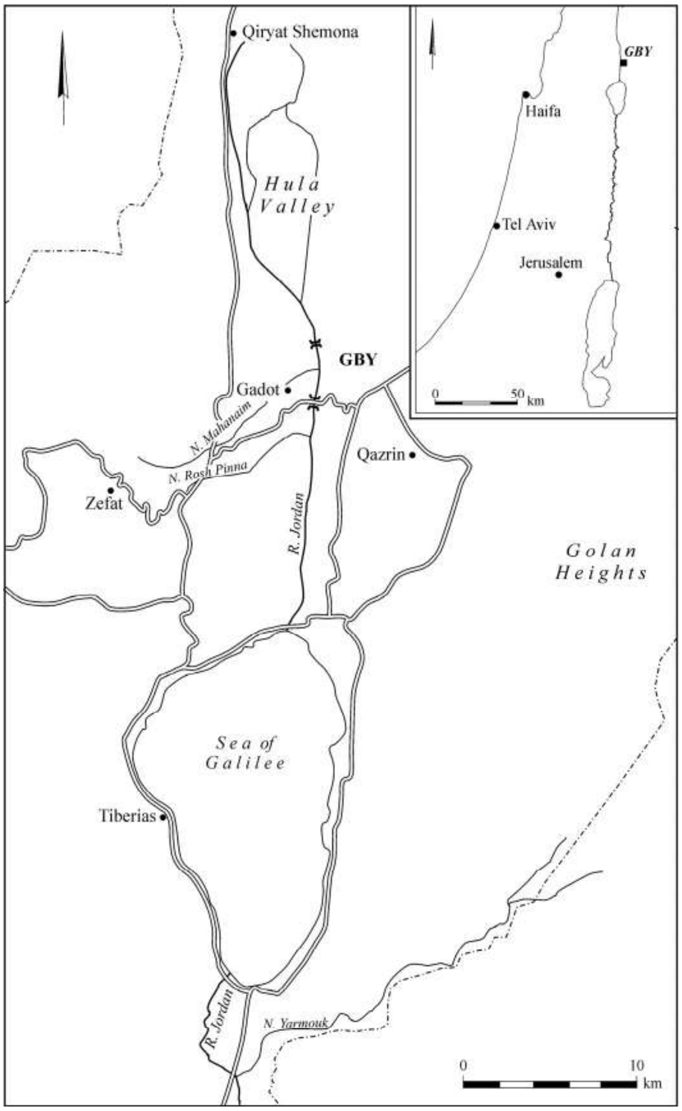

Figure 23. Location map of the Gesher Benot Ya'aqov Acheulian site.

Excavated Area – The total area excavated at GBY is about 120 m^2 (Goren-Inbar et al. 2000). The bifaces studied here originate in the seven sub-layers of Layer II-6, located in

Area B, and in Layers V-2 to V-6 of Area C. Area B is the main excavation area at GBY, located adjacent to geological Trench II (Fig. 25). The surface exposure in Area B is about 12 m^2 (Goren-Inbar et al. 2002). To the south of Area B, the smaller Area C, opened in 1995, has yielded a very rich assemblage of stone tools, as well as faunal remains.

Geology – The Acheulian horizons of GBY were embedded in the layers of the Benot Ya'akov Formation (BYF). As a result of tectonic activity (Belitzky 2002), the GBY deposits tilt 25–45^{o} to the southwest (Goren-Inbar and Belitzky 1989). The BYF deposits accumulated beside the paleo-Lake Hula and represent a lake and lake edge environment (see Goren-Inbar et al. 2002 for a detailed report on the geology and stratigraphy of the GBY site). As established by the presence of the type fossil *Viviparus apameae* (Goren-Inbar et al. 2000), the BYF is of Early to Middle Pleistocene age.

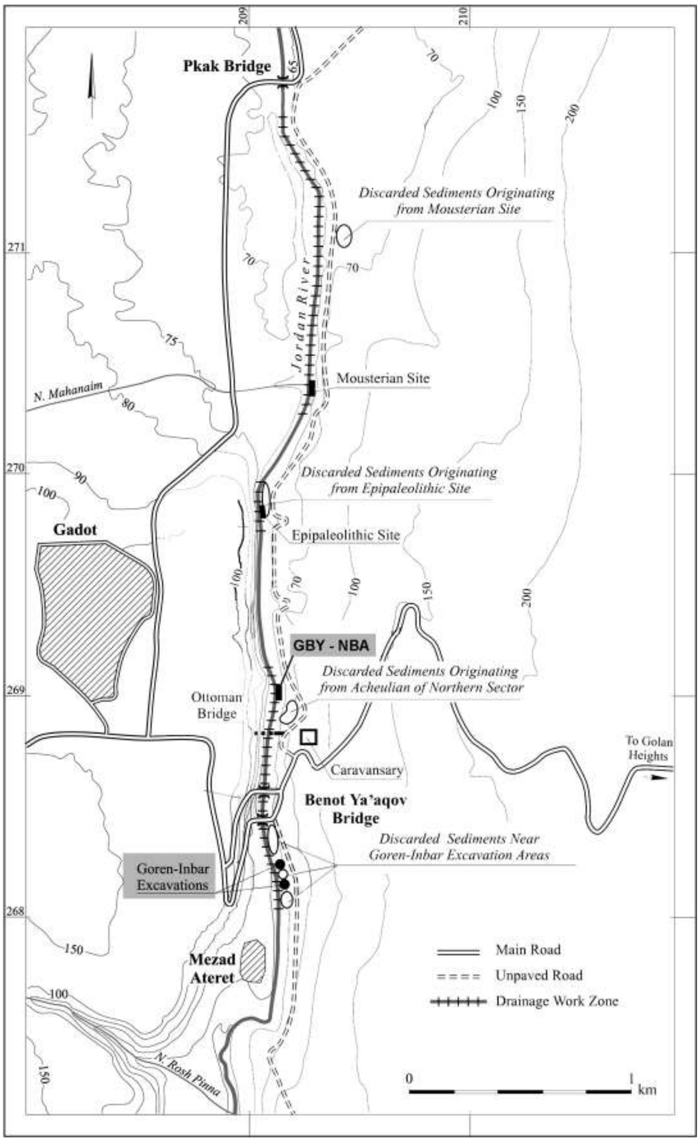

Figure 24. Location of the GBY Acheulian sites (after Sharon et al. 2002).

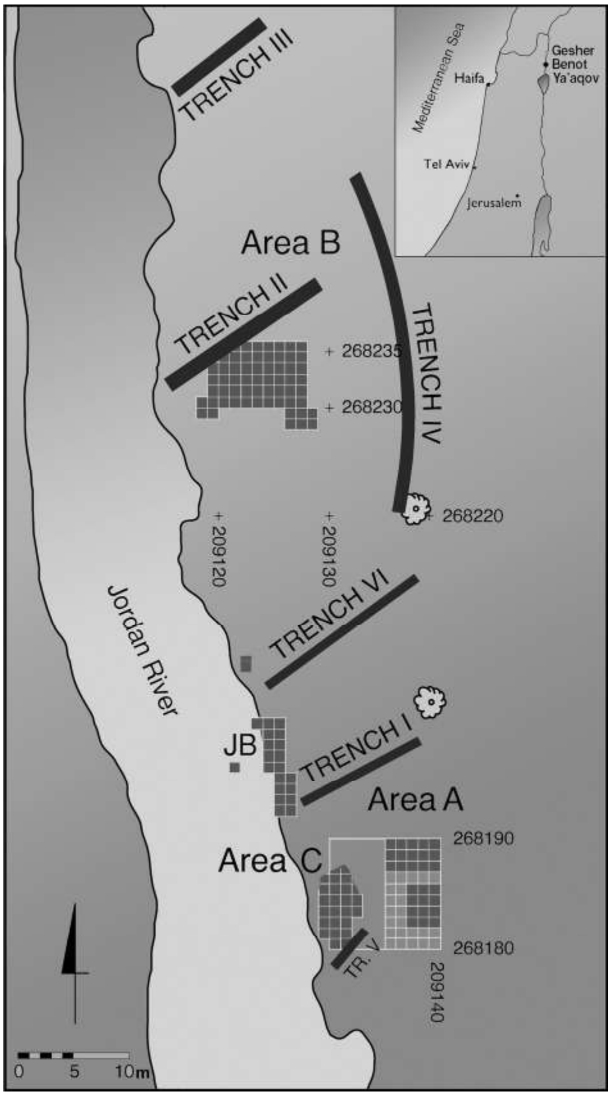

Figure 25. GBY main site excavation map (after Goren-Inbar and Sharon 2006).

Stratigraphy – Seven geological trenches, dug as a part of the new excavation at GBY, have exposed a 34 m section of the BYF (Fig. 26). The sequence consists primarily of cycles of organic-rich calcareous mud, coquinas and conglomerate deposits (Goren-Inbar et al. 2000; Goren-Inbar et al. 2002). Layer II-6 is about 1.5 m thick and tilts 40–45^{o} WSW (Goren-Inbar and Saragusti 1996). Seven sub-layers (levels) were identified in Layer II-6, the richest assemblage of LCTs, described in detail by Goren-Inbar and Saragusti (Goren-Inbar and Saragusti 1996; Saragusti and Goren-Inbar 2001), originating in Level 4. The exposure of archaeologically rich layers on the bank of the Jordan River led to the excavation of the area now known as Area C, immediately east of the river bank (Fig. 25). The layers of Area C (designated V after Trench V, in which their stratigraphy was exposed) are similarly tilted to the layers of Area B. The richest archaeological layers are the coquina of Layer V-5 and the underlying clayey Layer V-6.

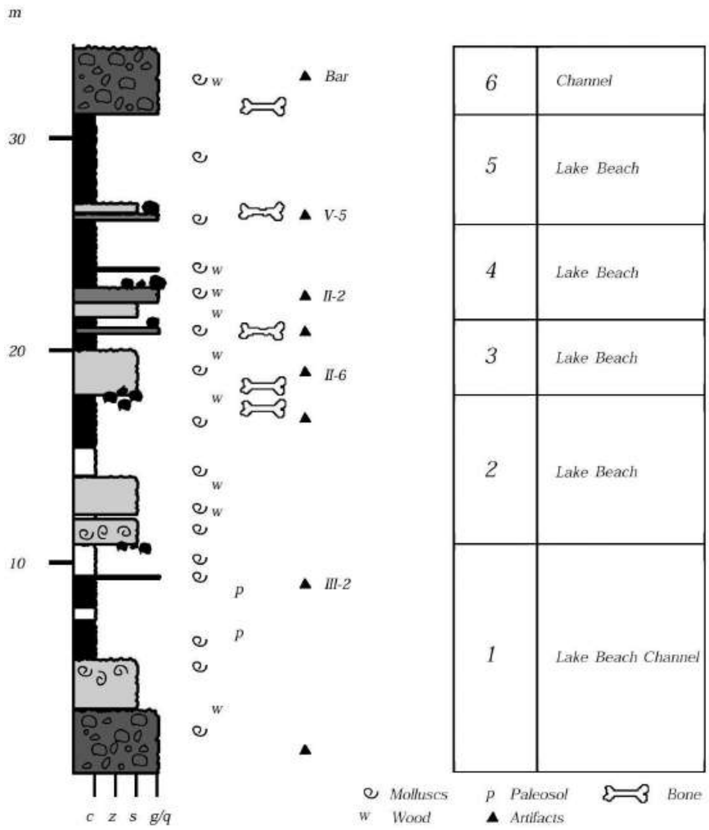

Figure 26. Stratigraphic sequence of the GBY type site (after Feibel 2004).

Environment and Fauna – Since its accumulation, BYF has been waterlogged in many of its areas. Due to these rare circumstances, the organic material at the site is exceptionally well preserved. A large assemblage of fossil bones and organic material has been retrieved from all layers of the site. These remains form part of an ongoing study that has facilitated a unique reconstruction of the area's environment during the period between the Lower and Middle Pleistocene (OIS 18–20; Feibel 2004). To date, the primary aspects that have been studied are the large wood assemblage (Goren-Inbar et al. 2002), the seeds and fruits (Melamed 1997) and the association between the organic finds and human behavior (Belitzky et al. 1991; Goren-Inbar et al. 2004; Goren-Inbar et al. 1994; Goren-Inbar et al. 2002).

Date – The age of the site is based on the magnetostratigraphy of its 34 m sedimentary sequence. The Matuyama-Brunhes chron boundary was identified in Layer II-14, 4 m below the base of Layer II-6 (Fig. 26), establishing the age of its assemblages as somewhat younger than 790,000 kya (Goren-Inbar et al. 2000).

Human Remains – Surface collection yielded two human femur bones (Geraads and Tchernov 1983). However, since the archaeological complexity of the site's vicinity has recently been clarified (Sharon et al. 2002), these bones can no longer be securely assigned to the Acheulian.

The Lithic Assemblage

Raw materials – Acheulian knappers at GBY probably encountered a wealth of basalt in the shape of boulders and cobbles (Madsen and Goren-Inbar 2004; Sharon 2000). Alkali olivine basalt was the main raw material used in the production of bifaces at GBY; over 90% of the handaxes and all of the cleavers are made of this material. Knappers also used flint, and very rarely limestone, in cases of very well-made handaxes (Goren-Inbar and Saragusti 1996). The raw material strategy of the knappers of GBY has recently been discussed by Sharon (2000) and Madsen and Goren-Inbar (2004).

General description by the excavator – The biface assemblage of GBY is one of the richest known concentrations of excavated LCTs. In Layer II-6, Level 4, which is less than 15 cm thick, the average density of LCTs is 14 per m^2. Detailed descriptions of portions of the site's lithic assemblage have been published elsewhere (Goren-Inbar and Saragusti 1996; Goren-Inbar and Sharon 2006; Goren-Inbar et al. 1991; Madsen and Goren-Inbar 2004; Saragusti 2003; Saragusti and Goren-Inbar 2001; Sharon 2000; Sharon and Goren-Inbar 1999; Zohar 1993).

The Collection Sampled

Location – The Hebrew University of Jerusalem, Israel.

State of preservation – Once they have been exposed and dried, the basalt artifacts, which had been deposited in waterlogged conditions, continuously deteriorate into clay (Goren-Inbar and Saragusti 1996). Steps to improve preservation have been undertaken, with limited success (see the discussion of the Chirki artifacts above for a similar problem).

Reconstruction of the stratigraphic location of artifacts – The artifact data are available in the GBY project's digitalized database.

The sample – N. Goren-Inbar and I. Saragusti have been recording and analyzing the GBY bifaces for many years, putting the entire dataset at the disposal of this study. All of the LCTs from Area B were analyzed for this study.

Gesher Benot Ya'aqov – North of Bridge Acheulian (GBY NBA)

Previous/Alternative Names – Jisar Benot Yaqūb (Stekelis 1937, 1960).

Location – On the bank of the Jordan River, about 500 m north of the main GBY excavation. Coordinates 33°00"53'N and 35°37"46'E.

Elevation above Sea Level – About 60 m.

History of Research – The pioneer researchers of GBY worked mainly north of the present-day bridge (Fig. 24), in an area rich in finds (Goren-Inbar and Belitzky 1989; Goren-Inbar et al. 2002; Stekelis 1960). Many find spots were identified and a very general stratigraphy was suggested for the GBY prehistoric sequence (Stekelis 1960). The new excavation by Goren-Inbar is located a few hundred meters south of this area (Fig. 24), and has significantly extended our knowledge of Acheulian find distribution. During the fall of 1999, the Kinneret Drainage Authority undertook a large-scale operation to deepen the Jordan River at its outlet from the Hula Valley. This operation caused massive damage to the already badly disturbed archaeological and geological layers in the area (see Sharon et al. 2002 for a detailed discussion). In the course of the work, large quantities of Acheulian tools and fossil bones were identified along the river in the area now known as GBY NBA (Fig. 24). The find spots of both Stekelis (1960) and Gilead (1970) were located here, more than 6 m above the present finds. In many visits to the site during and after the drainage operation, artifacts were collected from the surface and from the piles of BYF sediments that were dumped about 100 m east of the Jordan River (Sharon et al. 2002). During 2002, a geo-archaeological survey (participants: S. Belitzky, C. Feibel, B. Madsen, O. Marder and G. Sharon), initiated by the Hebrew University and the Israel Antiquity Authority, was conducted to evaluate the drainage damage and to record new data that had been exposed by the massive shifting of earth.

Excavated Area – Artifacts were collected along ca. 50 m of the Jordan River bank and from piles of sediments (Fig. 24). During the 2002 survey, three sections of the Jordan River bank were cleared and their geology studied. In one of these sections (Section 02-5), an Acheulian living floor was exposed in an area of 1.5 m^2. 10 handaxes and cleavers were recovered from this very small area (Figs. 27-28).

Geology – Although the geology of the BYF has recently been described in some detail (Belitzky 2002), and the stratigraphy of the GBY main site is well known (Goren-Inbar et al. 2000; Goren-Inbar et al. 2002), the correlation between these data and the strata of the BYF north of the Benot Ya'aqov bridge is still unknown. The strata underwent massive tectonic disturbance and the area has been damaged by 150 years of drainage operations, causing a problem in correlation of strata along about 3 km of the Jordan River bank. One of the aims of the 2002 geo-archaeological survey was to gain further understanding of this issue. Work is ongoing, and some preliminary observations can be offered. The BYF consists of a series of lacustrine sediments. In the area north of the Benot Ya'aqov Bridge, the sand and silts of the BYF seem to inter-finger with basalt flows of differing thickness. These basalt flows have created the Jordan River bottleneck at its Hula Valley outlet and dictate the shallow depth of the water.

Figure 27. Excavation of Acheulian living floor in GBY NBA Section 02-5, looking east (scale 10 cm).

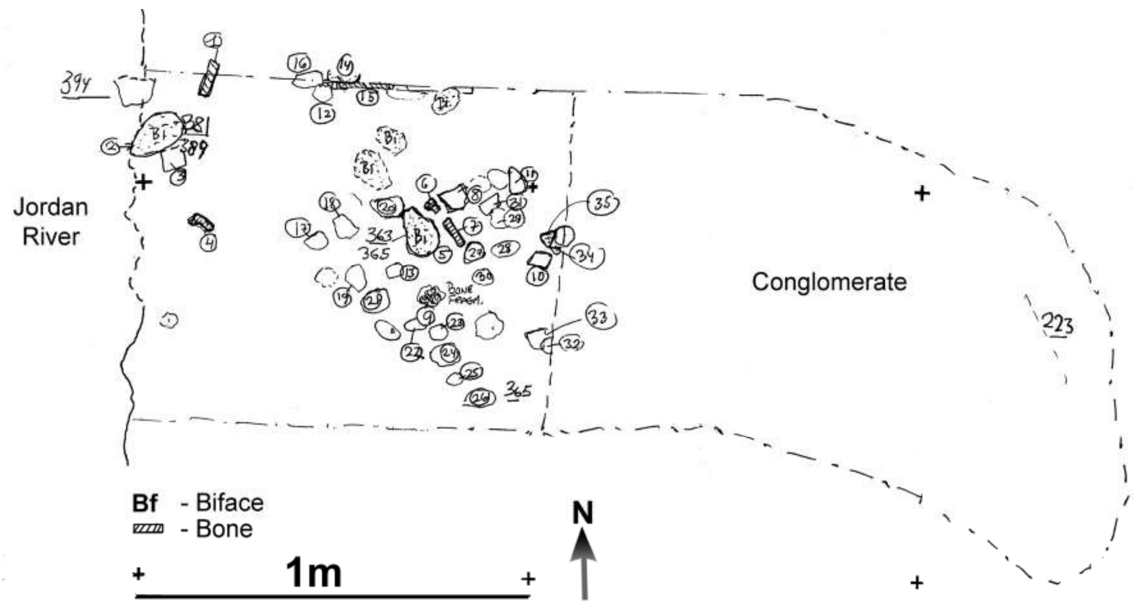

Figure 28. Acheulian living floor in GBY NBA Section 02-5 (drawing by B. Madsen).

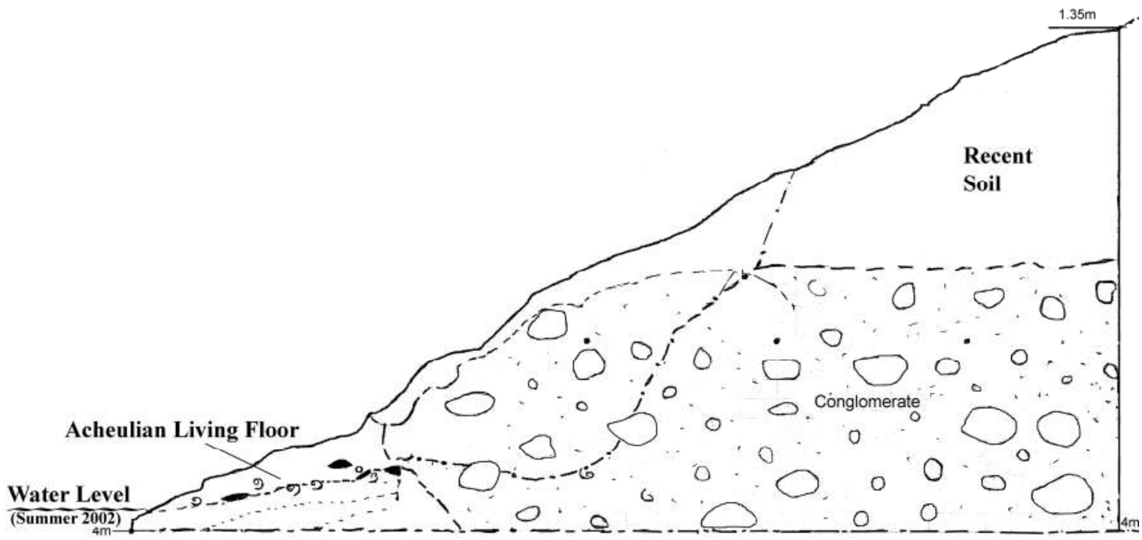

Figure 29. North face of GBY NBA Section 02-5 (drawing by B. Madsen).

Stratigraphy – The geological and stratigraphic data in this study are based on a series of sections cut into the east bank of the Jordan River, geological cores that were drilled to a depth of 10 m along the river, and C. Feibel's drawings and geological interpretation of the sections and cores (personal communications). The tool-bearing BYF layers at this locality are deposited on a basalt flow, ca. 4 m thick. In a layer (Layer 4 in Section 02-5) of gray basaltic sand covering this flow was exposed the Acheulian living floor, yielding tools and bones in mint condition. The upper part of this section (Layer 02-5, 3) comprises a conglomerate of boulder-to-pebble sized basalt and small flint pebbles, in which heavily rolled Acheulian artifacts are abundant. In many instances, breakage is evident on handaxe tips and tool edges are notched, indicating transportation in a high-energy watery environment. Many of the tools in the GBY NBA collection originated in piles of sediments removed from the river banks and riverbed by heavy mechanical equipment. Hundreds of LCTs and other stone artifacts, as well as animal bones, were collected from these piles (Fig. 31). While it is unknown how many archaeological layers they represent, it is clear that the GBY NBA assemblage originates in several depositional environments. It can also be argued that the tools that were found in fresh condition had originated in a primary context, as was attested by the finds from the living floor of Section 02-5.

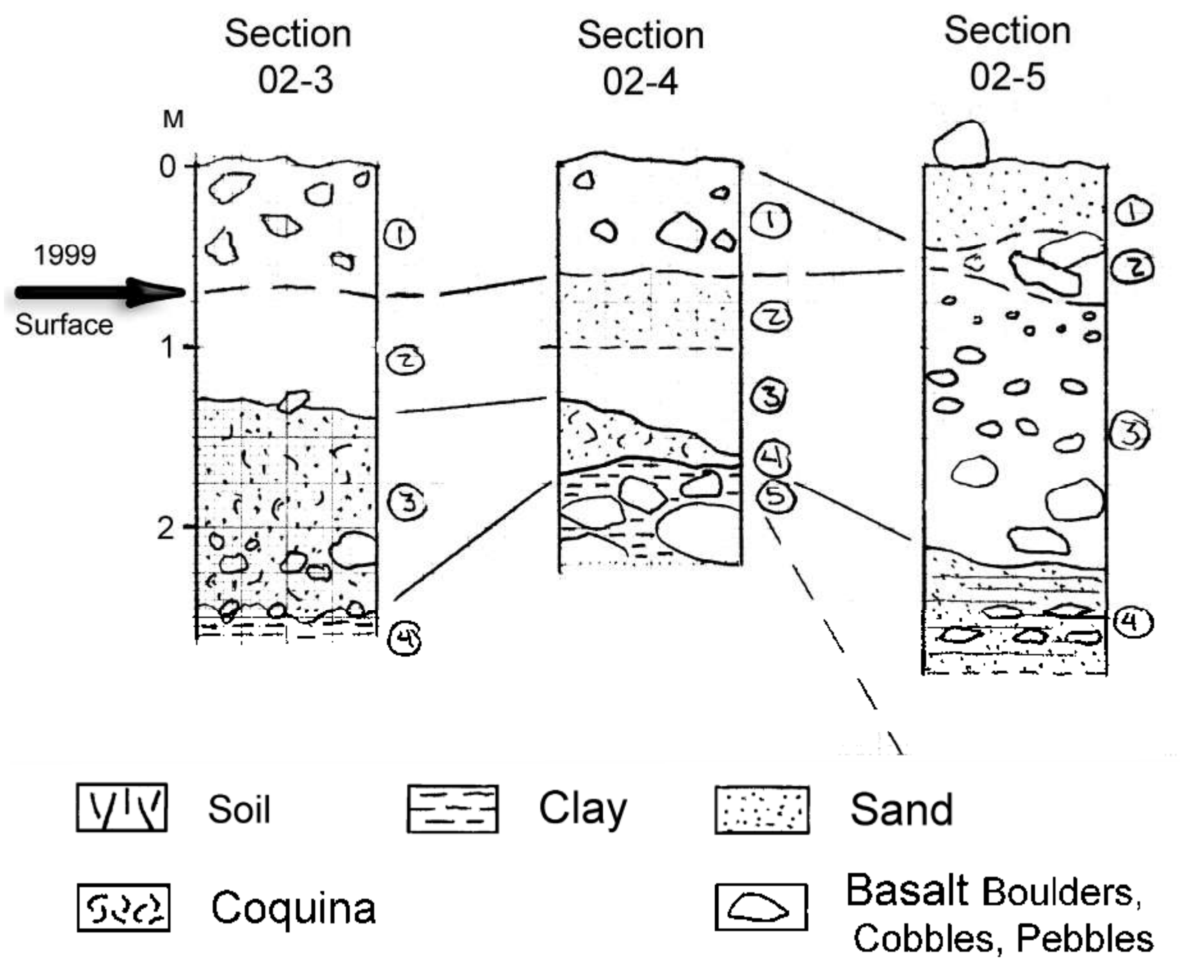

Figure 30. Jordan River, east bank Sections 02-3, 02-4 and 02-5 (drawn by C. Feibel).

Environment and Fauna – Bones are preserved in the GBY NBA layers. The nature of the sediments and finds suggest an environment similar to that described in the GBY excavation. Obviously, the sample and the scale of the excavation reported here are too small to facilitate any further observations (Sharon et al. 2002).

Date – A sample of the basalt underlying the Section 02-5 living floor was submitted to radiometric dating (Ar/Ar), and its age was determined as 664±20 kya (G. Feraud, CNRS Geosciences Azur Lab). An age of early Middle Pleistocene can thus be attributed to the LCT assemblage of GBY NBA Section 02-5. The lithic assemblage from GBY NBA resembles the GBY excavated assemblage in most of its aspects (typology, technology, raw material preference, etc.).

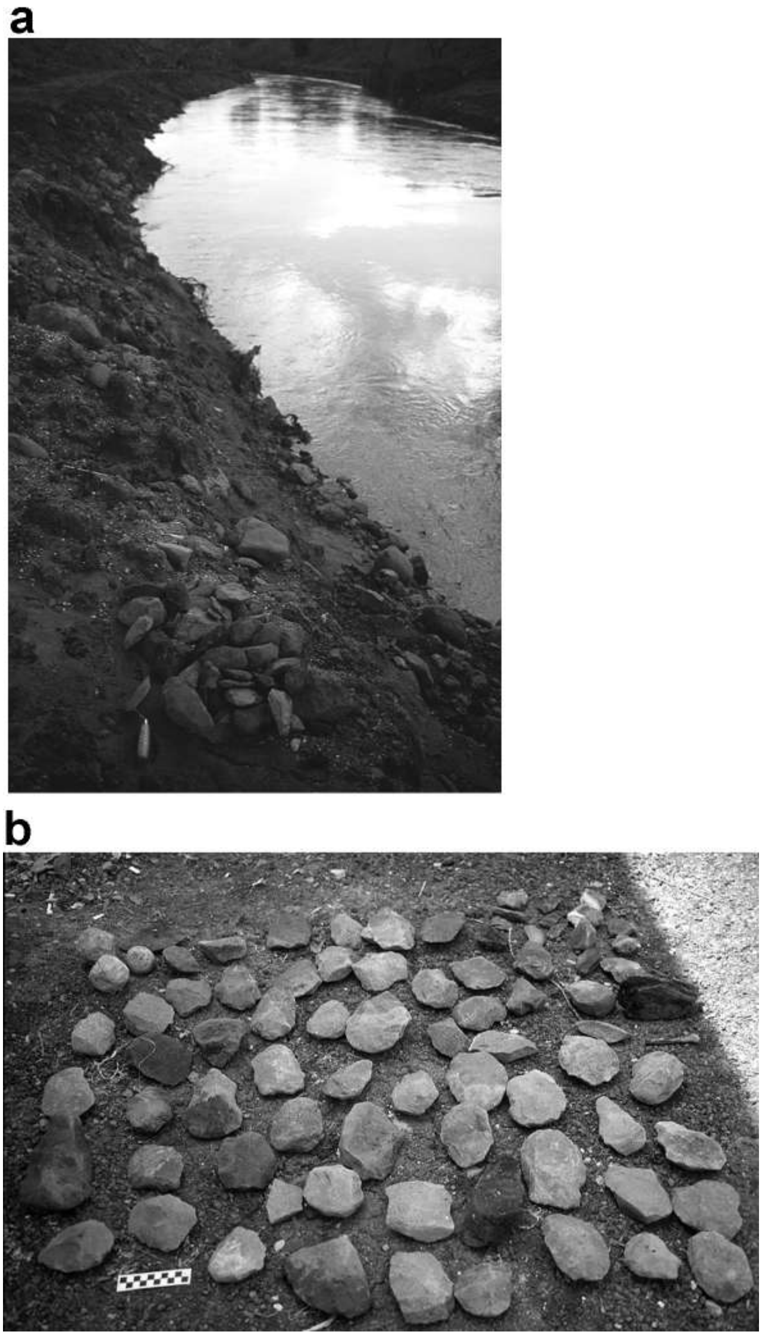

Figure 31. Jordan River bank. a. Pile of LCTs, December 1999. b. Artifact collection (during a twenty-minute visit in the summer of 2000) of Acheulian LCTs, bones (upper right) and spheroids (upper left).

Human Remains – None.

The Lithic Assemblage

Raw materials – See GBY.

Size of excavated assemblage – 179 handaxes and 98 cleavers were collected from the Jordan River banks and piles of sediments dug in this locality. In addition, 8 handaxes and 5 cleavers were recovered from Section 02-5.

The Collection under Study

Location – The Hebrew University of Jerusalem, Israel.

State of preservation – The preservation state of the assemblage is presented in Table 7. It is interesting to note that the basalt tools from GBY NBA are less badly exfoliated (i.e. weathered) than many of the GBY basalt tools, which are typified by severe weathering.

Table 7. Preservation state of GBY NBA LCTs.

Preservation State	N	%
A. Cleavers		
Fresh	19	16.8
Slightly abraded	61	54.0
Abraded	27	23.9
Rolled	4	3.5
Exfoliated	2	1.8
Total	113	100.0
B. Handaxes		
Fresh	32	14.9
Slightly abraded	80	37.2
Abraded	72	33.5
Rolled	30	14.0
Exfoliated	1	.5
Total	215	100.0

Reconstruction of the stratigraphic location of artifacts – The great majority of the tools from GBY NBA were collected from the east bank of the Jordan River. Tools from Section 02-5 and some additional tools were excavated in a primary in-situ context. All are recorded in the GBY project digitalized database.

The sample – All bifaces from the 1999–2002 surveys, collected and excavated alike.

Ma‘ayan Barukh

Previous/Alternative Names – El Hamari (Stekelis and Gilead 1966), Hamara (Saragusti 2003), both Arabic names for the area, deriving from the word for “red”.

Location – The site is located in the northern Hula Valley between Kibbutz Ma‘ayan Barukh and Kfar Yuval (Stekelis and Gilead 1966). Coordinates 33°5"00'N and 35°36"20'E.

Elevation above Sea Level – 250–275 m (Stekelis and Gilead 1966).

History of Research – Collection of Acheulian stone tools in the vicinity of the site began in the 1920s. The site has never been excavated and all finds are the result of surface collection. During the 1950s and 1960s, A. Asaf amassed the main collection of surface finds (Stekelis and Gilead 1966, Map 1). During the 1970s, a large collection of tools was assembled from IDF anti-tank trenches (Ronen et al. 1980).

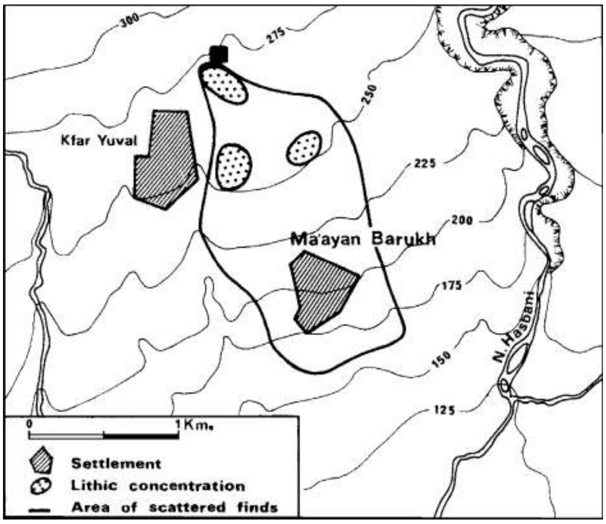

Figure 32. Location of main Ma‘ayan Barukh LCT find spots (after Stekelis and Gilead 1966).

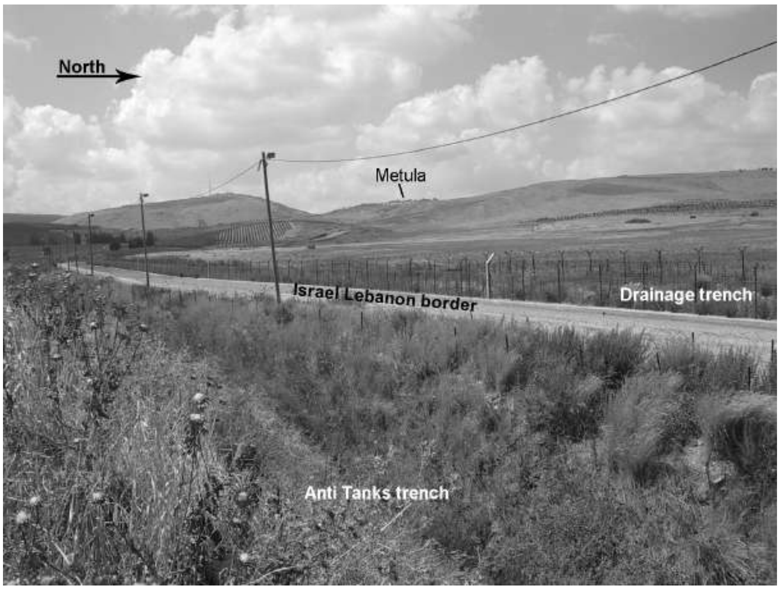

Figure 33. Ma‘ayan Barukh main trenches on the Israel-Lebanon border, looking northwest.

Excavated Area – The surface area from which artifacts were collected is estimated to be 2 km^2. Two trench sections, dug by the IDF along the Israel-Lebanon border fence (Fig. 33), have yielded a small assemblage. These are the only artifacts from Ma‘ayan Barukh to have come from a possibly in-situ context (Saragusti, 2003).

Geology – The geology of the area includes a layer of soil (*terra rossa*) covering a thick layer of travertine (Kfar Yuval Travertine), which in turn overlies basalt bedrock (Hasbani basalt; Stekelis and Gilead 1966 after Picard 1963).

Stratigraphy – The tools apparently originated in the red-colored soil topping the *tufa* (travertine) layers. For unclear reasons, varying quantities of travertine cover some of the tools.

Environment and Fauna – A few elephant tusks and molar fragments have been found.

Date – Heimann (1990) described the Kfar Yuval Travertine as being intercalated with Hasbani basalt dated to ca. 0.9 mya. However, the Acheulian tools that were found in the upper travertine layers are very likely younger (Saragusti 2003). Attempts to date the travertine in situ have yielded results that were beyond the limit of the dating method (Saragusti 2003; Scwarcz et al. 1980). Thorium-230/Uranium-234 dating was applied to the travertine coating of two handaxes from the Mt. Scopus collection. The results were very close to the limit of the method and suggest an age very close to the system equilibrium, dating the assemblage to ca. 450–500 kya (M. Bar-Matthews, personal communication).

Human Remains – None.

The Lithic Assemblage

Raw materials – A large majority of the tools were made on high-quality gray flint, apparently Eocene. It is assumed that the outcrops are situated in Lebanon, some 6 km north of the site. There are 48 flint nodules and blocks in the collection, 15 of which demonstrate 1–3 flake removals. Due to the geo-political situation in the region, no sourcing study of these finds could be pursued. Although the vicinity of the site is rich in basalt, only a very few tools (4 handaxes) were made of this raw material. All flint tools are covered by patina in various shades of red, resembling the color of the site's soil (Stekelis and Gilead 1966).

General description by the excavator – The majority of handaxes were produced on flint pebbles, while some were made on tabular flint and some on flakes. These flakes are usually either primary (cortical) or a cobble that has been split in two. In many examples, the striking platforms and bulb of percussion were removed by flaking. The workmanship of the tools is very good, as indicated by the high degree of symmetry, the fine bifacial knapping and the fine retouching and shaping of the edges. 45.6% of the handaxes are cordiform and 41.6% are round or ovate. Together they present a very pronounced dominance of ovate shapes (over 90%) over pointed ones. There is also a small group of cleavers, six of which were made on flakes (Stekelis and Gilead 1966).

Size of excavated assemblage – The report records 3775 items in the assemblage (Stekelis and Gilead 1966). Although claims have been made that an even higher number of bifaces was collected from the site, no record is available.

Table 8. Typology of Ma'ayan Barukh LCTs (after Stekelis and Gilead 1966, 8).

Type	N	% (of tools)
Handaxes (including broken and cleavers)	2503	85.2
Disks	42	1.4
Chopping tools	24	2.5
Spheroids	11	0.4
Racloirs	40	1.4
Choppers	13	0.5
Other tools	252	8.6
Hammerstones	4	
Cores	32	
Retouched flakes	29	
Flakes	349	
Handaxe fragments	200	
Cobble and blocks	48	
Waste	178	
Total	**3775**	

The Collection Sampled

Location – Prehistoric Museum at Kibbutz Ma'ayan Barukh, Israel.

State of preservation – Most of the artifacts (95.2%) are fresh. Some of the tools are weathered or even rolled, but it seems that water activity was not responsible for their condition.

Figure 34. Handaxe storage in the Ma'ayan Barukh Museum.

The sample – 125 handaxes were sampled and analyzed by N. Alperson and T. Goldman as part of a project sponsored by the Israel Science Foundation, and directed by N. Goren-Inbar. Some additional attributes were later recorded in connection with the current study.

Chapter 4: The Technology of Acheulian Large Flake Blank Production

Opening Remarks

This chapter is dedicated to the production of large flakes that were intended for use as LCT blanks. Its debate will center on various Acheulian giant core knapping methods, along with other technological aspects of the large-flake production stage of the LCT *chaîne opératoire*. The range of Acheulian giant core technology includes several core methods, seven of which will be described here: bifacial, sliced slab, cobble opening flake (*éclat entame*), Kombewa, Victoria West, Tabelbala-Tachenghit and Levallois. The discussion will be supplemented by reference to the Chirki cleaver core method (Corvinus 1983b), the Kerzaz method (Alimen 1978) and the block-on-block method. Although the obtainment of LCT blanks from cobbles or slabs did not require the use of a core method, it too will be considered here, as it is relevant to Acheulian handaxe production (White 1995).

In order to reconstruct Acheulian core technology, we shall base ourselves on morpho-technological observations arising from the sampled LCTs, i.e. the end-products of the reduction sequence. Study of the initial stages of the reduction sequence will necessitate the reconstruction from the beginning of all stages of a tool's *chaîne opératoire*. Workshops and quarry sites constitute the best sources for this type of technological information, as they provide the appropriate surroundings for refitting tool waste back onto its core (e.g. Cziesla et al. 1990; Davidzon and Goring-Morris 2003; Delagnes and Roche 2005). Unfortunately, giant cores are sparse in Acheulian assemblages, and such reconstruction was not feasible with regard to most of the sampled sites (Madsen and Goren-Inbar 2004). Nevertheless, bifaces and waste flakes in themselves preserve a considerable amount of information about the core method used in their production. Experimental data, especially that yielded by the GBY experimental lithic project (Madsen and Goren-Inbar 2004; Sharon 2000), have made a great contribution to the understanding and reconstruction of the giant core *chaîne opératoire*.

The Dimensions of a "Giant"

Based on observation of the GBY core assemblage, Madsen and Goren-Inbar defined size categories for giant cores (Madsen and Goren-Inbar 2004, 36). At the site of Isenya, East Africa, Texier and Roche (1992) separated the cores used for LCT blank production into "dormant" and "mobile" core groups. Dormant cores were static, very large blocks of raw material "to be worked on the outcrop at the cost of a basic preparation", while mobile cores were smaller (albeit still "large") blocks or flakes (in the case of the Kombewa core) that underwent preparation prior to flake detachment. In the current study, I attribute a core to the LFB Acheulian industry if it is large enough to have permitted the detachment of at least one flake that was suitable to serve as a LCT blank. It should be noted that the majority of Acheulian handaxes were larger than 10 cm. In order to attain a finished tool at least 10 cm in size, its blank had to be larger, thus allowing for the process of reduction and shaping (Kleindienst 1962; see also size data for LCT blanks, below). Fig. 35 plots the sizes of cores according to their site of origin. A distinction can be drawn between giant cores (maximal length >250 mm; maximal width > 200 mm) and large cores (maximal length 150–250 mm; maximal width 80–200 mm).

All the giant cores included in this study come from the site of GBY (Madsen and Goren-Inbar 2004; Sharon 2000). The large core group, also shown in the data of Fig. 35, actually represents three groups, denoting three different technological scenarios. The first group (three cores from GBY) in effect comprises exhausted giant cores, which were discarded at the stage when they began to yield flakes that were no longer sizeable enough to serve as LCT blanks. The second group (Victoria West cores from Canteen Koppie, Doornlaagte and Riverview Estate, and Tabelbala-Tachenghit cores from Tachenghit) consists of "preferential flake" method cores (term after Boëda 1995). In this method, the core was shaped in such a way as to produce a single predetermined flake that was large enough to serve as an LCT blank. The third group (the large Grotte des Ours Levallois cores and a few non-Victoria-West cores from the South African Vaal River sites) encompasses smaller cores designed for the production of flakes that were smaller than 10 cm, and probably did not serve as LCT blanks. Fig. 36 presents counts of core scars, which assist in identifying the different core groups.

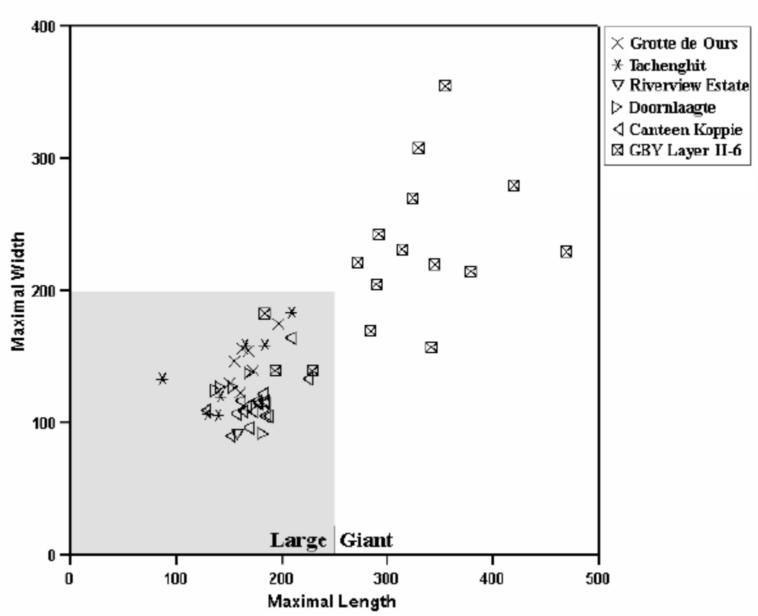

Figure 35. Size (mm) diagram of large and giant cores by site.

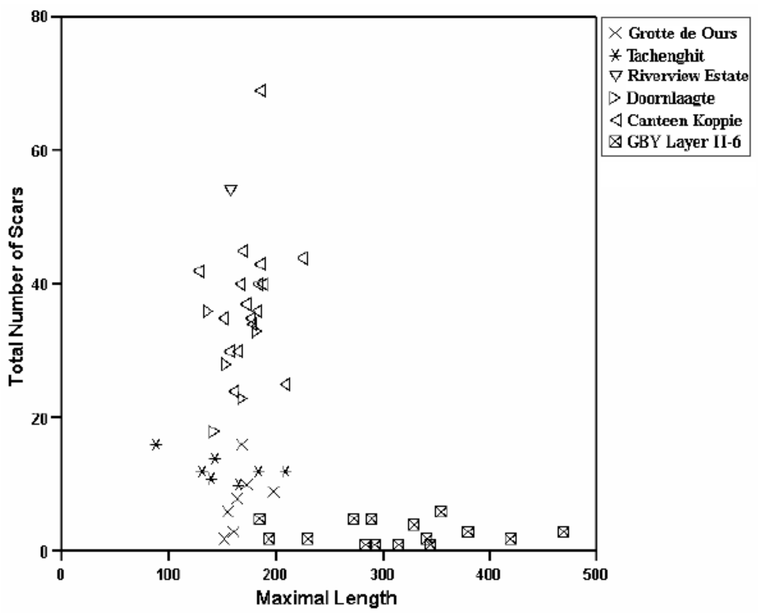

Figure 36. Total number of scars per core by site.

The lowest number of scars is demonstrated by the GBY giant core group, followed by the large Levallois cores from Grotte des Ours. The Victoria West cores of South Africa, as well as the Tachenghit cores, demonstrate that the preparation of a core for the extraction of a preferential flake required the highest number of flake removals. In other words, the combination of core size and scar count can provide a technological criterion for classifying large cores into technological sub-groups, as described above.

Acheulian Giant Core Methods

Bifacial Method

Most Acheulian giant cores probably started out as boulders that were collected from riverbeds or quarried at raw material outcrops. Bifacial removal of large flakes from these large blocks of raw material was recently described by Madsen and Goren-Inbar, based on the giant cores excavated at GBY and on substantial experimental study (2004). The bifacial reduction sequence (Madsen and Goren-Inbar 2004, Fig. 22) could have resulted in as many as seven core types. All of these forms are grouped together under the heading "bifacial giant core method", because they all entail the application of the same general knapping procedure to raw materials of different shapes and sizes, with assorted intentions as to the exploitation of the raw material. After detaching a primary, cortical opening flake, the knapper worked alternately along the core's periphery, removing a series of flakes from both faces of the core, while using the scar of the previously removed flake as a striking platform for the next (Fig. 37:a). The blows were most frequently applied to the sides of the negative of the bulb of the previously removed flake. In his discussion of the Stellenbosch type II cores, van Riet Lowe described this method thus (Söhnge et al. 1937, 79):

> "Occasionally advantage was taken of the negative flake scar of a previously detached flake by using it as striking platform for the removal of the next flake. This platform occasionally gives the impression of having been prepared (Tachenghit technique), but whether this preparation was intentional or not we cannot, of course, say."

This sequence was then repeated and another series of flakes was removed, using the same technique along the perimeter of the core (Fig. 37:b). The core gradually lost volume and was discarded when its size became too small for the production of LCT blanks (Madsen and Goren-Inbar 2004).

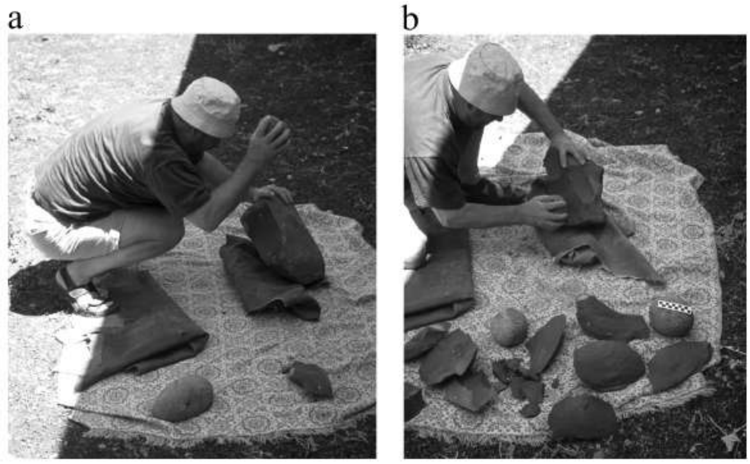

Figure 37. Experimental use of the flake on flake scar technique. a. Using the scar of an opening flake as a striking platform. b. A more advanced stage of the same reduction sequence (experimental core No. B-25, knapped by B. Madsen).

Although very few bifacial cores have been found in an excavated archaeological context and even fewer of them have been published, a few examples can be cited here. GBY core number 2703, described in detail by Madsen and Goren-Inbar (2004, 13, Fig. 4B), was excavated in layer II-6 Level 1 in association with a butchered elephant (Goren-Inbar et al. 1994). The core is bifacially knapped and shows a great deal of preplanned flake removal morphology, its final shape assigning it to the discoid-cubic morphotype group. Due to its method of alternate knapping, the volumetric approach of the debitage face and the striking platform face (Boëda 1995), and the predetermined, well-controlled sequence of removals, many scholars would probably opt to classify this core as a Levallois core (see discussion of Levallois cores below). At the site of Isimila K-18, a giant core was found on the surface of Trench 2E (Fig. 76:d below; see also Howell et al. 1962). This core, measuring 45.7 x 30.5 x 20 cm, was shaped on a very large quartzite block. It has 12 scars on one face and 25 on the other, 8 of them being very large. The scar pattern on both sides is radial and only a small patch of cortex remains on one of the faces. Clearly, the core was knapped in accordance with all the principles of bifacial knapping, as described above. At the site of Morgaon, India, a number of giant cores and large flakes were retrieved from a pile of stone removals on the margin of a field (Fig. 38; S. Mishra, personal communication). Some of these cores were clearly knapped by the bifacial knapping method. Bifacially knapped giant cores were also reported in the quarry site of Isampur, India (Petraglia et al. 1999), where they were shaped from large limestone slabs (Paddayya et al. 2006, Fig. 15).

Use of the bifacial core method in the production of large flakes from giant cores was common wherever LCTs were produced from such blanks. This is a general term, grouping a variety of core morphotypes that could potentially be produced by this flexible reduction method (Madsen and Goren-Inbar 2004). The archaeological and experimental data presented above suggest that this efficient and practical core method can be regarded as the default method used by Acheulian knappers whenever large flakes were produced from boulder-size cores.

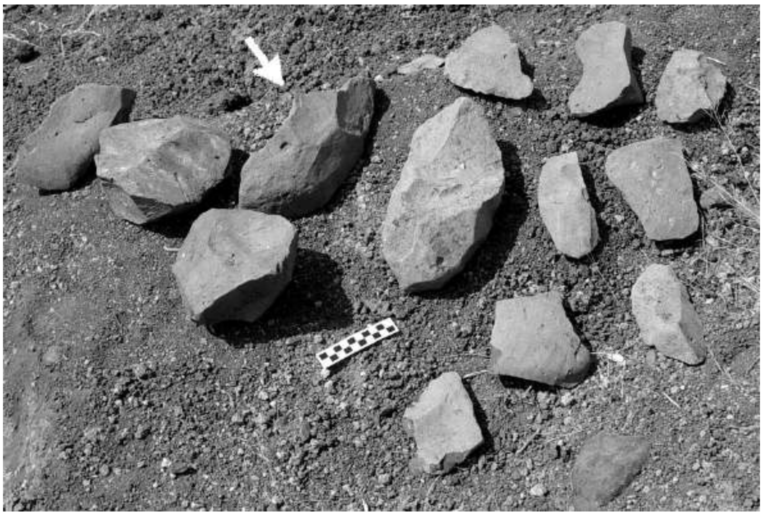

Figure 38. Giant cores and large flakes at the site of Morgaon, India. Arrow marks giant bifacial core. Scale: 10 cm. Courtesy of Dr. S. Mishra.

Sliced Slab Method

In this study, the term "sliced slab cores" groups together cores that were made on large, flat slabs of raw material by a slicing method that resembles the slicing of a wedge of cheese. This method was reconstructed from technological observations made on giant cores from the GBY sites and LCTs from the site of Hunsgi. In the vicinity of GBY, basalt is frequently available in the shape of large slabs. These typical slabs were formed during the cooling process of the basalt flows that streamed down the Golan Heights. An area termed the "middle crushed area", in the midst of the basalt flow, was formed between the upper and lower colonnades. Here, dense horizontal slabs of basalt of good knapping quality were formed. Meter-length slabs, with a homogenous thickness of about 20–25 cm, eroded from the flows into the riverbeds of the Golan Heights. The eroded slabs had a natural flat surface that could have been used as a striking platform for flake removal (see below). This type of basalt flow structure was describe by Mor (1986) and was observed in the vicinity of the GBY Acheulian excavation during the GBY experimental lithic project (Fig. 39). It should be noted that the colonnade section of the flow is also a source of good-quality basalt, but its morphology is less suitable for knapping (Fig. 40:b). It seems plausible to argue that such basalt slabs were available to the GBY knappers, either in riverbeds or in localities where the streams, running down from the Golan Heights into the Northern Jordan Rift, exposed the basalt flows along their banks (Fig. 40). These slabs were used by the GBY Acheulian knappers as cores for the production of large flakes by a variety of knapping methods, as described by Madsen and Goren-Inbar (2004).

The GBY assemblages include a few very large basalt slabs showing scars of large flake removals (Fig. 41). It is evident from the examples in Fig. 41 that at least two core reduction methods were applied to these slab cores. While core 41:a was knapped by the bifacial method described above, cores 41:b and 41:c display scars of flakes that were detached from the narrow flank of the slab. The flat natural face of the slab was used as a striking platform for the removal of flakes throughout the core’s thickness. This is termed the sliced slab core method. Note that in core 41:b, bidirectional flaking is evident where short (unsuccessful?) flakes were removed from the opposite (bottom) face of the core into the same debitage face. It should be noted that LCTs displaying slice morphology are very rare at GBY, making it likely that most LCTs at the site were produced by other core methods.

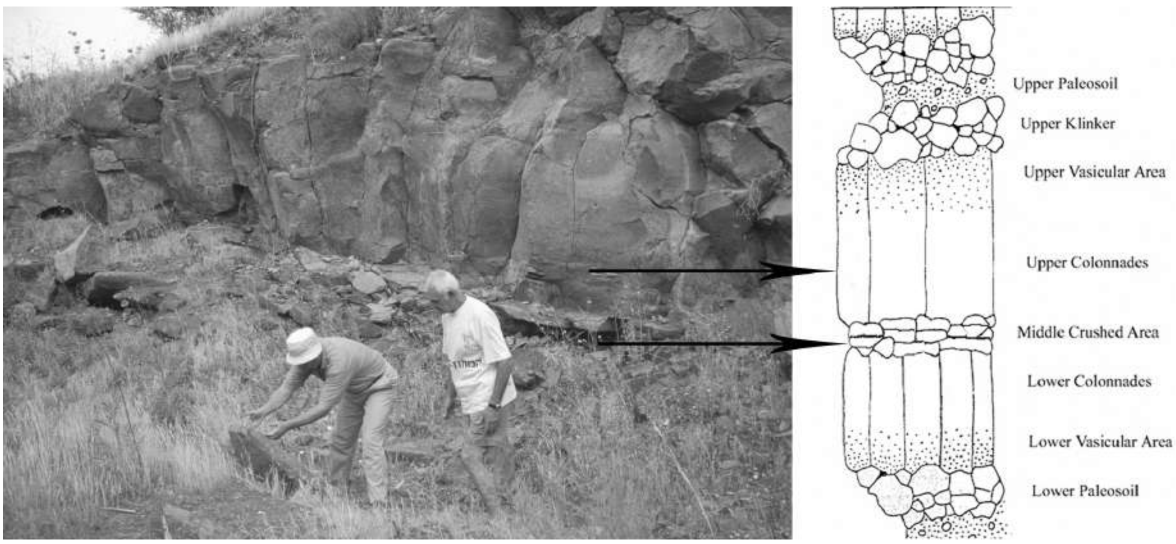

Figure 39. Collecting a basalt slab from a typical basalt flow outcrop in the vicinity of the GBY Acheulian site (flow section after Mor 1986, Fig. 25).

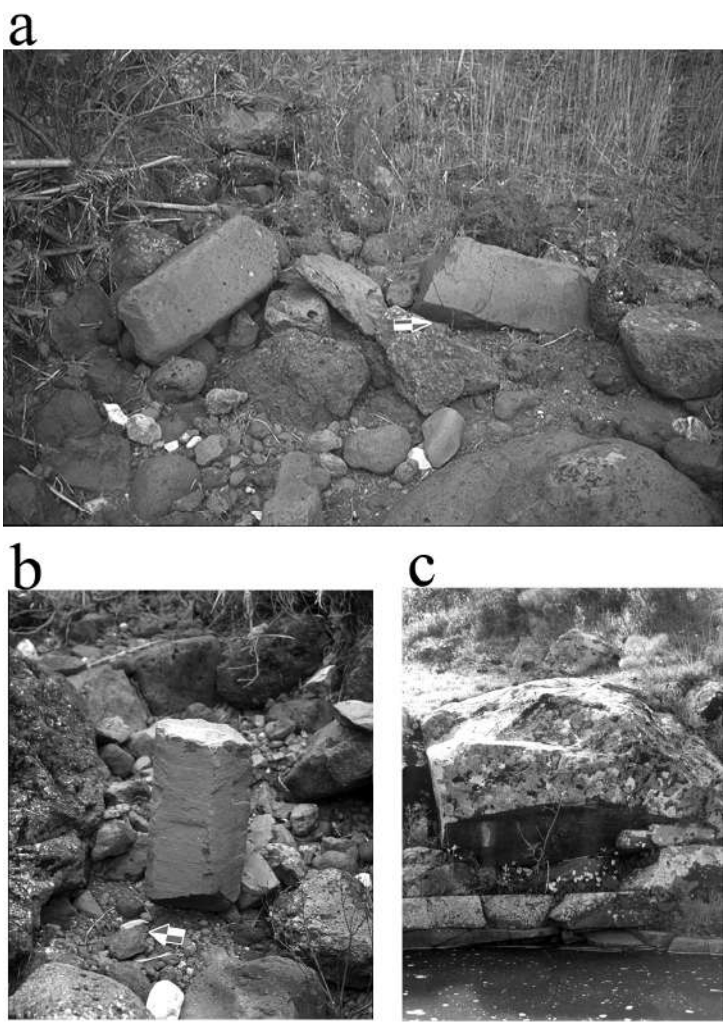

Figure 40. Natural basalt slab in the vicinity of GBY. a. Basalt slabs at Nahal Hamdal. b. Basalt hexagon at Nahal Hamdal. c. Basalt slabs at bottom of flow at Nahal Mahanayem.

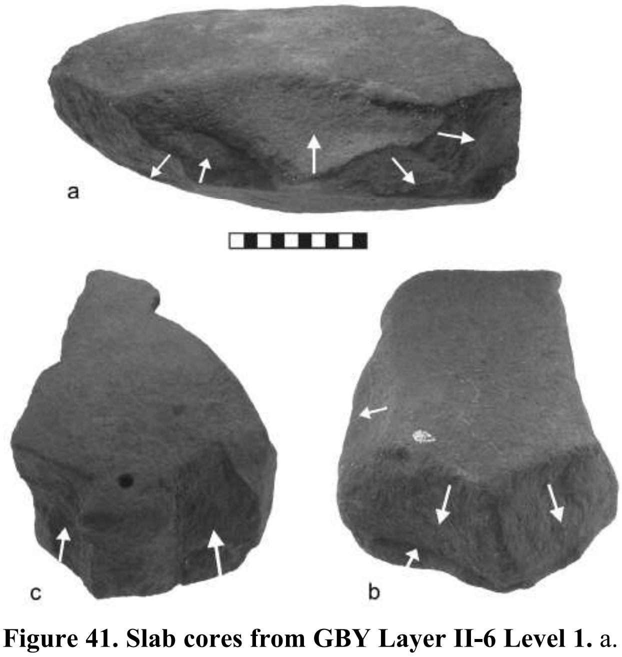

Figure 41. Slab cores from GBY Layer II-6 Level 1. a. Bifacially knapped slab core. b–c. Sliced slab cores. Arrows indicate the reconstructed blow direction of the removed flakes. Photograph by G. Laron.

LCTs from the site of Hunsgi, India, particularly Hunsgi cleavers, represent flakes that were extracted by the slab slicing method. The Hunsgi bifacial tools were shaped on siliceous limestone and show a unique morphology that technologically can be explained as originating in slab giant cores (Fig. 42). The nearby quarry site of Isampur (Petraglia et al. 1999), where the limestone bed was naturally formed in the shape of large flat slabs, can be viewed as a possible source of limestone raw material. Full reconstruction of the methods used in production of large flakes from giant slab cores in this and similar sites cannot yet be attempted, as many stages are still missing. The following observations, however, link the Hunsgi LCTs to the slab slicing method. They are relatively thick and show steep lateral edges. In some of the tools, the butt and lower part of the lateral faces are cortical (Fig. 42:a, b, e, f, g). Many of them have two flat faces that resemble a "Janus" flake (Fig. 42:b–h; Newcomer and Hivernel-Guerre 1974). A good way to conceptualize the morphology and technological origin of the Hunsgi LCTs is by comparing the tools' shape to a wedge of cheese (Fig. 43). Note the resemblance between the two in the cortical cover of the butt and sides, the steep margins, the two ventral faces ("Janus" flake), the sharp cutting edge and the general morphology.

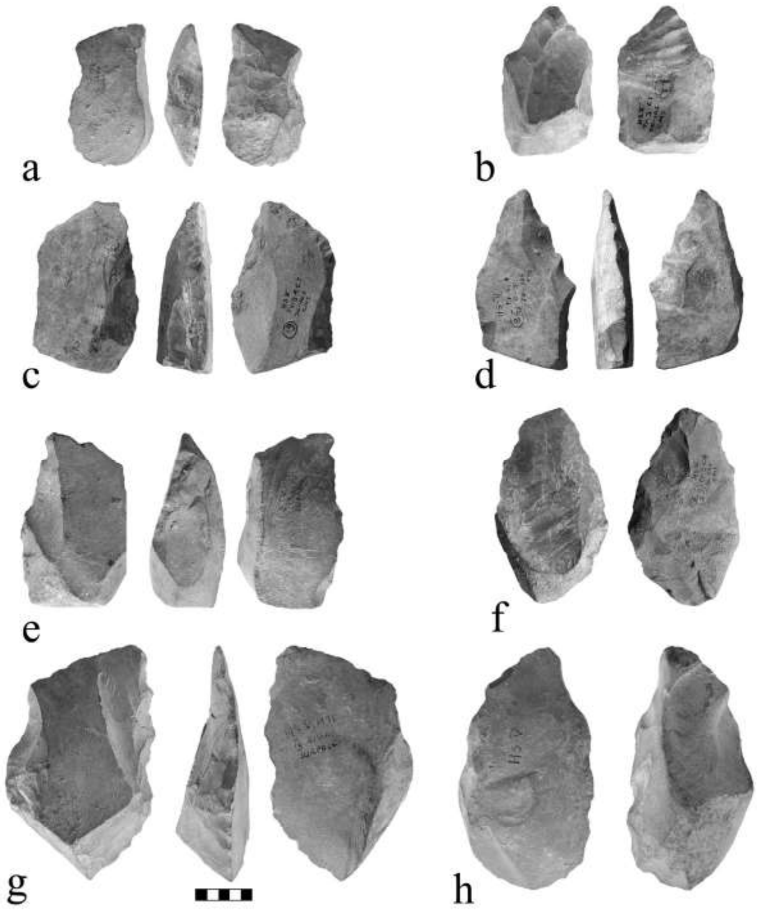

Figure 42. Hunsgi LCTs with slice morphology.

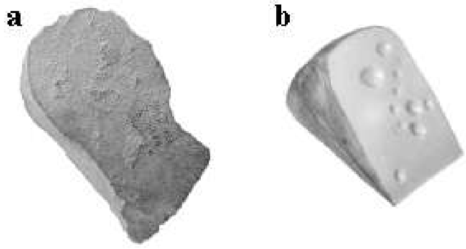

Figure 43. a. A Hunsgi cleaver shaped on a sliced flake. b. A wedge of cheese.

A partial hypothetical reconstruction of the slicing method, based on the limited data at our disposal, is presented in Fig. 44. Three stages are suggested:

Stage 1: Opening the core and preparing the flaking surface. After a suitable slab was selected, a cortical opening flake was removed, using the flat natural face of the slab as a striking platform. In many cases, this opening flake removed the corner of the slab. The example shown in Fig. 44:1 demonstrates the removal of two such primary flakes (1 and 2), named "shoulder flakes" here, along with an actual archaeological flake from Isampur. These are also found among flakes originating in GBY and Hunsgi (Fig. 45; Paddayya et al. 2006, Fig. 32). Between the scars of the removed shoulder flakes a ridge was created, which was eliminated in the next step (Fig. 44:1, No. 3). This removal, a crucial intermediary core maintenance stage, formed a preparatory "wedge" flake, which was followed by others as the knapper proceeded in the giant slab core knapping process. Striking wedge flakes regulated the debitage surface and flattened the face that was intended to become the dorsal face of the next slice, as described in Stage 2. The wedge flake, exemplified in Fig. 44:1, is relatively wide and is responsible for the removal of most of the core's debitage face area. Other wedge flakes were much narrower, removing only the crest between two slice scars (Fig. 46).

Stage 2: Slicing the core and removing the first "desired" sliced flake. This side flake was struck using the natural upper face of the core as a striking platform and had a cortical butt (a remnant of the slab core's lateral face). The flake had a plain dorsal face (resembling a Kombewa flake, see below) that was predetermined by the wedge flake removal of Stage 1 (Fig. 44:2a). If properly knapped, some of these sliced flakes resembled a cleaver in shape and needed minimal secondary retouch during the shaping of the finished tool (Figs. 42, 47). This sequence of slab core maintenance through wedge flakes and the removal of sliced flakes was repeated many times, as the knapper sliced the core as if it were a large cheese.

An alternative flake at this stage was half a slice. In some instances, the sliced flake did not run through the entire thickness of the slab core. This could have been the result of either a miscalculated blow lacking sufficient energy or a preplanned procedure. The resulting flake had a steep, thick butt, one lateral face, and a sharp cutting edge that was created by the other lateral edge (Fig. 44:2b). These sliced "knives" can be observed among the Hunsgi LCTs (Fig. 42: a, d, f; see also an example from Isampur Quarry, Paddayya et al. 2006, Fig. 21).

Stage 3: The discarded slab core resembles the GBY slab cores (Figs. 44:3, 41). The Hunsgi slicing method was especially suited to the production of cleaver blanks, as summarized in Tables 9 and 10.

Table 9. Frequency of blank types, Hunsgi sample.

Type	N of Sliced blanks	% of Sliced blanks	N of Other blanks	% of Other blanks
Cleavers	17	35	32	65
Handaxes	4	4	87	96
Flakes	5	7	70	93
Total	26	7	189	-

Table 10. Descriptive statistics for Hunsgi cleavers by blank type (complete tools only).

Blank		Weight	N of scars ventral face	N of scars dorsal face	Max. length	Max. width	Max. thickness	Circum.
Slice	Mean	639	7	11	145	90	51	390
	N	17	16	16	17	17	17	17
	S.D.	206	6	8	19	12	11	52
	Minimal	272	0	2	115	66	30	303
	Maximal	1017	24	26	186	109	73	490
Other	Mean	659	6	11	145	93	45	395
	N	31	31	31	31	31	31	31
	S.D.	286	6	6	24	15	9	59
	Minimal	247	0	1	107	73	28	292
	Maximal	1453	21	25	206	140	71	537

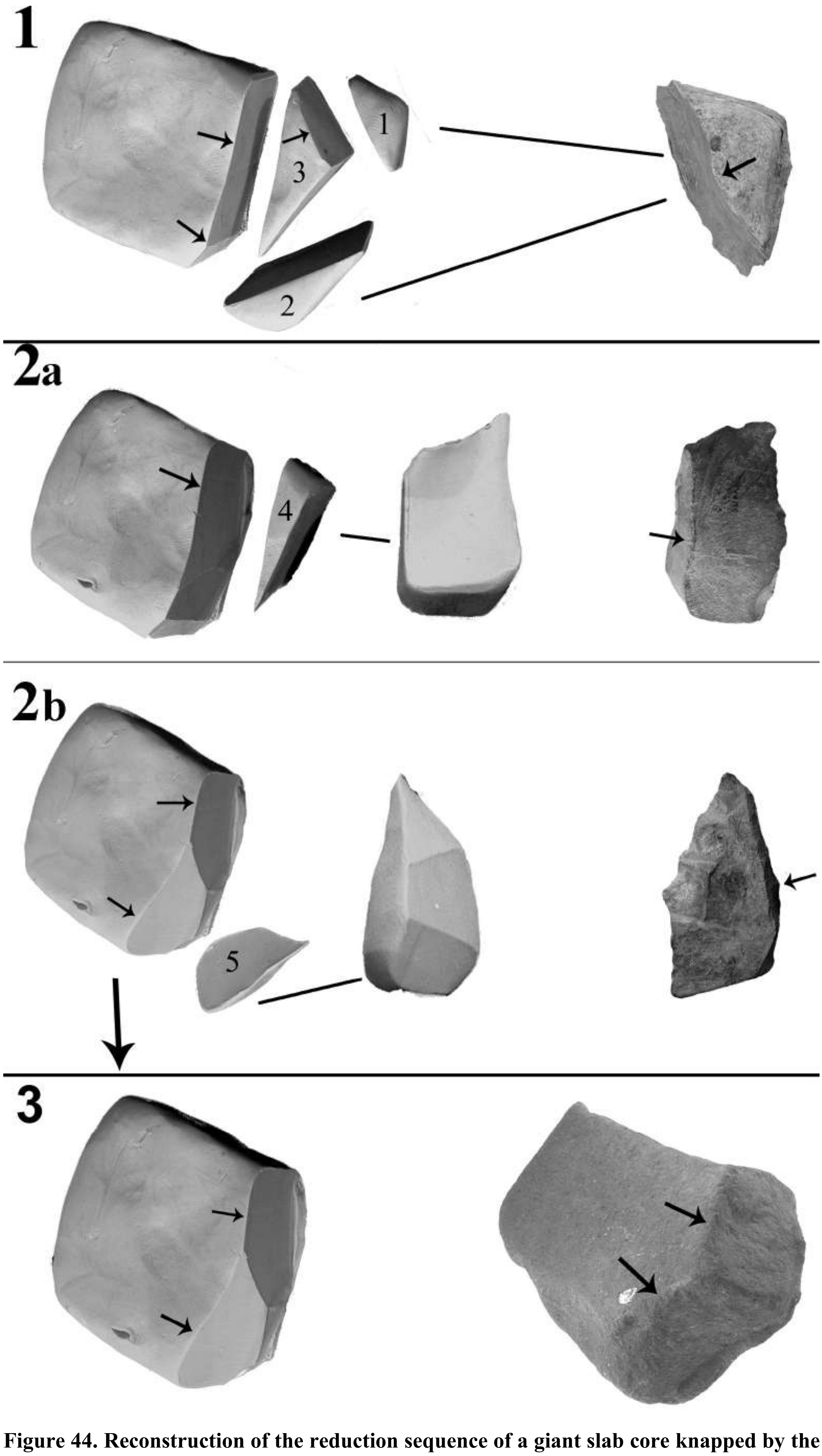

Figure 44. Reconstruction of the reduction sequence of a giant slab core knapped by the slicing method. Left and center: modeling-clay models. Right: archaeological equivalents. Numbers represent the place of a flake in the order of removals; arrows represent blow direction.

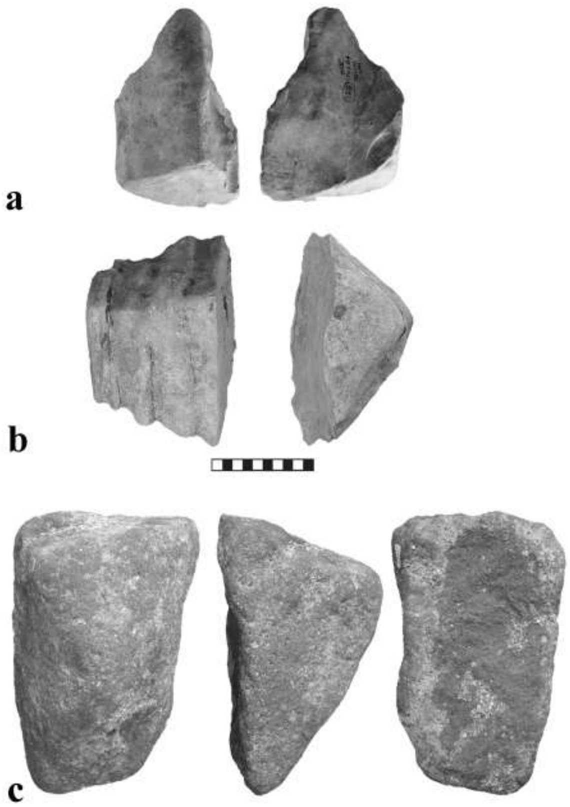

Figure 45. Slab shoulder flakes from Stage 1 of the slicing method. a. Hunsgi. b. Isampur (after Paddayya et al. 2006). c. GBY.

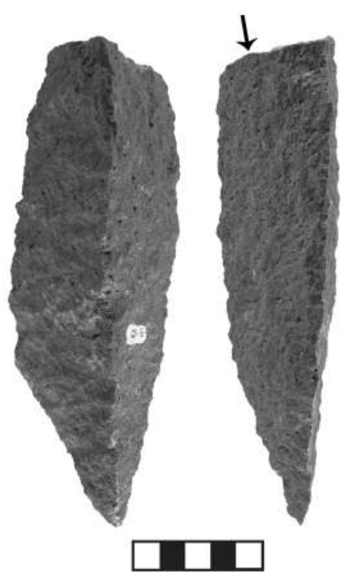

Figure 46. Experimental narrow wedge flake from a basalt slab core (knapped by B. Madsen; photograph by G. Laron).

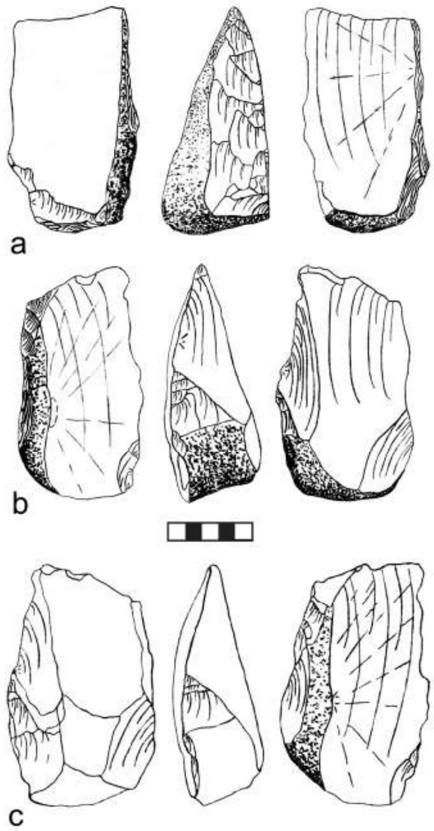

Figure 47. Slice cleavers from Hunsgi.

Other methods in addition to the slicing technique were employed in the production of the Hunsgi cleavers (Table 9), which were in fact predominantly produced by these alternate methods (Petraglia et al. 1999; Petraglia et al. 2005). In terms of both tool size and scar quantity, no differences are apparent between the various core methods. Nevertheless, slicing comprised a highly efficient core method that exemplifies the knappers' adaptability to the exploitation of the large limestone slabs that were available in their region.

Cobble Opening Flake (*éclat entame*)

Following the study of the LCT assemblage from the site of Ternifine, this sophisticated but uncomplicated core method, frequently used at the site, was identified and defined. It entailed the detachment of opening cortical flakes (*éclat entame*; see Inizan et al. 1999) from large cobbles and their use as blanks for LCT production. A cobble was struck once at a precise location on the cortex and at an obtuse angle (for the 7 flakes that were measured, the average angle was 131^{o}). The strike produced a blank that was perfectly suited to handaxe production (Fig. 48), with minimal necessity, if at all, of secondary retouch. This method was highly controlled, due to the meticulous attention paid both to raw material size and shape selection and to the systematic removal of a single, preplanned primary flake. A minority of the cortical blanks at Ternifine (n=7) display plain, non-cortical striking platforms. These flakes were apparently removed after a flake had already been extracted from the cobble core, the knapper using the scar of the opening flake as a striking platform.

When the *entame* blanks were used for the production of cleavers (Fig. 48:a, b), they resembled type 0 in Tixier's cleaver typology (Tixier 1957) and were alternatively termed "*proto-hachereaux*". Such cleavers have been reported in many Acheulian assemblages from North Africa and the Iberian Peninsula (e.g. Alimen 1978; Balout et al. 1967; Mourre 2003; Raposo and Santonja 1995; Santonja and Villa 1990). J. de Heinzelin de Braucourt has identified these cleavers as one of his four main classification groups and has suggested the name "*hachereaux de Ternifine*" (Heinzelin de Braucourt 1962).

Experimentally produced *éclat entame* (Fig. 49) has shown that this method was productive only when applied to relatively flat cobbles, which had the appropriate surface for striking at the required angle. Because the blow had to be applied well into the thickness of the cobble, spherical cobbles produced flakes that were too thick to serve as LCT blanks.

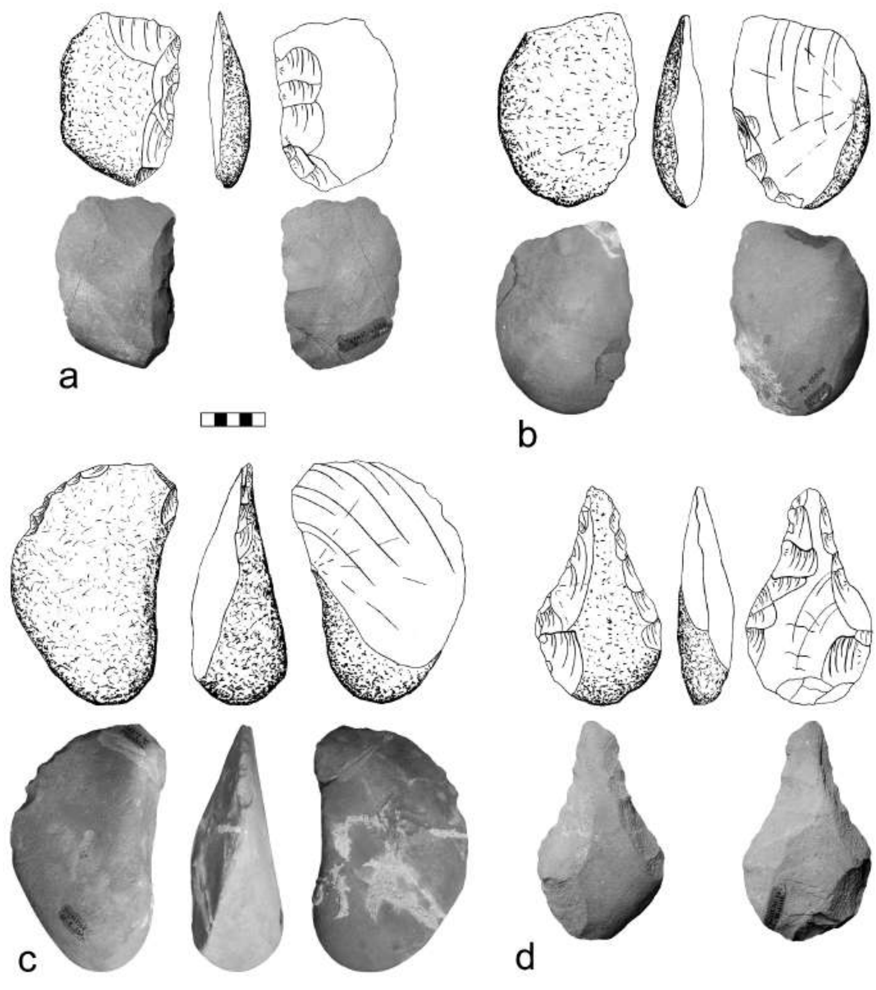

Figure 48. Line drawings (top) and photographs (bottom) of large flakes and bifacial tools on *entame* blanks from Ternifine.

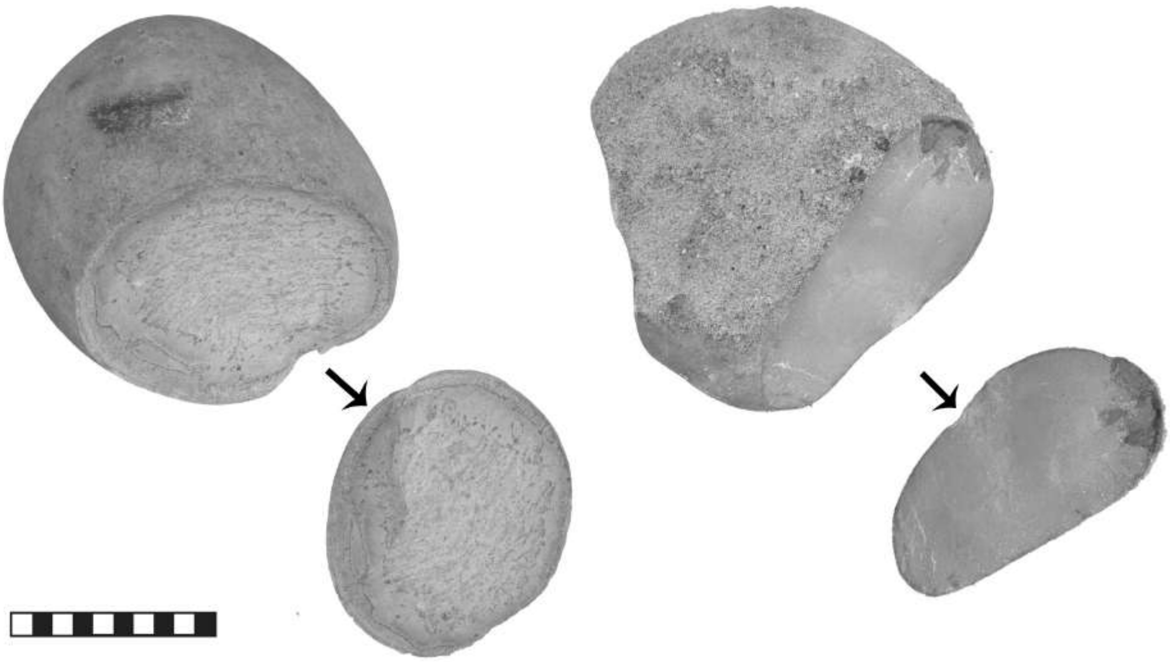

Figure 49. Experimentally produced *éclat entame* (knapped by G. Sharon).

Of all the assemblages that were sampled for this study, Ternifine is the only site that yielded a substantial number of blanks produced in this manner. The Ternifine *éclat entame* method should not be confused with the use of cobbles as blanks in the production of LCTs. In some cases, the use of a flat cobble as a blank involved the removal of the entire cortex from one face of the cobble, resulting in an artifact that was somewhat similar to an *éclat entame* flake. In order to avoid confusion, the presence of a cortical striking platform and a ventral face should be taken as an indication of a true *entame* tool. The Acheulian LCT makers at Ternifine systematically used medium-sized quartzite and sandstone cobbles, which are visually similar. However, no flat cobbles – either complete (unstruck) or in the form of cores – were available for study in Ternifine's assemblage. It is possible that some of the Ternifine cobble tools, like those described by Biberson (Balout et al. 1967), were in actuality cobble cores that were used for the production of *entame* flakes. Due to the lack of data pertaining to Ternifine cobble cores, the reconstruction presented here is based on LCT and large flake morphology alone. From experimental study, it can be roughly estimated that an *entame* flake comprised approximately one quarter or less of the parent cobble core. If the mean maximal dimension of *entame* flakes from Ternifine was 147.6 mm, we can estimate that the maximal diameter of the cobbles chosen as cores was ca. 250–300 mm and that their weight was probably between 500 and 3000 grams (Table 11).

Table 11. Descriptive statistics for Ternifine tools on *entame* flakes (complete tools only).

	N	Minimal	Maximal	Mean	S.D.
Weight (gr)	38	203	1018	514.0	222.1
Max. length (mm)	39	108	185	147.6	16.9
Length (mm)	8	80	161	114.5	27.0
Max. width (mm)	39	61	175	100.0	26.4
Max. thickness (mm)	39	31	60	44.3	6.7
Circumference (mm)	28	103	517	367.3	81.8

Although differing in their technology of manufacture, the *entame* flakes are similar in size to other Ternifine LCTs. Fig. 50 shows a size comparison (maximal length to maximal breadth) between complete *entame* flake handaxes from Ternifine and handaxes made on other blank types. The scattergram indicates that the former are slightly larger than the latter, but the difference is minor and the size distribution of the *entame* flakes falls well within the range of all Ternifine handaxes.

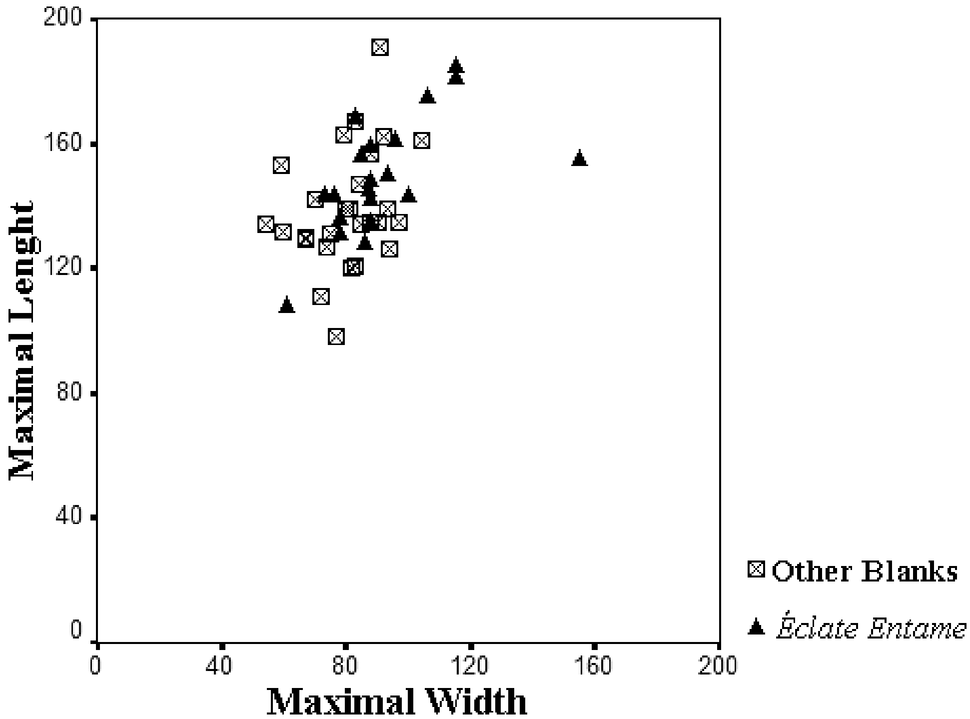

Figure 50. Size of complete Ternifine handaxes by blank type.

Most of the *entame* blanks were used for the production of handaxes (Table 12). It is worth noting, however, that typologically these handaxes can in many cases be classified as "knives', because they present a lack of symmetry between the margins, one side being steep and blunt and the other sharp (Isaac 1977, 120; see further definitions in Clark 2001a; Kleindienst 1962). I have chosen not to use the "knife" definition, since this shape resulted from blank production technology and either formed the basis for shaping handaxes, cleavers and large scrapers, or was left with no retouch at all.

Table 12. Ternifine *entame* use as blanks by type.

Type	*entame*		Other blanks	
	N	%	N	%
Handaxe	25	44	32	56
Cleaver	7	15	47	85
Flake	10	24	31	76
Total	**39**	**35**	**113**	**-**

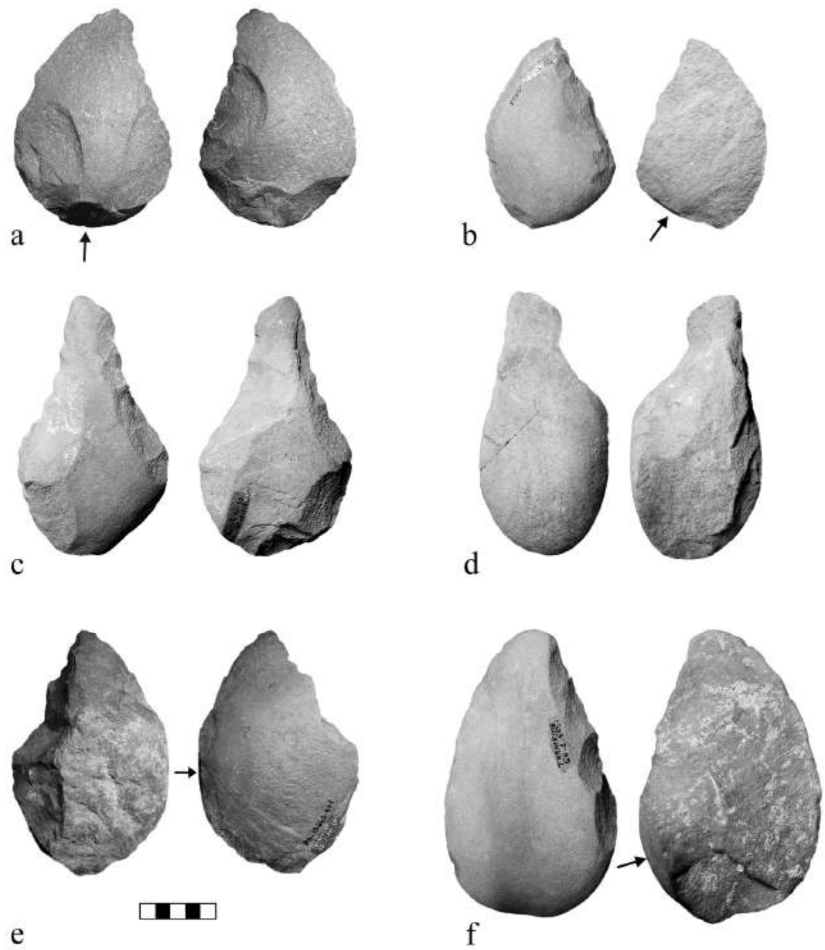

Figure 51. Handaxes on *entame* flakes from Ternifine (arrows indicate blow direction when identifiable).

Technological Aspects of éclat entame Production

The distribution of the blow direction for all the Ternifine *entame* flakes is presented in Fig. 52 (cleavers, handaxes and flakes are all grouped together, due to the small size of the samples). Right-side-struck flakes (directions 3 and 4) clearly dominate. The dominance of direction 4 shows that there was a preference for “special side-struck” flakes, which had their bulb of percussion (the thickest part of the flake) on the lateral proximal left side of the flake, along with a thin tip – the ultimate shape for a handaxe blank (Fig. 51:b, f).

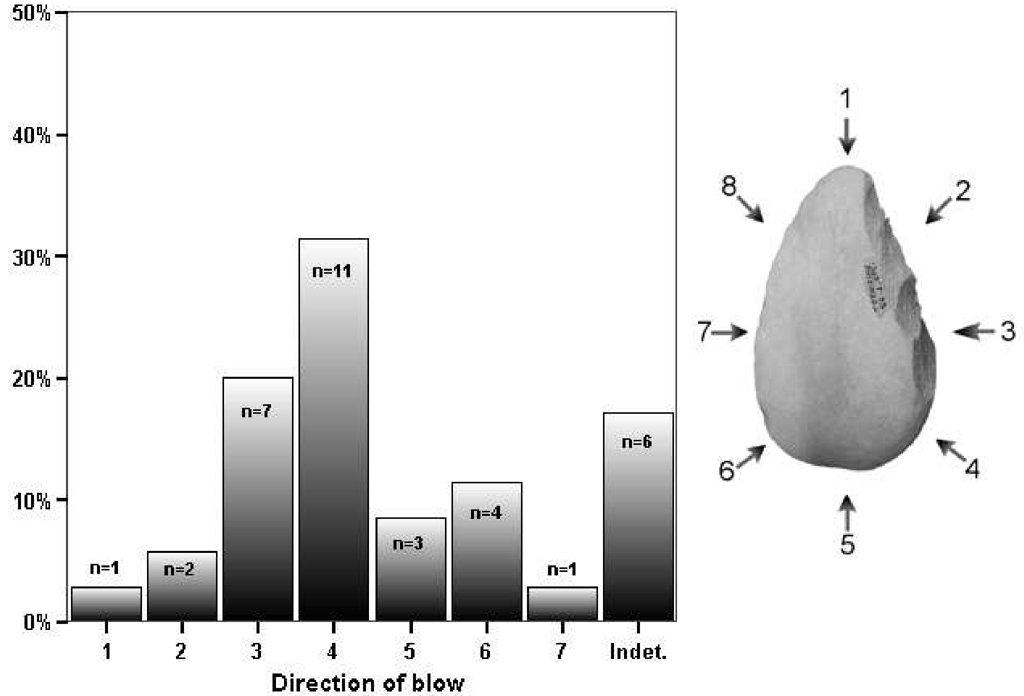

Figure 52. Ternifine *entame* flake blow direction.

The *éclat entame* core method required a relatively low intensity of work and was highly efficient. The minimal secondary shaping that took place was carefully invested in shaping the cutting edges, a final touch for a very well-designed tool, as demonstrated by the following technological attributes:

Cortex cover: Table 13 presents the percentage of cortex covering the dorsal face of *entame* blank tools and flakes. In 85% of these tools, the cover takes up over 50% (see also Figs. 48, 51), suggesting a low rate of secondary retouch during the shaping stage of tool manufacture.

Table 13. Percentage of cortex cover on dorsal face of Ternifine *entame* blank tools.

% of Cortex Cover	N	%
0–25	1	2
25–50	6	13
50–75	16	36
75–100	22	49
Total	45	100

Scar count on tool faces: Table 14 presents scar counts for all sampled North African sites. The scar count of *éclat entame* Ternifine handaxes is significantly lower than that of handaxes produced on other types of blanks in Ternifine itself, and also that of other types of handaxes sampled from other sites.

Table 14. North African Acheulian site handaxes, number of scars per face.

Site			N.S. ventral face	N.S. dorsal face
STIC	handaxe	Mean	12	13
		N	76	77
		SD	6	6
		Minimal	3	4
		Maximal	33	41
Ternifine	***entame***	**Mean**	**9**	**4**
		N	24	23
		SD	7	4
		Minimal	0	0
		Maximal	24	13
	handaxe	Mean	11	14
		N	32	32
		SD	6	8
		Minimal	1	1
		Maximal	27	29
Grotte des Ours	handaxe	Mean	11	12
		N	70	62
		SD	6	6
		Minimal	2	1
		Maximal	24	29
Tachenghit	handaxe	Mean	22	31
		N	27	29
		SD	10	7
		Minimal	6	17
		Maximal	39	45

Intensity of retouch: Fig. 53 records the extent of flake-removal scars (retouch) on each face of Ternifine handaxes by type of blank.

The extent of retouch on the ventral face (Fig. 53:b) for Ternifine *éclat entame* handaxes is somewhat similar to that for handaxes made on other blank types. However, for the dorsal face (Fig. 53:a) scars on *entame* handaxes are fewer in number than those on handaxes of other blank types. Moreover, the dorsal face of *entame* flake-based handaxes is less extensively retouched than the ventral face of these tools, a very unusual pattern in flake-based LCTs in general (see Chapter 5).

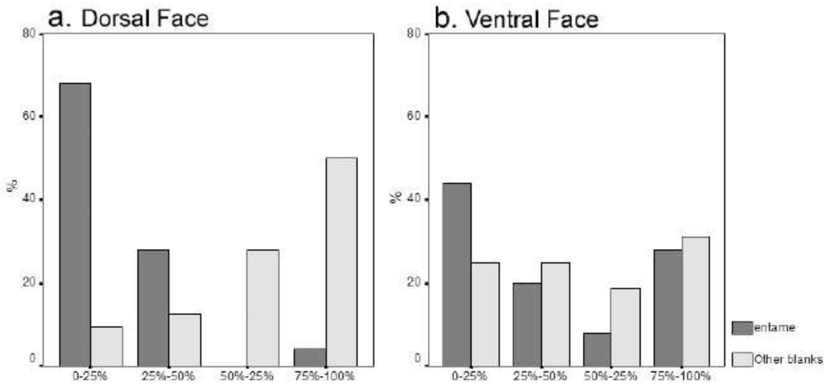

Figure 53. Quantity of retouch on dorsal and ventral face by type of blank. a. Ventral face. b. Dorsal face.

It would seem that *entame* flakes were brought to the site both as finished tools and as flakes bearing no secondary retouch. These large flakes (n=7) may have been blanks whose morphology needed no further modification when detached from the cobble core, or alternatively blanks that for unknown reasons were never processed further.

The *éclat entame* core method has been identified in other sites in addition to Ternifine: LCTs made on cortical primary flakes were recorded at STIC Quarry (n=4), Grotte des Ours (n=3), Riverview Estate (n=2), Hunsgi and GBY (Figs. 54, 55). Alimen (1978, Figs. 51, 55) described such tools under the title "Type I cleavers" in West Saharan Acheulian sites. Corvinus (1983a) published other examples from the west coast of Namibia. However, the best examples of relatively extensive use of the *entame* method come from the Acheulian sites of Spain (e.g. El-Sartalejo, Moloney 1992; Santonja 1985).

Mourre (2003, Vol. 3, 19) noted that 57% of the El-Sartalejo cleavers are of Tixier type 0, which resembles tools manufactured by the *éclat entame* core method. In the Portuguese site of Milharós (Raposo 1996, 154), the use of *entame* flakes was actually described as one of the main technological features of the site's LCT blanks. Nevertheless, in most sites this method was rarely used.

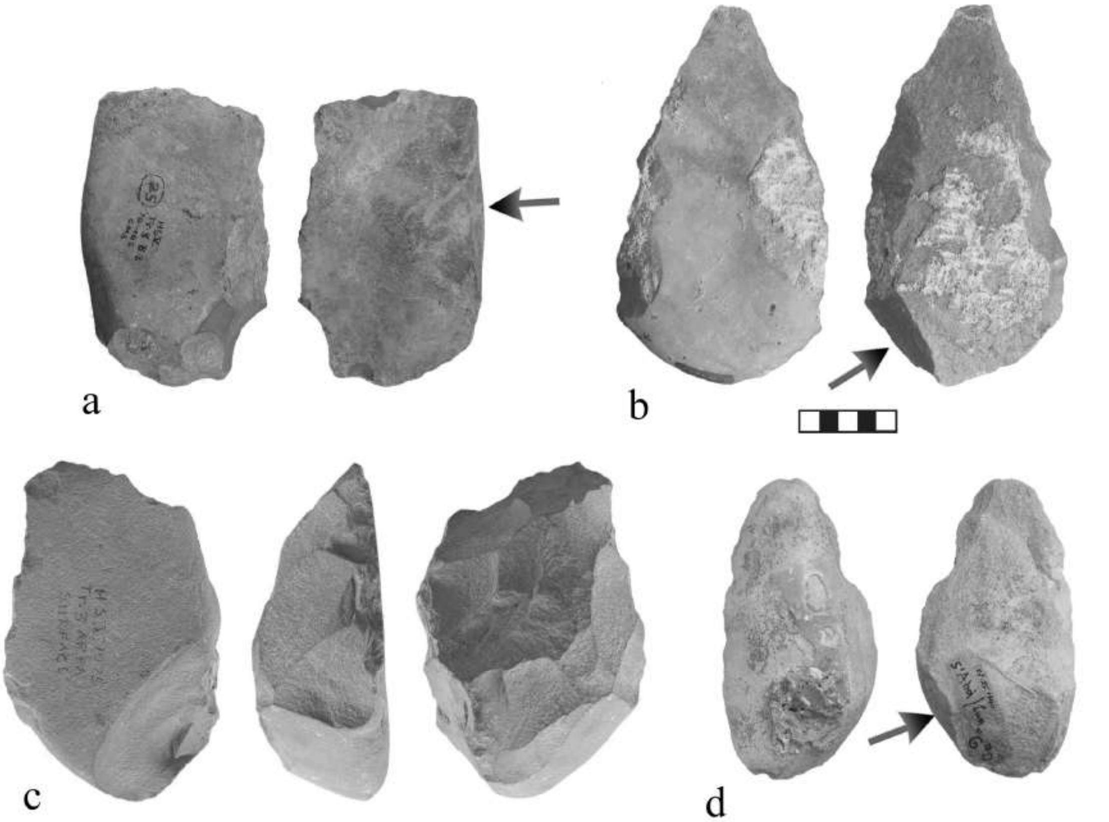

Figure 54. Tools on cortical (*entame*) flakes. a, c. Hunsgi, India. b. STIC, Morocco. d. Grotte des Ours, Morocco.

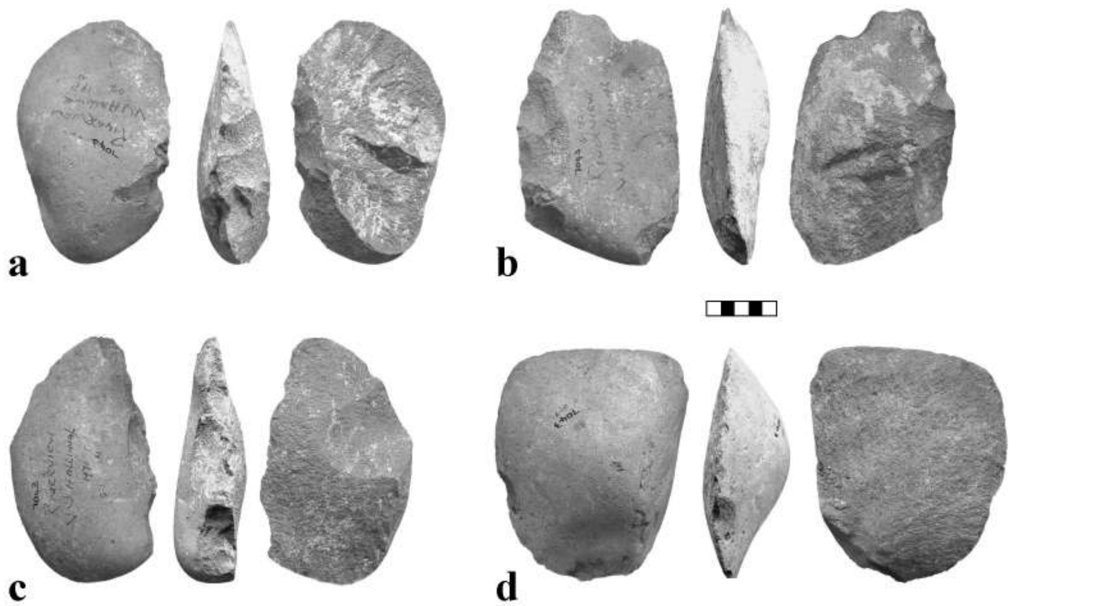

Figure 55. Flakes and LCTs on *éclat entame* (a, c) and cortical flakes (b, d) from Riverview Estate.

Kombewa Core Method

The Kombewa core method, named after four workshop sites in Kenya, facilitated the detachment of a flake from the ventral face of a larger flake in one blow, the pre-planned shape of the Kombewa flake comprising a long, sharp edge and two convex faces. Because Acheulian tools were reported in the vicinity of the Kombewa sites, the workshops were suggested to be of a similar age (Owen 1938). Texier and Roche (1992) perceived this method as representing the highest degree of predetermination to be found in Acheulian blank manufacture (together with the Levallois method; see below). According to Owen (1938), the method entailed the use of large (22.8 x 17.8 cm/ 9 x 7 inches), medium and small (no measurements were given) flakes as cores in order to create the dual-plane, plano-convex faces that typify the Kombewa flake (Fig. 56). The only modification applied to the large Kombewa core flakes was the preparation of a striking platform, which sometimes took a carefully rounded form. These striking platforms are observable on the resulting tools. As is often the case in workshop sites, only a few tools were found at the Kenya sites. Of these, 95% had typically Kombewa plain dorsal faces. Of the 120 cores in one of the assemblages, 102 demonstrated only one flake removal, 14 showed two removals and only three indicated three removals. All in all, the method seems to have been repeated consistently in the manufacture of a wide range of flake sizes intended for use as blanks for flake tools, although Owen noted that none were used as blanks for biface production.

Since Owen's publication, papers have been dedicated to the Kombewa method in predominantly North African assemblages (Alimen 1978; Balout, 1957; Dauvois 1981; Newcomer and Hivernel-Guerre 1974) and the method is now quite well understood. Use of the Kombewa technique has been reported in the Acheulian sites of Melka Kunture (Chavaillon and Piperno 2004), where the knappers of relatively small obsidian handaxes (mostly less than 10 cm in length) seem to have mastered this method (Chavaillon and Berthelet 2004). The importance of the Kombewa technique was also emphasized in connection with the assemblages of GBY (Goren-Inbar and Saragusti 1996; Goren-Inbar et al. 1991) and sites in Egypt (Haynes et al. 1997, 2001). Recently, Dag and Goren-Inbar (2001) have presented a summary of the different approaches to the "Kombewa issue". They demonstrated that dorsally plain flakes may serve as indicators of a variety of unintentional knapping procedures, and do not necessarily point to the Kombewa core method. Moreover, the presence of two striking platforms cannot serve as a categorical indication of a true Kombewa flake, whose main identifying characteristic is its intentional, predetermined nature, as expressed in the shape of its biconvex section. It was also suggested that it would be helpful to establish whether the flakes obtained were used as blanks for tools (Dag and Goren-Inbar 2001; Newcomer and Hivernel-Guerre 1974 for a discussion and references).

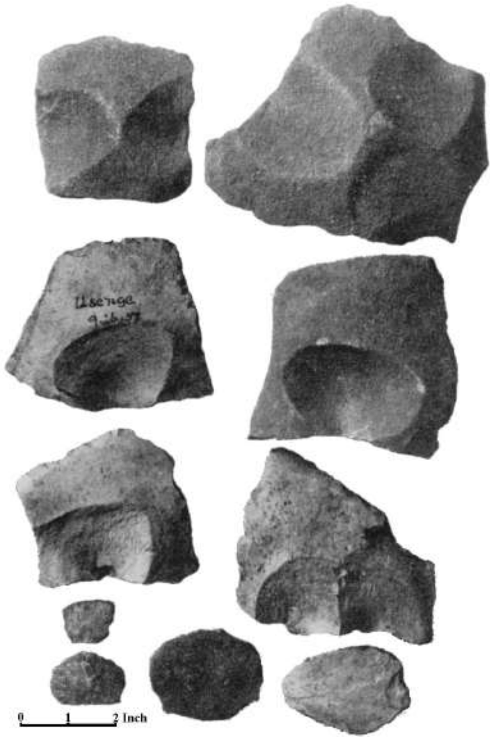

Figure 56. Kombewa cores and flakes (after Owen 1938; scale 2 inches).

Experimental knapping was used in an attempt to clarify this issue. As described above, core B-25 (Madsen and Goren-Inbar 2004) was knapped by the bifacial core method. The reduction sequence resulted in a total of 122 flakes larger than 2 cm, of which 27 were over 10 cm in maximal length, but none was identified as a Kombewa flake or showed a plain dorsal face. Eight of the flakes that were smaller than 10 cm were classified as having plain dorsal faces. In other words, plain dorsal small flakes quite often result from bifacial giant core knapping, but large Kombewa flakes are not to be expected, since their production was preplanned by knappers. In the present study, only large flakes and large cutting tools were examined. The criteria for definition of a Kombewa flake were the presence of two ventral faces and two identifiable striking platforms, one on each of the flake's faces (Fig. 57).

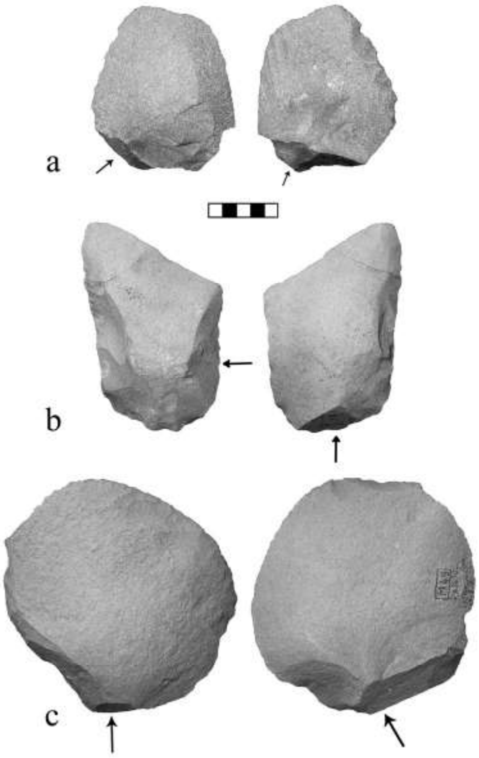

Figure 57. Kombewa flake tools from Ternifine.

Tables 15 and 16 present blank type frequencies in the assemblages under study. When two ventral faces were observed, but only one striking platform was present (in most cases due to the removal of the other striking platform by secondary retouch during the shaping of the tool), the term “Kombewa?” was applied.

Table 15. Frequency of blank types: handaxes.

	Flake		**Chunk**		**Indet.**		**Kombewa**		**Kombewa?**		**Probable Flake**		**Total**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
STIC	19	23	11	13	32	39			1	1	20	24	83	100
Ternifine	34	60	1	2	10	18	**1**	**2**	**1**	**2**	10	18	57	100
Grotte des Ours	25	31	9	11	37	46			1	1	9	11	81	100
Tachenghit	17	59	1	3	8	28					3	10	29	100
Hunsgi	23	52	5	11	5	11			2	5	9	20	44	100
Yediyapur VI	2	40			3	60							5	100
Chirki	14	35	8	20	12	30					6	15	40	100
Power’s Site	6	12	2	4	37	74			2	4	3	6	50	100
Pniel 6a	6	15	3	7	24	59					8	20	41	100
Riverview	21	45	5	11	15	32					6	13	47	100
Pniel 7b	12	30	2	5	23	58					3	8	40	100
Doornlaagte	8	47			5	29			1	6	3	18	17	100
Isimila K6	43	23	6	3	82	45			1	1	52	28	184	100
Isimila K14	11	44	1	4	7	28					6	24	25	100
Isimila K19	13	54	1	4	6	25					4	17	24	100
GBY NBA	41	25	15	9	74	45			5	3	29	18	164	100
Ma‘ayan Barukh	11	9	21	17	93	74							125	100
GBY Layer II-6	222	69	4	1	88	27			10	3			324	100
GBY Area C	6	60			4	40							10	100

Table 16. Frequency of blank types: cleavers.

	Flake		Chunk		Indet.		Kombewa		Kombewa?		Probable Flake		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
STIC	4	80									1	20	5	100
Ternifine	22	47					**7**	**15**	**15**	**32**	3	6	47	100
Grotte des Ours	3	30			4	40					3	30	10	100
Tachenghit	13	81							3	19			16	100
Sidi Zin	8	89									1	11	9	100
Hunsgi	37	76	1	2					7	14	4	8	49	100
Yediyapur VI	10	83									2	17	12	100
Chirki	34	71			3	6			3	6	8	17	48	100
Power's Site	87	74			6	5	2	2	12	10	11	9	118	100
Pniel 6a	74	73			2	2	1	1	14	14	11	11	102	100
Riverview	68	89	1	1	1	1			3	4	3	4	76	100
Pniel 7b	83	85			5	5	1	1	6	6	3	3	98	100
Doornlaagte	9	64			1	7			1	7	3	21	14	100
Isimila K6	23	82			3	11					2	7	28	100
Isimila K14	47	85			3	5			1	2	4	7	55	100
Isimila K19	35	88			1	3			3	8	1	3	40	100
GBY NBA	74	76			2	2	1	1	8	8	13	13	98	100
GBY Layer II-6	104	76			6	4	**10**	**7**	**16**	**12**			136	100
GBY Area C	13	81			1	6			2	13			16	100

Although Kombewa blanks were used for the production of bifaces in many of the sites under study, they are rare. One might add the site of Isenya (Roche and Texier 1995; Texier and Roche 1992), where only 1.8% of the handaxes and 3% of the cleavers were made on Kombewa flakes, to those listed in the above tables. Exception to these low frequencies are found in the sites of GBY and Ternifine. Kombewa flakes are much more frequent at GBY than in any other site (Goren-Inbar and Saragusti 1996). At Ternifine, seven cleavers and one handaxe were identified as Kombewa flakes. These data are in agreement with those presented by Tixier (Balout et al. 1967, 235), who identified 10 cleavers (9% of the cleavers) as type 6 (Kombewa) cleavers. Tixier (quoted in Balout 1967) suggested that there were two different Kombewa methods based on the use of large flat cobbles as a raw material block (Fig. 58). At Ternifine, the Kombewa flakes were detached in the second stage of manufacture after an *entame* flake had initially been removed from a flat cobble core (see "cobble opening flake" above), thus explaining the high frequency of Kombewa flakes at Ternifine. The evidence from Ternifine supports Owen's observation that Kombewa flakes were mostly used for the production of large scrapers rather than LCTs. The large scrapers on Kombewa flakes from Ternifine will be discussed in some detail in Chapter 6. Also noteworthy is the relatively high number of handaxes with plain dorsal faces that lack two distinct striking platforms (identified here as "Kombewa?") in the South African Vaal River sites. It seems that Kombewa flakes were most often used for the production of cleavers rather than handaxes, but our sample size is too small to facilitate further discussion.

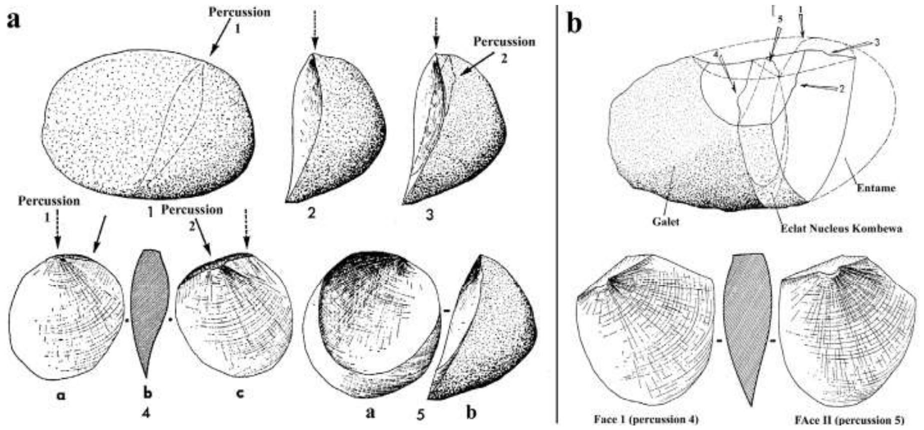

Figure 58. Kombewa method types I (a) and II (b) (after Tixier as quoted in Balout 1967).

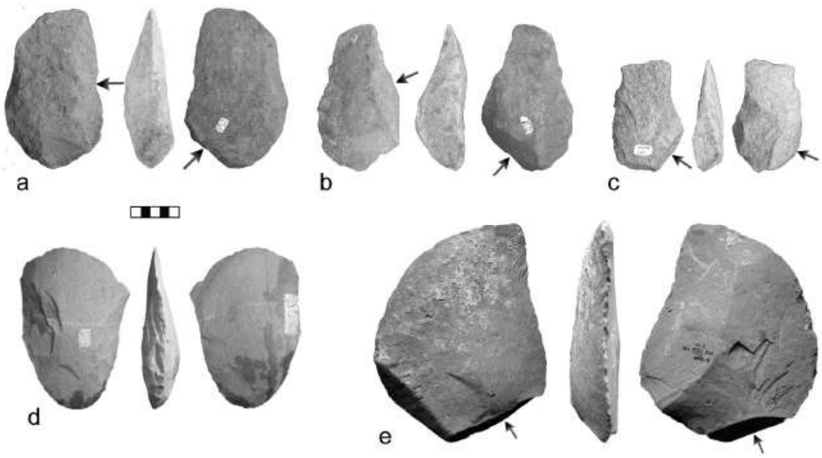

Figure 59. LCTs on Kombewa blanks. a. GBY NBA. b, c. GBY Main Site. d. Tachenghit. e. Pniel 7b. Arrows indicate blow direction.

Victoria West Core Method

F. J. Jansen (1926) first described cores belonging to this tradition in the region of the town of Victoria West, South Africa. Goodwin (1929, 1934, 1953) and van Riet Lowe (Söhnge et al. 1937; van Riet Lowe 1929, 1945) subsequently elaborated upon this core method. According to them, Victoria West cores are medium-sized cores (150–250 mm in maximal dimension) from which a single, large side-struck flake was removed (Fig. 60:b) for the purpose of Acheulian LCT blank production in many central South African sites (Goodwin 1929; Kuman 2001). Goodwin described the production of large flake blanks by this core technique as follows:

> "Briefly, a great, heavy unbalanced coup-de-poing was made. It was about ten inches long and of suitable width and thickness. It was made far thicker than the usual coup-

de-poing and only the one face was prepared with any real care. Virtually only stage 1 and 2 of the Abbeville technique were employed. Finally, using the flake scars of stage 1 as an appropriate striking-platform, a single blow was struck in such a way as to remove almost all of the prepared face of the stone. The core was discarded. The flake was now trimmed by a series of 'stepped' or 'resolved' flakes" (Goodwin 1953, 53).

Both Jansen (1926) and Goodwin (1934) identified three basic types of Victoria West cores: the "uncinate" or "hoenderbek" (fowl beak), the "horse-hoof" and the "high-backed" (Fig. 60:a). The high-backed type was distinguished by the steep nature of what would today be called the striking platform surface (Boëda 1995). However, as noted by Goodwin (1929, 55–56), all Victoria West types may include examples of high or low backing. The hoenderbek type, with one pointed end, was considered by Goodwin (1934) to be the earliest Victoria West form. In subsequent publications (Söhnge et al. 1937; van Riet Lowe 1945) it was referred to as VW I, while the seemingly later type, with a horse-hoof circular-plan form, was termed VW II (Sharon and Beaumont 2006). All of the above notwithstanding, a comprehensive overview of the Victoria West technology and its products has never been presented, in part because Acheulian sites that contain Victoria West tools and cores have never been extensively excavated or published (Chapter 3). The presence of similar techniques has been asserted for the sites of many regions, including India (Corvinus 1983b; see also Pappu and Akhilesh 2006 for references), Northwest Africa (Biberson 1961; Clark 1992) and the Sahara (Alimen 1978). Nevertheless, since a clear definition for the Victoria West technology has not been available, it has been difficult to verify these claims.

Below is a summary of several observations on the Victoria West Acheulian technological phenomenon, some of which have been published elsewhere (Sharon and Beaumont 2006). Most of the Victoria West cores discussed in this study are of type I and were collected at the site of Canteen Koppie, whose rich Stratum 2a lithic assemblage has been interpreted as representing the remnants of an Acheulian biface workshop (Beaumont 1990a; Beaumont and McNabb 2001; McNabb 2001). Victoria West type I cores are uniform in size and morphology, as demonstrated in Table 17 and Fig. 61. All of the cores in the sample are made of relatively fine-grained andesite, the raw material most common in the majority of Acheulian sites in the lower Vaal River Basin.

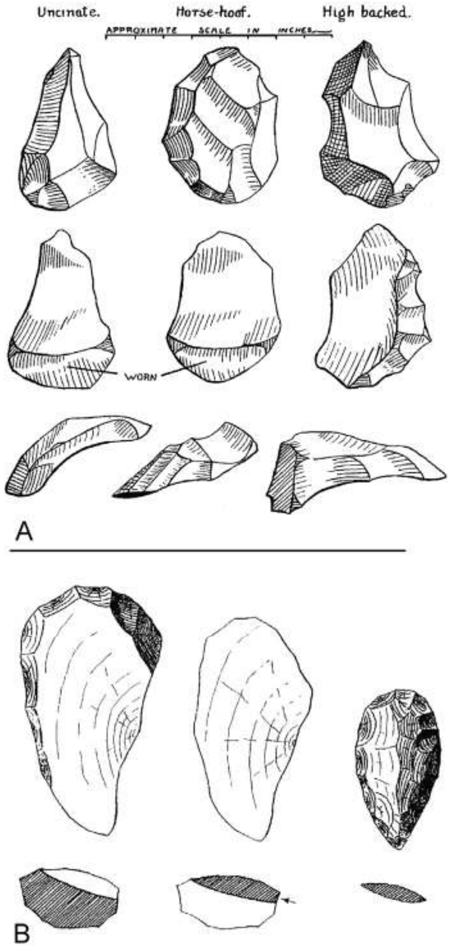

Figure 60. Victoria West cores. a. Typology (after Goodwin 1934). b. Technology (after Söhnge et al. 1937).

Table 17. Metrical data for Victoria West cores by site.

Site		**Weight**	**Max. Length**	**Max. Width**	**Max Thickness**	**Circum.**	**Number of Scars 1**	**Number of Scars 2**	**Blank Scar Length**	**Blank Scar Width**
Riverview	Mean	733	158	91	47	402	22	32	75	105
	N	1	1	1	1	1	1	1	1	1
	S.D.	.	.	.	.	.	.	.	.	.
	Minimal	733	158	91	47	402	22	32	75	105
	Maximal	733	158	91	47	402	22	32	75	105
Doornlaagte	Mean	1693	163	121	85	477	12	14	104	121
	N	4	4	4	4	4	4	4	3	3
	S.D.	1041	17	20	45	39	5	2	33	17
	Minimal	971	143	92	53	452	7	11	67	106
	Maximal	3195	183	138	150	535	17	16	130	139
Canteen Koppie	Mean	1430	176	111	82	460	14	25	85	133
	N	15	15	15	15	15	15	15	14	14
	S.D.	372	18	10	16	39	6	5	14	18
	Minimal	975	151	90	58	404	7	17	56	86
	Maximal	2394	225	133	106	569	32	37	117	153

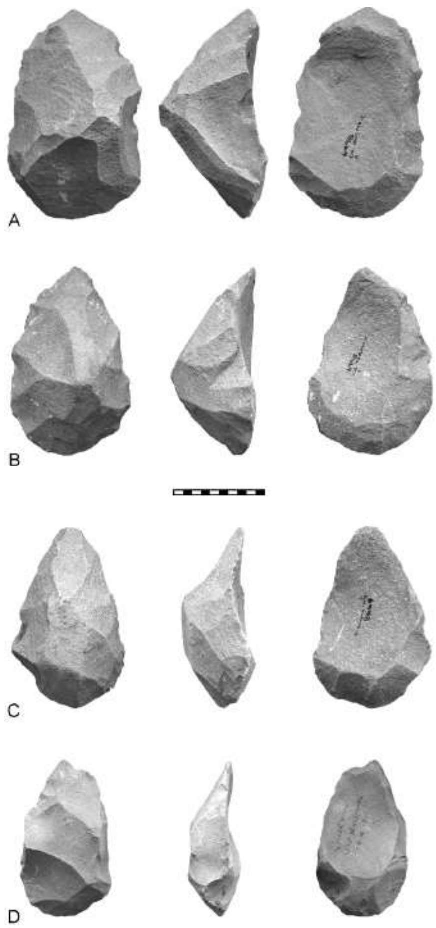

Figure 61. Victoria West Type I cores. a–c. Canteen Koppie. d. Riverview Estate (after Sharon and Beaumont 2006).

Core/Preform Preparation

The preparation of the Victoria West Type I core was highly sophisticated and a great deal of work was invested in the process. The terminology of the Levallois volumetric approach is applicable to both faces of the core in this method. Boëda (1995) defined these surfaces as the debitage (or flaking) surface and the preparation of striking platform surface. The two faces are markedly asymmetrical, creating the typical section of the Victoria West core (Fig. 61). The scar pattern on the debitage face exemplifies the vast knowledge and energy evident in the preparation of Victoria West cores. A carefully planned radial scar pattern was achieved through the removal of well-spaced, well-arranged, shallow and thin flakes, the number of scars in Canteen Koppie averaging 14.2 (Table 17). This typical pattern can be seen on all cores and on the dorsal face of some of the cleavers that were removed from Victoria West cores. The mean total number of scars per core is very high in comparison to other Acheulian large flake blank production core types (Fig. 35). It should also be noted that other types of cores from Canteen Koppie have a mean number of only 6 scars (McNabb 2001).

A few Victoria West cores from which the final removal of the large flake blank was never carried out have been identified. Fig. 63 presents three unstruck Victoria West cores whose size and shape are similar to those of struck cores (Table 18; compare with Table 17).

One of the Canteen Koppie cores is of particular interest. A medium flake scar visible on the debitage surface of the core (Fig. 63:a; arrows indicate blow direction) constitutes clear evidence of an unsuccessful large flake removal attempt. The cross-section view of this core shows two Victoria West asymmetrical, convex surfaces that distinguish it from rough picks, although similar crude forms were considered to be picks at the site of Doornlaagte (102 such tools were reported, versus a mere 89 handaxes and no cleavers: Mason 1988, 625). An alternative view can now be suggested, interpreting these artifacts as unstruck Victoria West cores (Fig. 64).

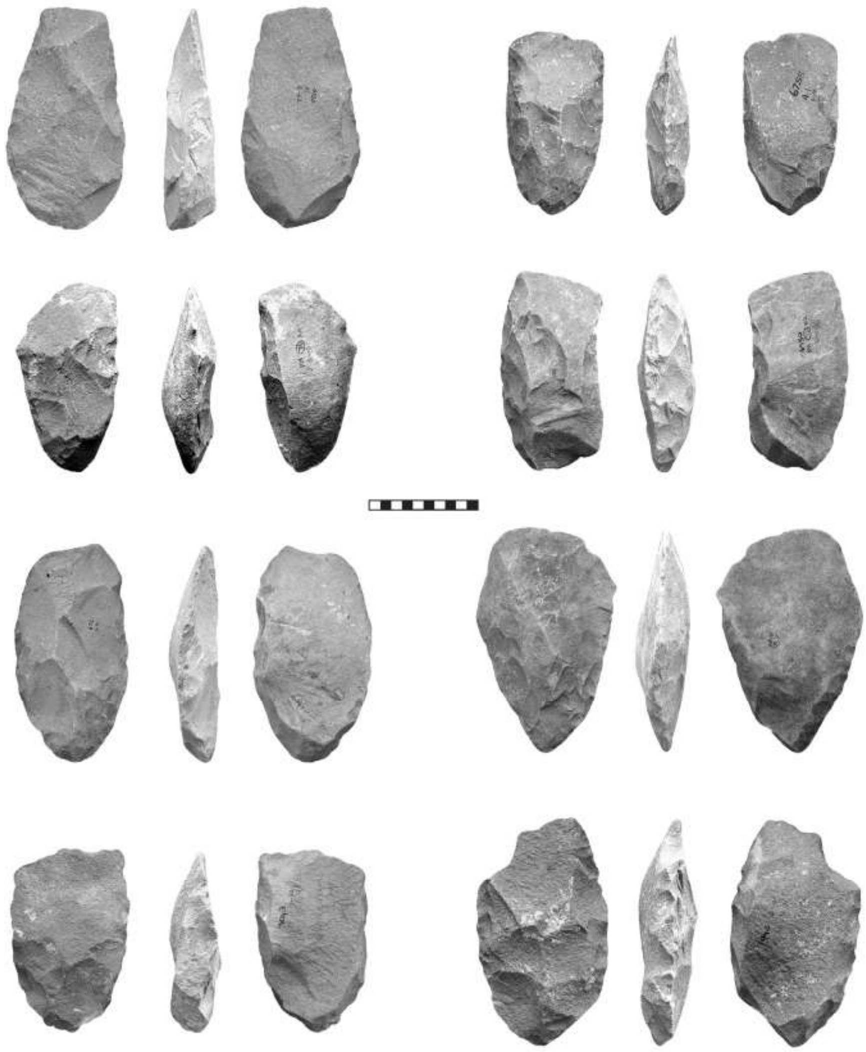

Figure 62. Victoria West cleavers from the Vaal River Acheulian sites (after Sharon and Beaumont 2006, Fig. 4).

Table 18. Metrical data for Victoria West preforms by site.

Site		Weight	Max. Length	Max. Width	Max. Thickness	Circum.	Number of Scars Face 1	Number of Scars Face 2
Riverview	Mean	1390	204	107	62	512	19	19
	N	4	4	4	4	4	4	4
	S.D.	327	7	9	12	34	9	7
	Minimal	947	194	95	46	488	9	13
	Maximal	1708	210	113	76	563	28	25
Doornlaagte	Mean	1250	197	108	67	493	16	17
	N	7	7	7	7	7	7	7
	S.D.	283	10	10	8	27	5	7
	Minimal	983	177	96	53	465	9	8
	Maximal	1732	209	121	75	535	24	27
Canteen Koppie	Mean	1236	170	113	95	447	16	15
	N	1	1	1	1	1	1	1
	S.D.	.	.	.	.	.	.	.
	Minimal	1236	170	113	95	447	16	15
	Maximal	1236	170	113	95	447	16	15

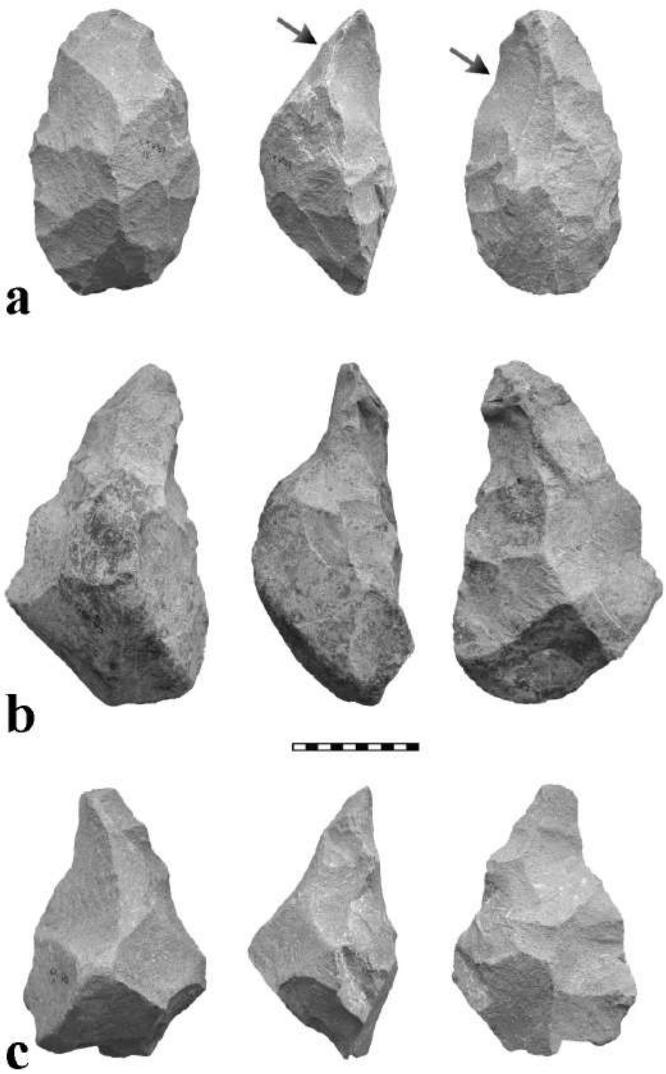

Figure 63. Unstruck Victoria West Cores from Canteen Koppie (after Sharon and Beaumont 2006, Fig. 5).

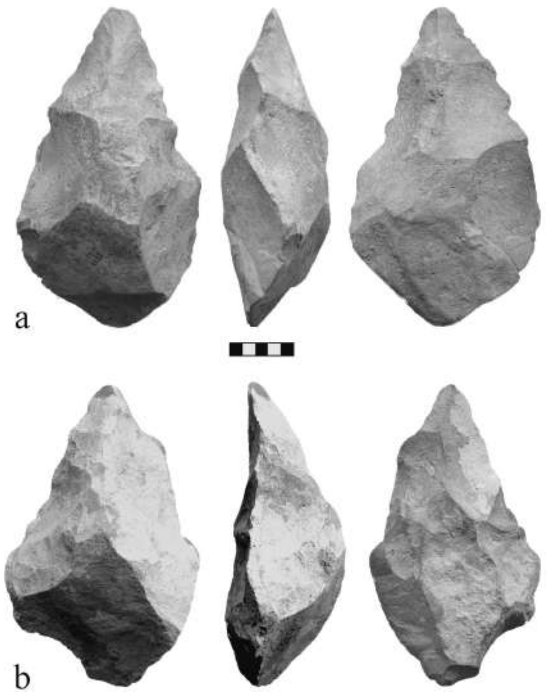

Figure 64. Unstruck Victoria West cores/preforms from Doornlaagte.

The special morphology of some of the Victoria West cores can explain the intriguing presence of numerous blades in some South African Acheulian assemblages. The Victoria West reduction sequence sometimes resulted in a core that was almost pyramidal in shape (Fig. 65), the flakes deriving from it having the proportions of blades. These were byproducts that could have been used as tools.

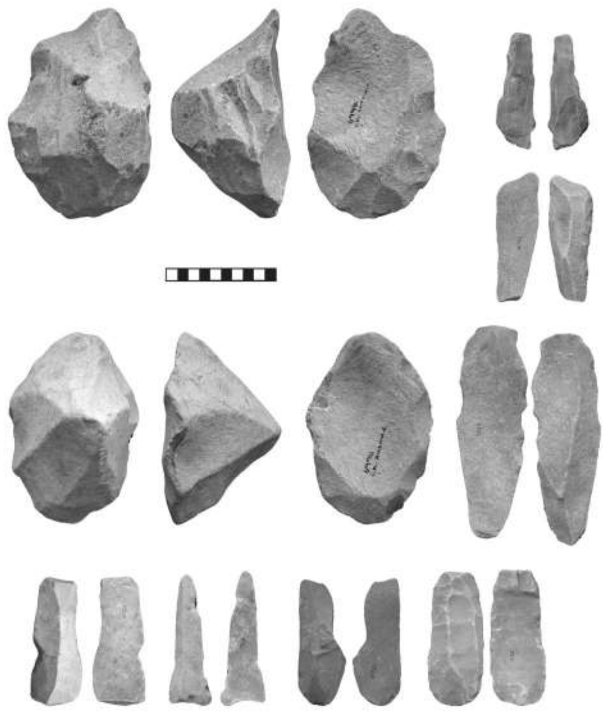

Figure 65. Victoria West pyramidal cores and Acheulian blades from the Vaal River sites.

Removal of a Cleaver Flake from a Victoria West Core

The uniformity that was exercised in Victoria West core preparation continued into biface flake blank extraction. All of the cores in the assemblage under study were struck from an identical point on the same face of the preform. They were struck at a similar distance from the preform edge and **from the same direction** (Fig. 61). The distribution of cleaver blow direction in the different Vaal River Acheulian assemblages is presented in Fig. 66.

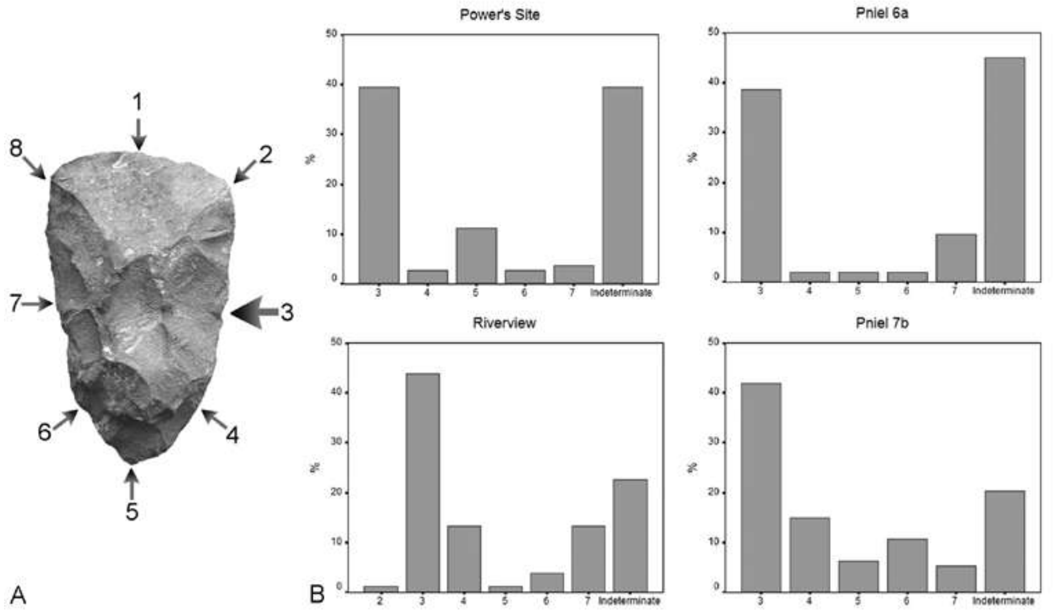

Figure 66. Vaal River cleaver blow direction by site (after Sharon and Beaumont 2006).

A very large majority of the cleavers was struck from the left (direction 3), which is the direction to be expected in view of the blow direction observed on the Victoria West sample cores. The results are even more striking, given that not all cleavers in the assemblage are necessarily the product of Victoria West cores. Blow direction 3 also appears very frequently on handaxes, but less so than on cleavers.

Predetermination of a Victoria West Flake Blank

The morphology of a Victoria West blank was predetermined both by the morphology of its core and by the location of the blow on the core. During flake removal, the preform (core), shaped in the form of a rough biface, was held with the tip pointing toward the knapper and the striking platform preparation surface facing up. When removed, the large flake carried with it the tip of the bifacially designed preform (Fig. 68). This tip became the characteristic steep pointed butt of many of the Vaal River cleavers and handaxes, which bears scars on both sides. On cleavers, the Victoria West origin is evident in a typical scar pattern on the ventral face of the cleaver butt (Fig. 67). In cleavers a–d of Figure 67, the entire tip of the original core was removed with the flake, thus formulating the butt of the finished cleaver. In cleavers e and f, the detached blank has removed only a part of the core's tip, and the cleaver's proximal end bears scar remnants on only one side of its butt.

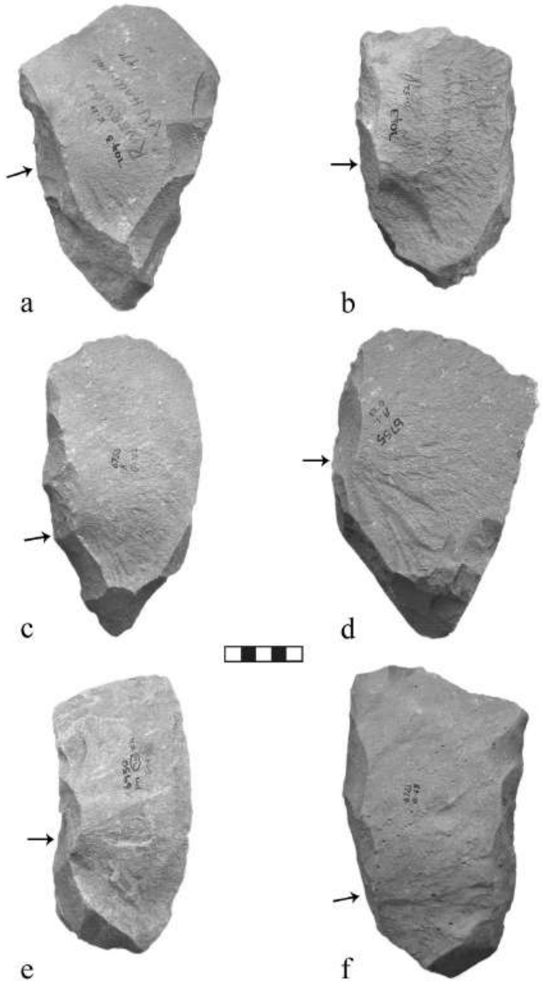

Figure 67. Typical Victoria West ventral faces on Vaal River cleavers. a–b. Riverview Estate. c–d. Pniel 6a. e. Pniel 7b. f. Power's Site. Arrows indicate blow point and direction. Note the typical remnants of the core's tip on the steep pointed butt.

Fig. 68 illustrates this unique reduction practice, the core in the figure originating in Canteen Koppie and the cleaver in Pniel 6a. When the procedure was successful, the detached flake was larger than the scar that was left on the core. In this sense, the drawings and descriptions of the Victoria West technique by Goodwin and other pioneer researchers (Goodwin 1929; Söhnge et al. 1937; van Riet Lowe 1945) are inadvertently misleading (Fig. 60:B), particularly with regard to the size of the finished biface. The blank is shown as similar in size to the scar remaining on the core, without taking into consideration the facts that the tip of the preform was removed together with the blank, and that the blank could have been much larger than the scar remaining on the core (Fig. 61). Up to now, there seemed to be a contradiction between the relatively small size of the Victoria West type I cores and their final scar (Table 17) and the actual size of the Vaal River Acheulian LCTs. This problem can now be resolved. While the average scar's maximal width was 132.5 mm, the actual flakes/blanks removed by this method were well within the size range of those used to produce the typical Vaal River Acheulian cleaver.

It is hard to determinate the frequency in which Victoria West blanks were used for the production of bifaces at the Vaal River sites, as opposed to other blank types. The use of this core method can usually be detected through the following typically morphological features of the tools:

a. A ventral face bearing the remnants of the original core's tip.

b. A pointed steep butt representing the tip of the bifacial core, from which the blank flake was struck.

c. A striking platform that has resulted from a blow applied directly onto the bifacially knapped face of the core.

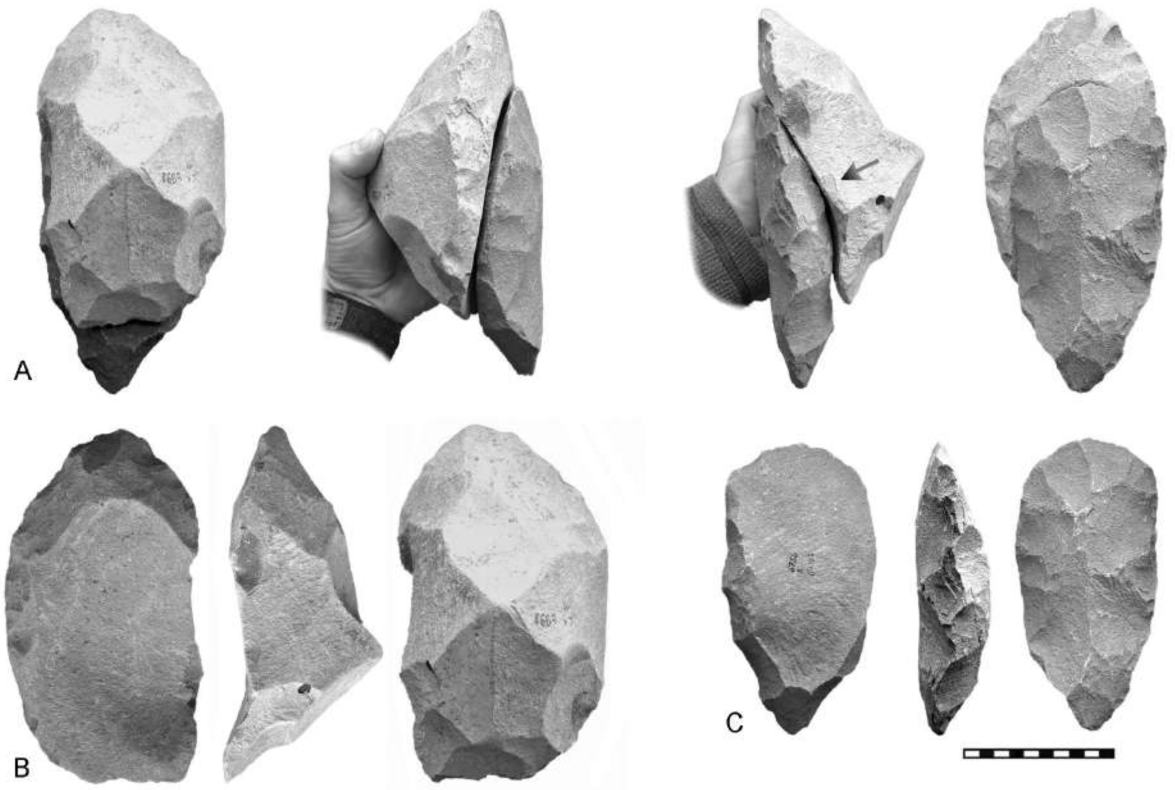

Figure 68. a. Refitting of Victoria West Type I. b. Core from Canteen Koppie. c. Cleaver from Pniel 6. After Sharon and Beaumont 2006; arrow indicates point of percussion.

Sometimes, due to extensive secondary retouch of the tool, one or more of these attributes is absent from a Victoria West biface, rendering it impossible to identify. It should also be noted that we are describing tool samples from surface collections. In order to get some sense of the quantity of Victoria West blanks that were used at the Vaal River sites, I divided the blanks into "Victoria West" blanks and "other" blanks. The results are presented in Table 19.

Table 19. Frequency of LCT blank types at the Vaal River Acheulian sites (raw counts).

Site	**Victoria West**			**Other**		
	Cleavers	Handaxes	Total	Cleavers	Handaxes	total
Pniel 7b	63	10	73	20	41	61
Riverview	46	15	61	17	43	60
Pniel 6a	72	7	79	18	42	67
Power's Site	89	6	95	25	44	69

Surprisingly, the frequencies are similar in all of the assemblages. It is clear that Victoria West blanks were preferred for the production of cleavers. It should be noted that scars cover the handaxes more extensively than they do the cleavers, possibly masking the blank type used for handaxe production. Nevertheless, it can be suggested that the main reason for the low number of handaxes produced on Victoria West blanks is because the method was designed to produce a wide, sharp distal cutting edge morphologically suited to cleavers, rather than a pointed handaxe tip.

Distal Dorsal Edge of Victoria West Cleavers

McNabb (2001, 43) observed that the cutting edge (or "blade", to use his terminology) of most Vaal River cleavers was formed by the joint of the ventral face with one large scar (Fig. 62) or, less frequently, with a natural (cortical) surface of the dorsal face. One would expect, however, that the distal dorsal edge of cleavers manufactured from Victoria West Type I cores would display several relatively small radial patterned scars, resembling a mirror image of the scar pattern that is observable on the parent Victoria West Type I core (Fig. 68). One possible explanation for this discrepancy might lie in the fact that many of the Vaal River cleaver blanks that show a single large scar on the distal dorsal face did not originate in Victoria West type I cores, but rather in other Victoria West core types. At Riverview Estates, for example, van Riet Lowe (1935, 54) described an Acheulian workshop containing large Victoria West cores:

> "Several cores are normal in size, that is, up to about 9 in. (22.3 cm) in length, but others are more than 15 in. (38.1 cm) long by 8–10 in. (20.3–25.4 cm) broad and deep

and up to 150 lb. (68 kg) in weight. Twelve-inch flakes were struck from these great cores – cores frequently trimmed in typical Victoria West fashion before the flakes were removed".

Many of the cleaver and handaxe blanks at the Vaal River Acheulian sites may have come from such large and less formal Victoria West cores (Fig. 69). The LCT blanks detached from these other Victoria West core types would probably bear a smaller number of larger scars on the distal end of their dorsal face. This is indeed the pattern that is seen on many of the Vaal River cleavers (Fig. 70).

In addition, other core methods were used at the Vaal River Acheulian sites. These methods included blank production from boulder cores, as first recorded by van Riet Lowe (Söhnge et al. 1937), from proto-Levallois cores (McNabb 2001), and even Kombewa cores (personal observation, GS; Fig. 70:e). Nevertheless, the type of the striking platform, the typical shape of the biface butt and the scar pattern on the ventral face of the cleaver all strongly suggest that the great majority of the LCTs at the Vaal River Acheulian sites was made from flakes that derived from the various Victoria West core types.

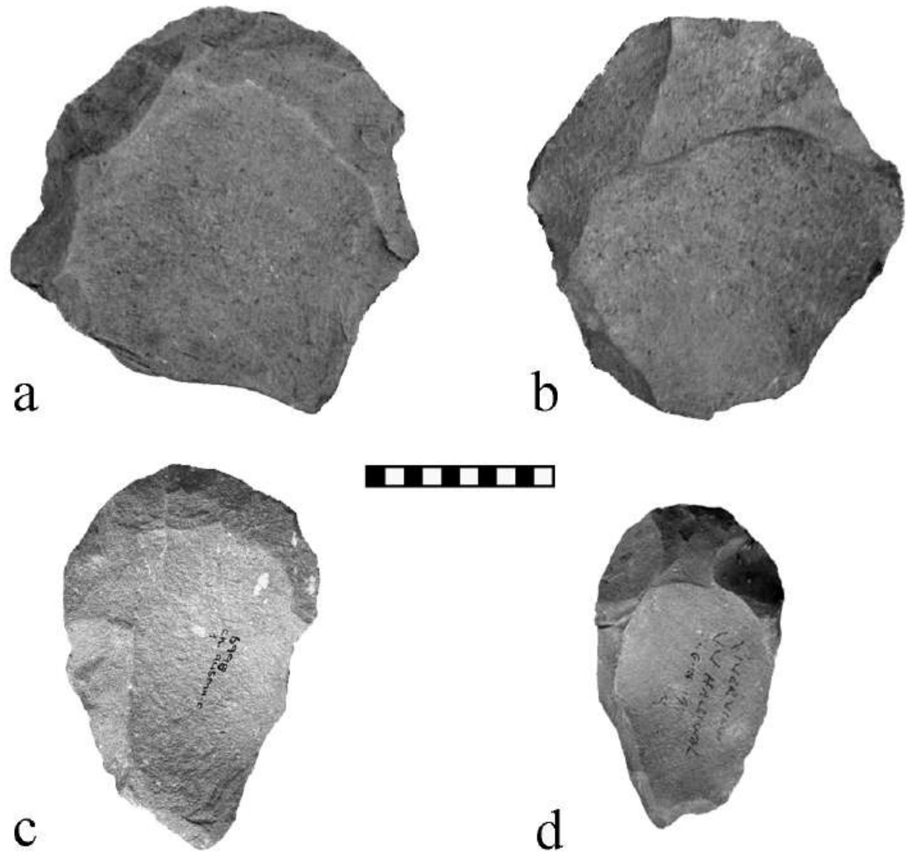

Figure 69. Large and small (Type I) Victoria West cores from the Vaal River (collections of the McGregor Museum).

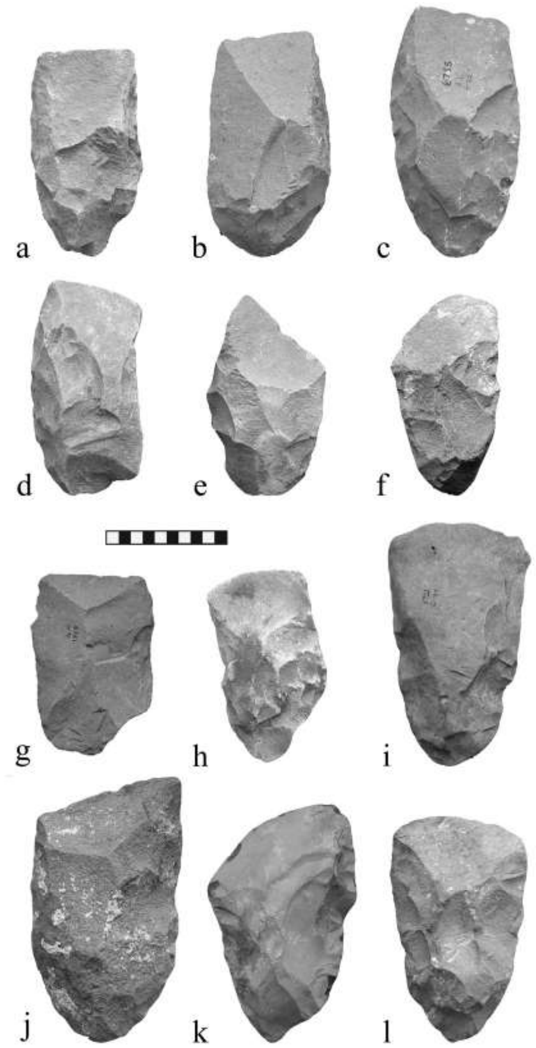

Figure 70. Dorsal distal scar on Vaal River cleavers. a–c. Pniel 6a. d–f. Pniel 7b. g–i. Power's Site. k–l. Riverview Estate.

Dominance of Cleavers

The analysis presented here has demonstrated that the Victoria West core reduction sequence was actually intended for the production of large flakes that were considered suitable as blanks for **cleavers**. This is also evident from the marked presence of cleavers in most of the Vaal River assemblages and the high frequency of typically Victoria West features (striking platforms, shape of butt and direction of blow) on them. Handaxes were also made from Victoria West blanks, though to a lesser degree (Table 19). Although all of the assemblages under study came from surface collection, the dominance of cleavers is notable in all Vaal River Acheulian sites. As a test case, all of the McGregor Museum LCTs collected at Power's Site (Pniel 1) were typologically defined and counted. Of 347 LCTs, 271 (78%) are cleavers and only 76 (22%) are handaxes. The dominance of cleavers reflected in the Vaal River assemblages is not a common phenomenon among Acheulian industries worldwide (Ranov 2001; see, however, Roche et al. 1988 for similar type frequencies at Isenya). Other potential end-products that could have been produced by the Victoria West reduction sequence, e.g. "Victoria West knives" (McNabb 2001), were not observed in the Vaal River collections that were examined for this study. The dominance of cleavers and the extensive use of a core method designed for cleaver blank production at the Vaal River Acheulian sites cannot as yet be fully explained. There may have been a particular utilitarian demand for these LCTs, or alternatively the innovation of the highly controlled Victoria West technology may have prompted knappers to produce more efficient, preplanned cleaver blanks.

Tabelbala-Tachenghit Core Method

This unique core method is the most similar to the Victoria West technique and will be discussed briefly here, due to the small sample size that was available to the present research. The method was first defined by the Abbé Breuil (1930) and later described in detail by Tixier (1957), Champaulte (1951, 1956, 1966) and Alimen (1978). On the basis of Saharan geological formation correlations, the method was ascribed to the Middle Acheulian (Alimen 1978; Clark 1992). Of the small sample of Tachenghit cleavers that was studied here, only a few were identified with certainty as deriving from the Tabelbala-Tachenghit core method (Fig. 71:a–d), while other cleavers in the sample display only partial Tabelbala-Tachenghit morphological attributes (Fig. 71:e). A small sample of cores was analyzed, and some of these are probably Tabelbala-Tachenghit cores.

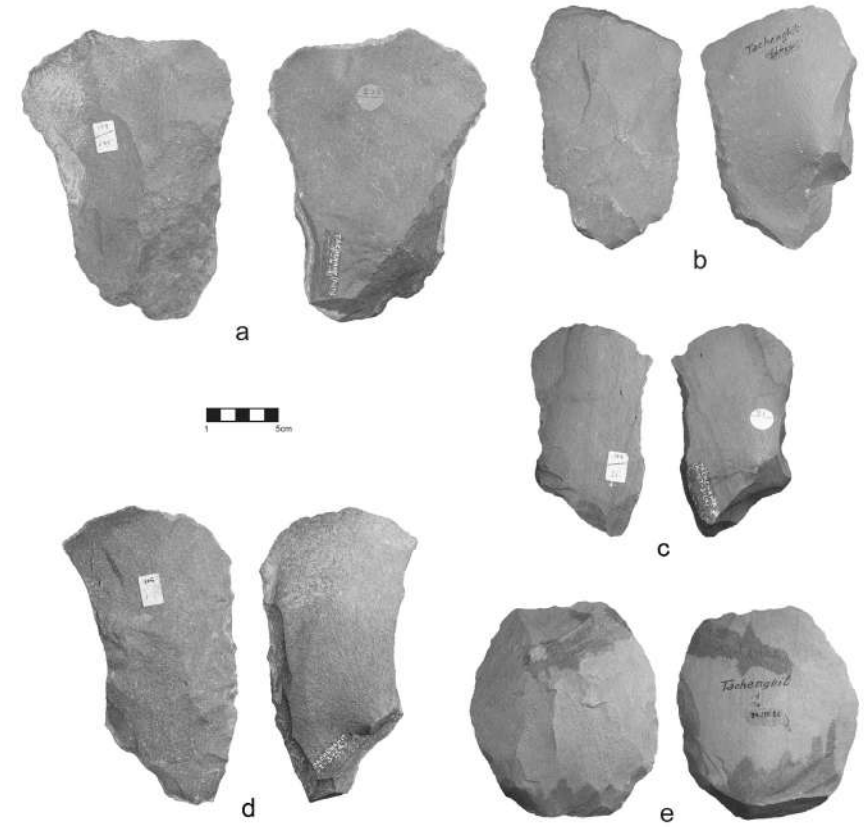

Figure 71. Tabelbala-Tachenghit cleavers (collections of the Musée de l'Homme, Paris).

Of several alternative descriptions for the Tabelbala-Tachenghit method that have been suggested in the literature, Tixier's (1957) reconstruction is the most frequently quoted (Fig. 72).

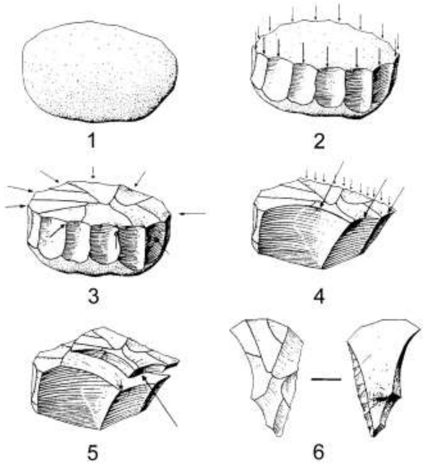

Figure 72. Tixier's (1957) reconstruction of theTabelbala-Tachenghit core method.

Alimen (1978, 133–135, Fig. 39) claimed that Tachenghit cleavers (type 4) could have been produced by two core methods, the Levallois (type 4a) and the Kombewa (type 4b). In her description of the Levallois Tachenghit cleaver (type 4a), she pointed out that the important stage of striking platform preparation can be observed on the tools (Fig. 73: removals 1, 2 and 3 on C1 and C'2).

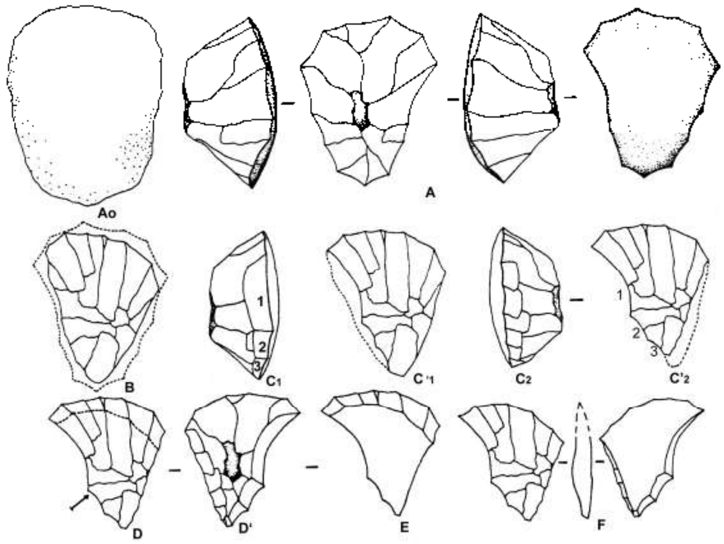

Figure 73. Alimen's (1978) reconstruction of theTabelbala-Tachenghit core method.

In light of the analysis of the Victoria West method presented above, an additional reconstruction may now be suggested for the Tabelbala-Tachenghit method. Fig. 74 presents three of the larger cores from the Tachenghit sites that were analyzed for this study. Cores b and c demonstrate the removal of a single large flake from the debitage face, which was totally covered in scar removals, very much like the Victoria West type I technique.

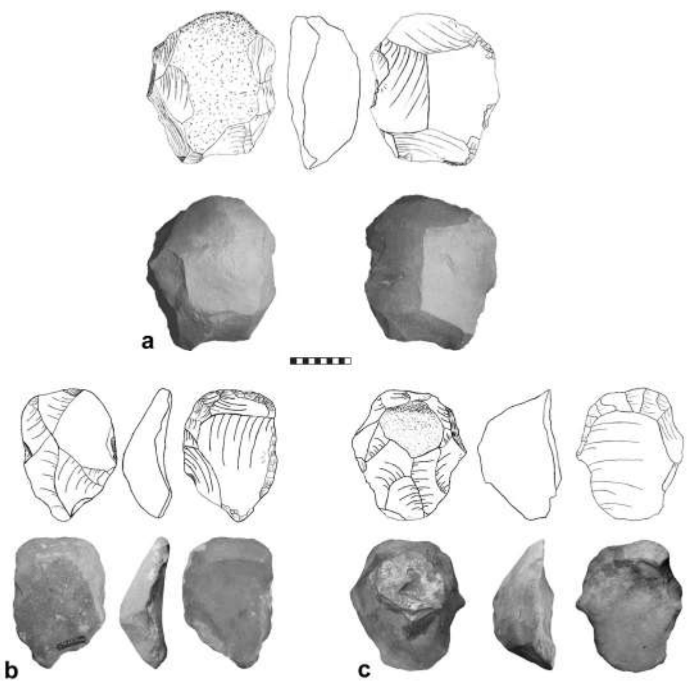

Figure 74. Three large cores from Tabelbala-Tachenghit area (drawings by G. Sharon).

The Tabelbala-Tachenghit core method is also observable on smaller cores, like the two presented in Fig. 75. Note that core b is shaped on a flake. Had they been found in a different context, these cores would probably have been classified as Levallois cores for a preferential flake, and this is indeed the terminology used by Alimen in her description of many of the Saharan cores (Alimen 1978). Nevertheless, it would seem that in the context of the Tachenghit Acheulian sites, one may safely argue that they resemble the larger Tabelbala-Tachenghit cores, which were designed for LCT blank production.

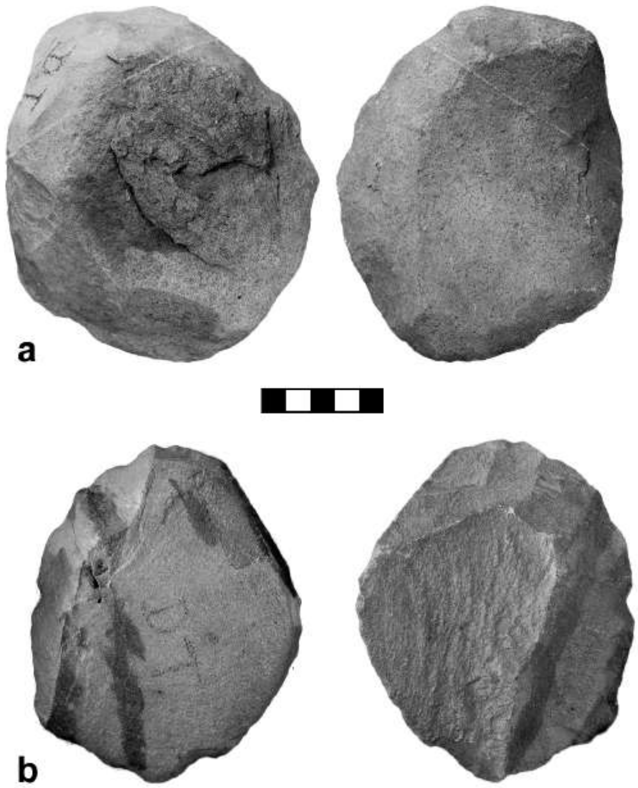

Figure 75. Small Tabelbala-Tachenghit cores from Tachenghit. Note that core b is produced on a large flake.

The Victoria West and the Tabelbala-Tachenghit core methods share many technological features:

- The removal of a single cleaver flake from a relatively small core.
- The preparation of two asymmetrical faces for the core.
- The removal of the tip of the core during the detachment of the flake.
- A high degree of preplanning many stages ahead.
- Uniformity in the direction of the blows that were intended to remove the blank.

One fundamental difference between these core methods is that the Tabelbala-Tachenghit flake striking platforms seem to be more carefully prepared and isolated from the surface, possibly in an attempt to ensure the accuracy of the blow. They are usually plain and a large incipient cone is visible (Fig. 71). On the Victoria West cleavers, the striking platform shows remnants of the bifacially knapped surface of the core (see further discussion below). Like the Victoria West method, it seems that the Tabelbala-Tachenghit method was restricted in area, in this case to the small region of the northwestern Sahara. Even within this area, tools that were made by this method seem to be limited. Consequently, it was probably a local invention which, given the huge geographical gap between this region and the Vaal River sites, had no connection with the Victoria West technology. This is the best example of which I am aware of the simultaneous innovation of a similar technological solution to a functional need.

The Levallois Core Method and Acheulian Giant Cores

Many scholars use the term "Levallois", originally coined for the description of Middle Paleolithic core technology, to describe Acheulian giant core technology. Frequent synonyms are "prepared core" and the less well-defined term "proto-Levallois" (Tryon 2003, 26), which is frequently employed to describe all prepared large cores in the Acheulian (Clark 2001b; Rolland 1995). Van Riet Lowe (1945) described Levallois giant cores from South Africa, Alimen (1978 and references therein) summarized the presence of this method in the Sahara, and Rolland (1995) has provided an overview of the technique in the Lower Paleolithic. The presence of the Levallois core method in small to medium core production of flake tools is well established in Acheulian study (Biberson 1961; Dibble and Bar-Yosef 1995; van Riet Lowe 1945; White and Ashton 2003). The connection between LCT knapping and Levallois flake production has also been noted (DeBono and Goren-Inbar 2001; Rolland 1995; White and Ashton 2003). I will focus on the presence of Levallois giant cores for the production of large flakes in a few Acheulian sites.

Many attempts have been made to present a comprehensive and precise definition of the Levallois method as a part of the Acheulian large-flake production *chaîne opératoire*, but none has fully succeeded (see Inizan et al. 1999 for a recent discussion and a history of debate). Boëda (1995, 46) has described the "Levallois Volumetric Conception" in accordance with the following two criteria:

“1. The volume of the core is conceived in the form of two asymmetrical convex secant surfaces. The intersection of these surfaces defines a plane.

2. The two surfaces are hierarchically related: one produces defined and varied blanks that are predetermined, and the other is conceived of as a surface of striking platforms for the production of predetermined blanks. In the course of a single production sequence of predetermined blanks, the role of the two planes cannot be reversed.”

Many Acheulian giant cores accord perfectly with these definitions. The Victoria West and Tabelbala-Tachenghit techniques are both obvious examples, but other, larger Acheulian giant cores also fall well within their boundaries. Fig. 76 shows a few examples that were collected from a wide geographical range. All clearly show a volumetric concept in which two hierarchical and irreversible surfaces were used. All cores have a distinct striking platform face, which in the cases presented here shows a significant remnant of the cortex and a clear debitage surface from which large flakes have been removed. Furthermore, they demonstrate the two methods that were defined by Boëda (1995, 56) as “preferential” and “recurrent”. One should note the magnificent Levallois core of a preferential flake from the Indian site of Kolihal in the Hunsgi Valley (Fig. 76:a). The Kolihal surface collection is reported to contain about 30–40 cores, ranging in size from 15 to 25 cm. Bifacial tools associated with these cores are relatively small and have thin cross-sections (Paddayya and Jhaldiyal 1998–99). However, the degree of apparent blank shape predetermination, necessary in order to fulfill Boëda’s next criterion for a Levallois core, may be questioned (see Schlanger 1996 for a discussion of the importance and implications of flake morphology predetermination in Mousterian Levallois core technology).

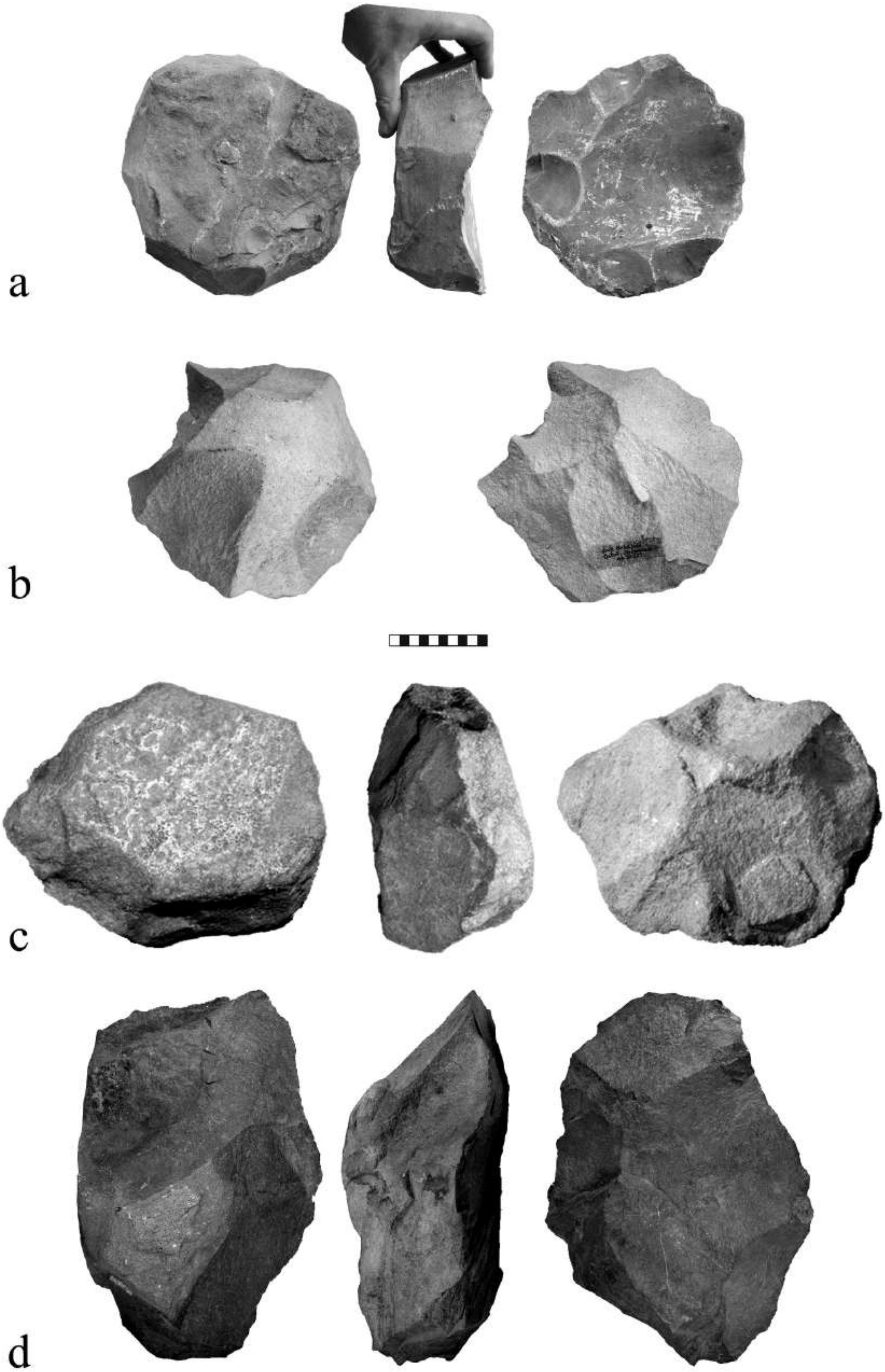

Figure 76. Acheulian giant cores showing Boëda's "Levallois volumetric conception". a. The preferential method from the site of Kolihal in the Hunsgi Valley, India (see Paddayya and Jhaldiyal 1998–99). b. Recurrent giant core from Stellenbosch (Smit Brickfield Dutoit), South Africa (exhibit in the Department of Prehistory, Musée de l'Homme, Paris). c. Recurrent Giant Core from Layer II-6 Level 1 at GBY, Israel (after Goren-Inbar et al. 1994; photograph by G. Laron). d. Bifacially knapped core from Isimila K-18 Trench 2E Surface (the Chicago Field Museum Collections; photograph by W. Pastle).

An alternative technological classification of the giant cores presented in Fig. 76 can be suggested under the heading “discoid volumetric concept” (Fig. 77).

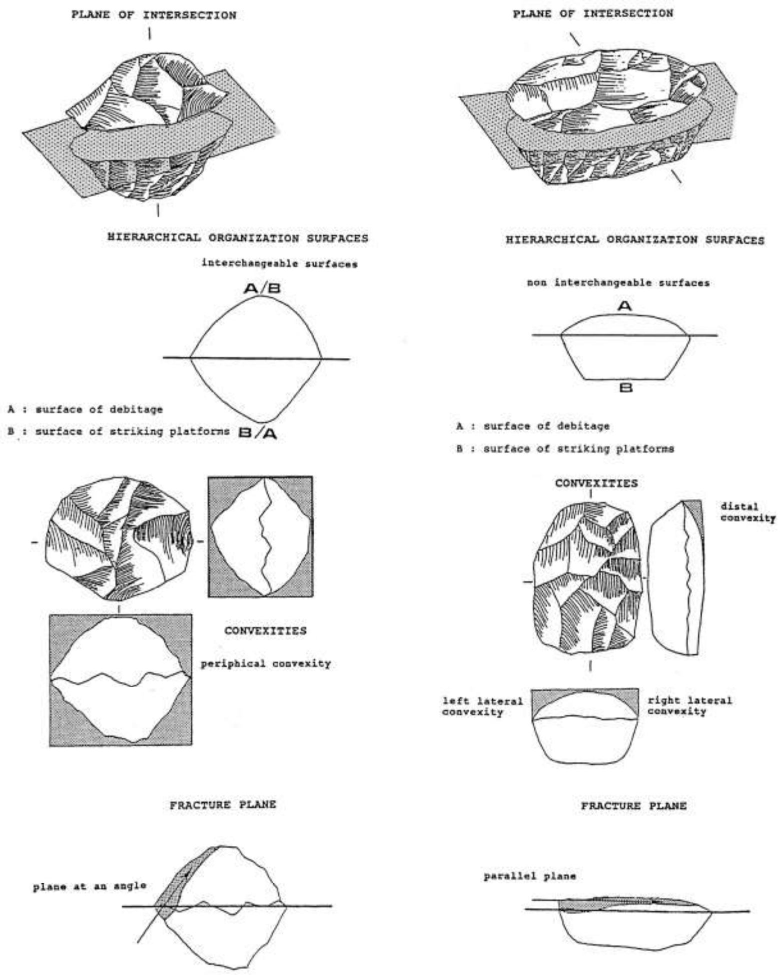

Figure 77. Discoid and Levallois volumetric concepts (after Boëda 1995, Fig. 4.33).

According to Boëda, the main differences between the Levallois and discoid concepts are the following. a) In the discoid concept the two faces of the core are not hierarchically related and their role can be inverted within a single reduction sequence. b) In the discoid concept a “peripheral convexity” is maintained, while in the Levallois concept a “lateral and distal convexity” is built up. c) In the discoid concept the flakes were removed at an angle to the plane of intersection of the two surfaces, while in the Levallois method the blanks were removed parallel to this plane (Boëda 1995, 61–63).

Fig. 76 clearly demonstrates that, judging by these three criteria, the cores should be considered within the realm of the Levallois concept. This is further buttressed by the fact that only a hard hammer was used, as is typical of Levallois production. It is unlikely that large flakes anywhere were produced by means of a soft hammer technique, as the strength of these hammers was insufficient for such a knapping procedure.

It should be noted, however, that there is a difference between the use of giant Levallois cores and small Levallois cores for flakes, which lies in the nature of the striking platforms. In most cases, large flakes do not need careful preparation of the striking platforms before removal. As demonstrated above, the scar of the previous flake was used as the striking platform for the next flake, predominantly resulting in a plain striking platform. The classic Levallois striking platform preparation (see detailed discussion and references in Schlanger 1996), which in many cases resulted in facetted striking platforms, is extremely rare in Acheulian large flakes (see below). Another difference lies in the design of the debitage face of the core. The desired product of the Acheulian giant core was a large flake, in many cases of a predetermined shape, for the production of an LCT. Hence, the debitage surface was shaped in such a way as to form a suitable blank for the production of a cleaver or a handaxe. Cleaver blanks were preplanned on the giant core to result in a scar on the distal end of the dorsal face that would form the cleaver's cutting edge. Clearly, they derived from very different debitage surfaces from those of the relatively small Levallois points or blades. The directions of knapping and the convexity rules defined by Boëda (1995) for Levallois cores are evidently unsuitable for the description of most Acheulian giant cores. The application of the definition and terminology developed for small cores to the world of Acheulian giant cores could in fact obscure our understanding of the Acheulian core. To describe Victoria West or Tabelbala-Tachenghit cores as nothing more than Levallois cores would result in the loss of many significant details.

Additional Giant Core Methods Depicted in the Literature

Chirki Cleaver Core Method

In her study of cleavers at the site of Chirki, G. Corvinus (1983b, 40–42) defined this core method as a prepared, non-Levallois core technique that was used for the production of cleaver flakes. The cores at Chirki ranged in size from those measuring 50 cm, intended for the production of a few flakes, to those measuring 15 cm, intended for the production of a single flake. She described the core method that was applied to large dyke blocks as follows:

> "From these (blocks) a few flakes were at one side and a 'base' was then prepared, which determined the future dorsal face of the cleaver flake [Fig. 78:a]. The preparation of the 'base' was, however, often quite simple and sometimes one flake

sufficed to determine the future cleaver edge. Therefore, some cortex is often to be seen on the dorsal face… A large, wide-angled cleaver flake (with angle of 105–120) was then detached along the 'base'. When one looks at the core in [Fig. 78:a], the would-be flake (highlight in gray) will have the cleaver edge to the left of the observer, when it has been detached from the prepared platform of the core. This detached flake [Fig. 78:b] has its talon on the right side" (Corvinus 1983b, 40).

Corvinus noted that most of the Chirki cleavers were detached in the same manner and had their striking platforms on the right (blow direction 3 in this study's methodology). Many of the resulting flakes show a facetted striking platform bearing two or three flake scars. The cleaver blanks that were detached by the Chirki core method "turned out often rather unlike each other and had to undergo secondary trimming till the shape was more or less as it has been desired" (Corvinus 1983b, 41). Cleavers dominated the Chirki assemblage. Corvinus noted that these cleaver flakes were, in many cases, shaped into narrow cleavers, handaxes with a cleaver edge and handaxes by means of reducing the breadth of the edge by retouch.

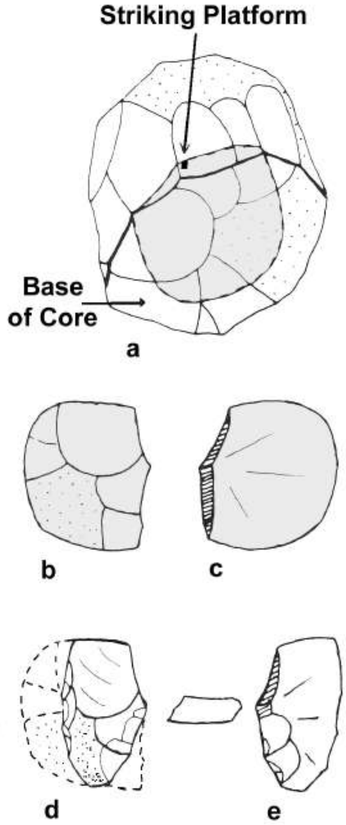

Figure 78. Chirki cleaver core method (after Corvinus 1983b, Fig. 1).

Kerzaz Core Method

An additional core type was defined by Alimen with regard to the Western Saharan site of Kerzaz (Alimen 1978, 127). This was a simple core for the production of a single long, relatively thick flake. The core was shaped on a natural cobble (Fig. 79), using minimum retouch along part of the margins of the debitage surface, and then one flake was struck parallel to the long axis of the core. The other face (cortical) was left unretouched.

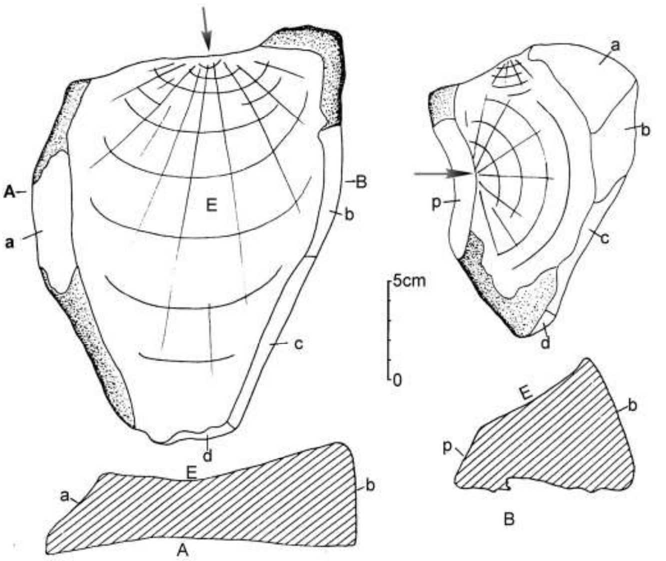

Figure 79. Kerzaz core method (after Alimen 1978, Fig. 37; arrows indicate blow point and direction of preferential flake).

Block-on-Block Method

In many publications, the term “block-on-block” is used to describe the production of large flakes from giant cores, with particular emphasis on the initial stages of the process (Kleindienst and Keller 1976 and references therein). An alternative term, the “direct anvil technique”, was suggested by Clark and Kleindienst (2001). In the block-on-block method, “flakes are removed by striking the piece against a stationary anvil” (Clark and Kleindienst 2001, 45). It has also been suggested that the method was mainly used in the production of large, thick flakes from boulders, and in breaking up boulders of hard rock by striking them against each other. In other words, it is clear that the term “block-on-block” describes a “primitive” method, by which two large blokes were smashed against into each other without any preparation or control over the resulting flake. In experimental work carried out to learn the process of knapping giant cores, modern knappers started by throwing very large hammerstones, and then progressed to smaller and smaller hammers as they gained expertise and knowledge. At the end of the process, many of them reported that the handheld hammer is the most efficient tool for large flake production. While the method of smashing giant hammers against large blocks was probably used on occasion by the Acheulian knapper, it usually served for "opening" large boulders and obtaining a striking platform. It would seem that the term "block-on-block" should not be defined as a separate giant core method.

Cobbles and Slab Blanks

An entirely different blank selection strategy was based on the selection of cobbles from riverbeds or flat slabs from which a handaxe could be shaped. Although cleavers were rarely produced on non-flake blanks, this strategy dominated some of the sites under study (Tabun Cave and Cuxton, see below) and required the availability of such raw materials as cobbles and slabs that were of suitable morphology and size. In light of his experimental study at Olduvai Gorge, Jones (1994) discussed the advantages of the flake blank over the cobble blank. Jones demonstrated that the shaping of a handaxe from a cobble blank required a much larger expenditure of time and energy than a flake blank. Large rounded river cobbles tend to be thick and the manufacture of a usable working edge from them was almost impossible, a fact which restricted the knapper to relatively small cobbles. A better alternative was to search for flat cobbles or slabs that were suitable in size and shape. River systems normally tend to produce rounded cobbles, but, depending on the original morphology of the raw material, flat cobbles can also be found and collected. Examples of such basalt cobbles from the Nahal Meshushim Stream inlet into Lake Kinneret are shown in Fig. 80.

Figure 80. Flat basalt cobbles, Nahal Meshushim, Israel (scale: 10 cm, after Sharon 2000).

All this notwithstanding, the benefits of the flake blank over the slab blank were clearly demonstrated by Jones (1994). Only limited geographical areas contained suitable natural slabs for LCT blank manufacture. Flat river cobbles were not always available and their knapping quality was sometimes problematic, due to their geomorphological history, which involved massive battering and rolling. Thus, the innovation of large-flake blank production for LCTs freed the Acheulian knappers from geographical restrictions.

The Efficiency of Acheulian Giant Core Technology

Both experimental and ethnographic data have demonstrated the efficiency of Acheulian giant core technology for LCT blank production. Once a suitable boulder of raw material was selected, an experienced knapper could have produced a great number of blanks in a very short time (Jones 1994; Madsen and Goren-Inbar 2004; Toth 2001). Jones (1994, 263), for example, was able to produce "…five to ten large usable flakes each over 0.5 kg in weight from a 13 kg core". Once the blanks were produced, Jones estimated that secondary retouch took fifty seconds to three minutes per tool (an average of 1.5 minutes), thus rendering biface shaping a very speedy process. In similarity to Jones's work at Olduvai, B. Madsen knapped several giant cores within the framework of the GBY experimental project (Madsen and Goren-Inbar 2004). Once the knapping properties of the tough local GBY basalt were understood and the knapper acquired the appropriate technological knowledge, the right boulder was selected and the ensuing sequence of large flake production from giant cores became extremely efficient. Core B-25, measuring 23.4 x 13.5 x 10 cm and weighing 35 kg, is a good example (Madsen and Goren-Inbar 2004, 30). It was collected from the bed of Hamdal River north of GBY, and comprises the best-quality raw material discovered during the experimental project. The bifacial core knapping process lasted 18 minutes, with the knapper using three different handheld basalt hammers. The resulting flakes, discarded core and hammers are presented in Fig. 81.

Figure 81. Experimental giant core No. B-25, knapping results. a. Six handaxe blanks. b. Nine cleaver blanks. c. Discarded core. d. Small flake waste and chips. e. Small flake tool blanks. f. Large flake waste. g. Three hammerstones.

Nine flake blanks suitable for the production of cleavers and six blanks suitable for handaxes were produced during this 18-minute experiment. It is likely that not every core was as good in terms of raw material type and shape, and that many of the Acheulian cores were discarded at an earlier stage (note the small size of the exhausted core in Fig. 81). Nevertheless, it can be extrapolated that the production of ten LCT blanks from one core took less than ten minutes. The efficiency of Acheulian giant core technology is further enhanced when it is compared to the technology of modern knappers. In his meticulous ethnographic study, Pétrequin described the process of axe blank production by the Langda people of the Irian Java Mountains (Pétrequin and Pétrequin 1993, 401, 217–228; see also Stout 2002). The process involves a long walk to the raw material source (giant basalt boulders in a river bed) and the breaking up of boulders through use of both fire and very large hammers. Neither preparation of the cores nor any predetermination of the flake morphology was observed. Pétrequin reported that in a full day's work, only one to five axe preforms per man are produced. These blanks each then require at least 20 minutes of work before polish can begin.

Acheulian Large Core Methods – A Summary

As many as seven different Acheulian giant core methods were described in this chapter. These include the bifacial method, the sliced slab, the cobble opening flake (*entame*), the Kombewa method, the Victoria West method, the Tachenghit-Tabelbala method and the Levallois method. Based on the literature, additional core methods were described (the Chirki cleaver method and the Kerzaz method of the Sahara). Slab/flat cobble blank selection was also mentioned as an important part of Acheulian blank collection strategies. Table 20 is a preliminary and partial representation of core method distribution at the sites under study. It clearly illustrates that, while some core methods were restricted to specific regions (Victoria West and Tabelbala-Tachenghit), others (e.g. Kombewa) were common in varying degrees in almost all of the sites. Cobble or slab use, while apparent in all assemblages, is not prominent in LFB assemblages. In most of the sites a single core method was dominant, but in no site was a single method exclusively used. At GBY, the presence of large cores and comprehensive study (including experimental work) enabled the identification of a large variety of core methods. Similar study of other sites (particularly workshop and quarry sites) will undoubtedly result in the identification of many other core methods. At Ternifine, for example, study of LCTs alone, in the absence of large cores, has yielded two significant core methods (*entame* and Kombewa). Cleavers may well have been produced at this site by an additional, as yet unrecognized, method.

Each of the core methods described above is fundamentally different from the others. Each represents a unique "volumetric conception" (Boëda 1995) and is a defined entity along the *chaîne opératoire*. Each represents an adaptive hominin response to an environment and raw material sources. Raw materials of different shapes, sizes and quality were exploited by sophisticated methods that were most suited to the challenges that they presented. Nonetheless, all of these techniques were intended to achieve the same goal: the production of large flakes suitable for use as blanks for bifacially knapped handaxes and cleavers. It is clear that the core technologies described here are by no means the only reduction sequence options, and that further study will both refine the descriptions presented here and illustrate new sophisticated giant core methods.

Table 20. Core methods used at the sampled sites. Key: +++ Substantial; ++ Present; + Rare; ? Possibly present.

Site	Bifacial	Slab	Éclat Entame	Kombewa	Victoria West	Tabelbala-Tachenghit	Levallois	Other Methods	Cobble Blank
GBY	++	++		+++			++		+
GBY NBA	?	?		+			?		+
Ma‘ayan Barukh									+++
Tabun									+++
Hunsgi	?	+++		+					+
Chirki	?	?		+				Chirki	++
STIC Quarry				+					++
Grotte des Ours				+			++		+
Ternifine			+++	+++					+
Tachenghit				+		+++	?		+
Isimila K6				+					+
Isimila K14				+					+
Isimila K19									+
Power’s Site				+	+++				+
Pniel 6a					+++				+
Pniel 7b				+	+++				+
Riverview Estate				+	+++				+
Doornlaagte				+	+++				
Canteen Koppie	?				+++		?		

General Technological Observations on Large Flake Production

Below is a comparative discussion of a few technological aspects of the large flake reduction sequence. This comparison illustrates some large-scale trends and strategies that were applied by Acheulian knappers along the LCT *chaîne opératoire*.

Blow Direction in Large Flakes

“Blow direction” defines the direction from which a large flake was struck from a parent giant core. This dictated the location of the striking platform on the flake, which in many cases was the thickest part of the flake. It was a struggle for the Acheulian large flake maker to achieve a large flake that was both as large as possible and thin enough for LCT production (Jones 1994). Due to the large force involved (see below), the detachment of a large flake required relatively large and thick striking platforms. The study of blow direction, attested by the location of the striking platform and bulb of percussion, can aid in retracing the design stages of the core that were geared to predetermine the shape of the resulting flake and the location of its cutting edge.

In many technological studies of LCTs, blow directions are defined in a minimalist fashion, in which they are termed “end-struck”, “side-struck” or “special side-struck”. I have used the method applied to the biface assemblage of GBY (Goren-Inbar and Saragusti 1996). In order to maintain consistency in describing blow direction, the biface was held with the dorsal face up, the working edge (or the tip in the case of a handaxe) was put in a distal position, and possible directions were read similarly to the demonstration in :. 4.48b. Strike directions 1 and 5 will result in an end-flake, directions 3 and 7 in a side-flake and directions 2, 4, 6 and 8 in a special side-flake. This recording method resembles the earlier approach of Tixier (Balout et al. 1967), which was applied to the Ternifine cleavers. Cleavers and handaxes are presented separately in an attempt to determine whether different technological approaches are reflected by these types. The numerous tools with indeterminate striking platforms were excluded from Figs. 82 and 83 in order to present a clearer picture.

Blow Direction – Cleavers

Table 21 and Fig. 82 present the distribution of the blow directions recorded for cleavers in sites whose sample numbered more than 10. In Table 21, “indeterminate” tools represent cases in which the blow direction could not be ascertained due to weathering or, more often, extensive retouch of the tool’s face.

Table 21. Cleaver blow directions.

	1		2		3		4		5		6		7		8		Indet.		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Ternifine			1	2	1	2	7	15	17	37	5	11	4	9			11	24	46	100
Tachenghit							1	7	4	27	6	40					4	27	15	100
Hunsgi					9	20	3	7	5	11	7	15	4	9			18	39	46	100
Yediyapur					2	17	1	8	2	17							7	58	12	100
Chirki	1	2			10	22	5	11	2	4			2	4	1	2	24	53	45	100
Power’s Site					42	40	3	3	12	11	3	3	4	4			42	40	106	100
Pniel 6a					36	39	2	2	2	2	2	2	9	10			42	45	93	100
Riverview			1	1	33	44	10	13	1	1	3	4	10	13			17	23	75	100
Pniel 7b					39	42	14	15	6	6	10	11	5	5			19	20	93	100
Doornlaagte					2	15	1	8					2	15			8	62	13	100
Isimila K6	1	4					6	24			2	8	2	8			14	56	25	100
Isimila K14					10	19	3	6	2	4	9	17	11	21	1	2	17	32	53	100
Isimila K19			1	3	8	21	3	8	3	8	1	3	13	34	1	3	8	21	38	100
GBY NBA	1	1			4	5	10	11	8	9	15	17	7	8	1	1	41	47	87	100
GBY L. II-6					11	9	15	12	19	15	22	17	23	18			38	30	128	100
GBY Area C					3	20	1	7	2	13	3	20	5	33			1	7	15	100

From these data, it is obvious that flakes detached from directions 1, 2 and 8 (the direction of the cleaver’s cutting edge) are scarce. This is not surprising, as by definition the desired cutting edge of a cleaver (Chapter 1) had to be thin and unretouched, and therefore could not be produced from the thickest part of the flake, i.e. the striking platform. It is interesting to note that direction 5, a blow in the opposite direction (Fig. 82:b) in which the distal end of the flake forms the cutting edge, is also relatively rare. For the most part, the preferred cleaver flake was side-struck (directions 3 and 7) or special side-struck (directions 4 and 6), with the exception of Ternifine, where 49% (n=17) of the cleavers were made on flakes that were end-struck in direction 5.

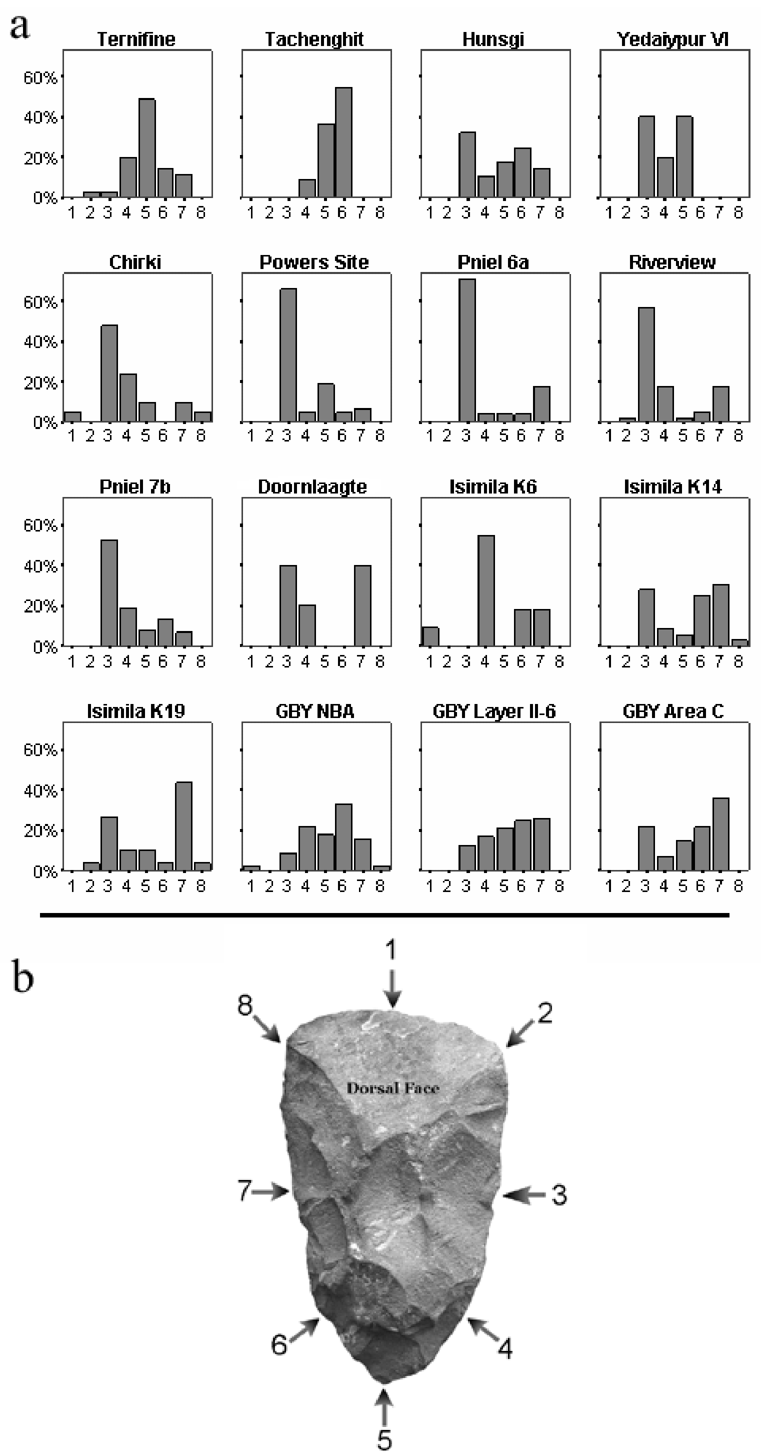

Figure 82. a. Cleaver blow direction frequency; b. Possible blow directions.

Some of the assemblages display a distinct dominance of a blow in a particular direction. The most pronounced cases are those of the Vaal River sites and the sites of Riverview Estate and Doornlaagte, which are located some distance from the main Vaal River site cluster (Chapter 3). In these sites, direction 3 (left side) was by far the most frequent (Table 21 and Fig. 82), probably due to the common use of the Victoria West core technique for the production of large flakes (Goodwin 1929; Sharon and Beaumont 2006; Söhnge et al. 1937; van Riet Lowe 1945). An analysis of a sample of Victoria West Type I cores from the site of Canteen Koppie has shown that all cores were struck in the same direction (3), as demonstrated by the resulting flakes (Sharon and Beaumont 2006). Isimila localities K-14 and K-19 show a dominance of side-flakes in cleaver production, struck from both left and right. In the site of K-6 (a small sample), on the other hand, a dominance of right special side-flakes (direction 4) is observable. The two Indian sites in Fig. 82 show different patterns. At Chirki, a clear preference for right side-flakes and special side-flakes (directions 3 and 4) is notable. Corvinus (1983b, 65) identified 77% of the bifacial tools produced on transverse flakes as having been side-struck from the right. At Hunsgi, directions 3 and 6 were chosen. The two large samples from GBY show similarities, indicating that directions 3 to 7 were all used for cleaver production.

To sum up, cleaver cutting edges were never located on the striking platform side of the flake that was used as a blank. In the majority of sites, the preferred flakes were side-struck or, more frequently, special side-struck. End-struck flakes were preferred only at Ternifine. While the knappers in some of the sites had a very strong preference for a specific blow direction, there are examples in which two or three directions were selected, and others, like GBY, where no clear preference for any given direction is discernible as long as the flakes are not end-struck. These patterns indicate a clear preference for specific morpho-technological features during the blank selection stage. At some of the sites, the direction of the blow was a part of predetermining the flake shape on the large core, e.g. in the production of Victoria West (and probably Tabelbala-Tachenghit) cleavers. The reason why such a great majority of the cores was struck in the same direction is unknown. To the modern eye, these symmetrical cores could have been struck from either right or left, and the actual point of percussion on these cores does not appear natural for a right-handed knapper. At other sites, such as Chirki, there was a clear preference for a specific blow direction (3), but no direct technological explanation for this can be suggested. The clear Ternifine preference for end-struck flakes is another unexplained pattern. A totally different blank selection strategy is observed at the GBY sites, where all flakes seem to have been deemed suitable, regardless of their blow direction, as long as they had a good cleaver edge.

This variety of blank selection strategies is one of the best pieces of evidence for the highly sophisticated decision-making process that was involved in LCT production. Although a clear techno-morphological preference guided blank selection in each of the sites, the process was flexible and suitable flakes were selected even if they deviated from the preferred blow direction, as long as their shape was suitable for cleaver production. It should be emphasized that the end-products of all of these strategies, approaches and preferences were cleavers, which at the end of the day were very similar everywhere.

Blow Direction - Handaxes

Handaxe faces are often extensively covered by flake scars, making it very difficult, and sometimes impossible, to determine handaxe blow direction. This is demonstrated by the high values of indeterminate cases in Table 22. Of the 125 handaxes in the sample from Ma'ayan Barukh, the blow direction could be determined in only five. Of the sites enumerated in Fig. 83:a, only eight sites had an adequate sample size after the exclusion of indeterminate cases. As these samples are small, the results should be regarded with due caution.

Table 22. Handaxe blow direction frequency.

	1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**Indet.**		**Total**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
STIC			1	4			7	27	5	19	8	31					5	19	26	100
Ternifine	1	2			7	16	6	14	3	7	6	14					20	47	43	100
Grotte des Ours							7	21	7	21	5	15	2	6			12	36	33	100
Tachenghit							1	5	4	19	3	14					13	62	21	100
Hunsgi					2	7	3	10	1	3	6	21					17	59	29	100
Chirki					1	5	4	20			1	5					14	70	20	100
Power's Site					1	9	1	9	2	18							7	64	11	100
Pniel 6a											1	7	1	7			13	87	15	100
Riverview			1	4	4	16	3	12	2	8	4	16	2	8	1	4	8	32	25	100
Pniel 7b					3	23	1	8	1	8	1	8	3	23			4	31	13	100
Doornlaagte					2	18	3	27			2	18	1	9			3	27	11	100
Isimila K6					3	3	4	4	5	5	16	17	5	5	1	1	58	63	92	100
Isimila K14					3	18	3	18			1	6	2	12			8	47	17	100
Isimila K19							2	12			3	18	1	6			11	65	17	100
GBY NBA					1	2	9	19	5	11	8	17	2	4			22	47	47	100
Ma'ayan Barukh							2	2	2	2	1	1					120	96	125	100
GBY Layer II-6			1	0	27	13	20	10	31	15	35	17	29	14			64	31	207	100

The overall preference for side-struck flakes is as pronounced for handaxes as it is for cleavers. In the largest sample, that from GBY Layer II-6, a pattern similar to that observed for the GBY cleavers can be seen, in which all blow directions between 3 and 7 were chosen by the knappers in almost equal proportions. In many of the sites, flakes that were struck from directions 4 and 6 were apparently the most commonly selected for use as blanks. This preference for special side-struck flakes is linked to the fact that when such flakes were detached from the giant cores, their natural shape closely resembled that of a handaxe. This predetermined a morphology in which a tip and a butt were already present on the blank, enabled the knapper to invest minimal work in shaping the final tool. The Ternifine *éclat entame* flakes are a good example of this strategy. In rare cases, the handaxe is shaped in way as to indicate that the blow direction was applied in directions 1, 2 and 8, next to its tip (Fig. 83:b). This shows that when a suitable blank was identified, it was chosen for handaxe production even when the blow direction did not fit into the "conventional" scheme of the Acheulian knapper (Fig. 84).

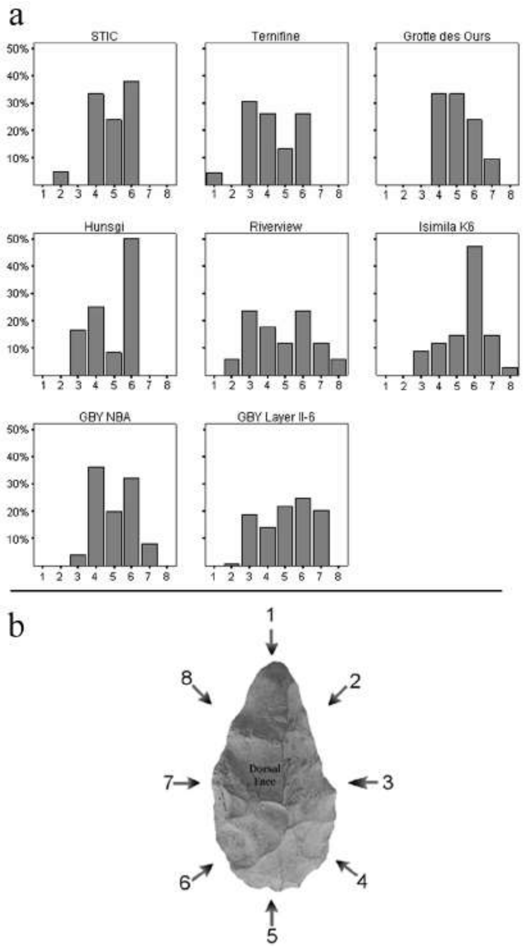

Figure 83. a. Handaxe blow direction frequency (sample size >10; indeterminate cases excluded). b. Possible blow directions.

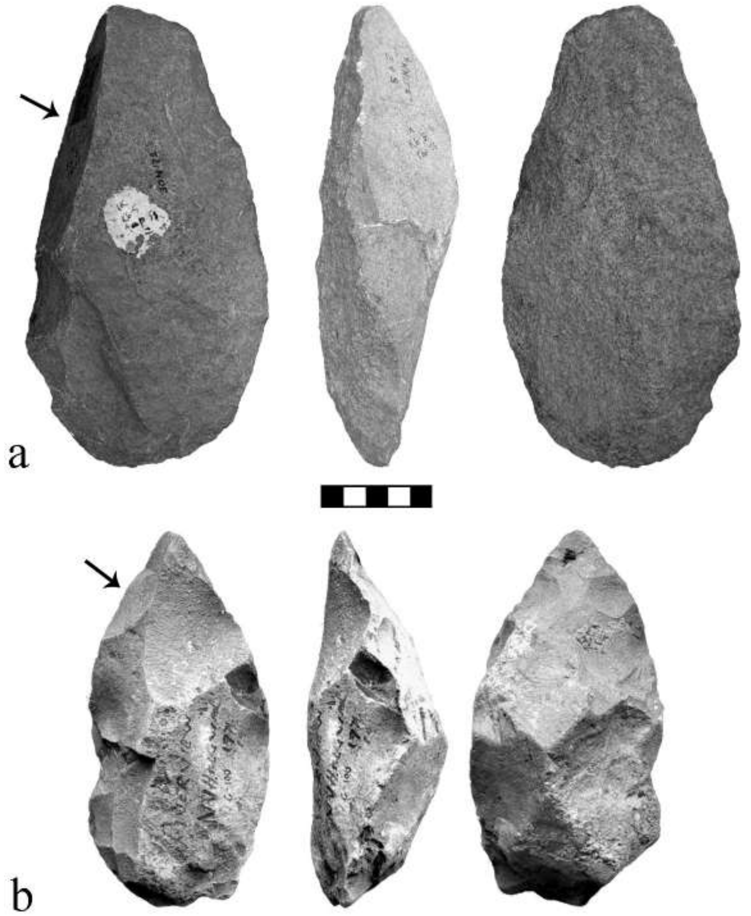

Figure 84. Handaxes detached in blow direction 8. a. Isimila (museum No. 304172). b. Riverview Estate. Arrows indicate blow direction.

Striking Platforms

Although the striking platforms discussed here were observed on LCTs, they in fact relate to the original flake blank that was detached from the parent giant core, providing much descriptive information about the core handling strategy, had influenced the nature of the striking platform (see appendix). Most LCTs made on flakes have only one striking platform, that of the blank flake. An exception is the Kombewa flake, on which two striking platforms are present (see above and details below). In the first stage of the discussion, all striking platforms on the ventral face of the flake blank are defined. Tables 23 and 24 and Figs. 85 and 86 present the frequency of striking platform types recorded for handaxes and cleavers.

Both cleavers and handaxes show the same frequency patterns in striking platform types. The difference between the tools lies in the fact that cleavers were made almost exclusively on flake blanks that entailed minimal secondary retouch (see below). However, the similarity of striking platform frequencies between handaxes and cleavers indicates that the same core methods were applied in the blank production of both of these tool types. It also suggests that the strategy of blank selection was conducted along similar lines. Below is a detailed discussion of the different striking platforms and their significance.

Table 23. Handaxe striking platform type frequency.

Site	Indet.		Cortical		Punctiform		Plain		Dihedral		Facetted		Removed		Missing		Victoria West		Total	
	N	%	N	%	N	%	N	%	N	%	N		N	%	N	%	N	%	N	%
STIC	1	4	4	15			15	58			1	4	5	19					26	100
Ternifine	1	3	11	28			8	20					20	50					40	100
G. des Ours	3	8	2	6			14	39					17	47					36	100
Tachenghit							2	11			1	5	16	84					19	100
Hunsgi			2	7			5	17					20	69	2	7			29	100
Chirki	1	7					4	27					10	67					15	100
Power's Site	1	11					1	11					7	78					9	100
Pniel 6a													10	100					10	100
Riverview							8	47					3	18			6	35	17	100
Pniel 7b							4	33					3	25			5	42	12	100
Doornlaagte							5	63					1	13			2	25	8	100
Isimila K6	5	9	4	7			21	39					21	39	3	6			54	100
Isimila K14			2	18			4	36					5	45					11	100
Isimila K19							1	7					13	93					14	100
GBY NBA	8	17	2	4			15	32					22	47					47	100
GBY II-6	5	3			1	1	61	34	4	2			101	56	7	4			179	100
Total	25	5	27	5	1	0	168	32	4	1	2	0	274	52	12	2	13	2	526	100

Table 24. Cleaver striking platform type frequency.

Site	Indet.		Cortical		Punctiform		Plain		Dihedral		Facetted		Removed		Missing		Victoria West		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Ternifine	2	5	2	5			19	44	1	2			19	44					43	100
Tachenghit			1	7			6	40	3	20			5	33					15	100
Hunsgi	1	2	7	15			10	22	1	2			23	50	4	9			46	100
Yediyapur							3	33					6	67					9	100
Chirki	1	3					9	24					27	73					37	100
Power's Site							11	10					97	90					108	100
Pniel 6a					1	1	6	6					88	93					95	100
Riverview	1	1	1	1			11	16					18	26			38	55	69	100
Pniel 7b			1	1			12	13	1	1			27	30			50	55	91	100
Doornlaagte							1	9					5	45			5	45	11	100
Isimila K6	3	16					4	21					11	58	1	5			19	100
Isimila K14	2	4	2	4			3	6					42	86					49	100
Isimila K19	2	6					7	19			1	3	26	72					36	100
GBY NBA	6	7	1	1	1	1	20	24			6	7	47	56	3	4			84	100
GBY II-6	1	1					27	22			3	2	83	67	9	7			123	100
GBY area C			1	7			3	20	1	7			10	67					15	100
Total	19	2	16	2	2	0	152	18	7	1	10	1	534	63	17	2	93	11	850	100

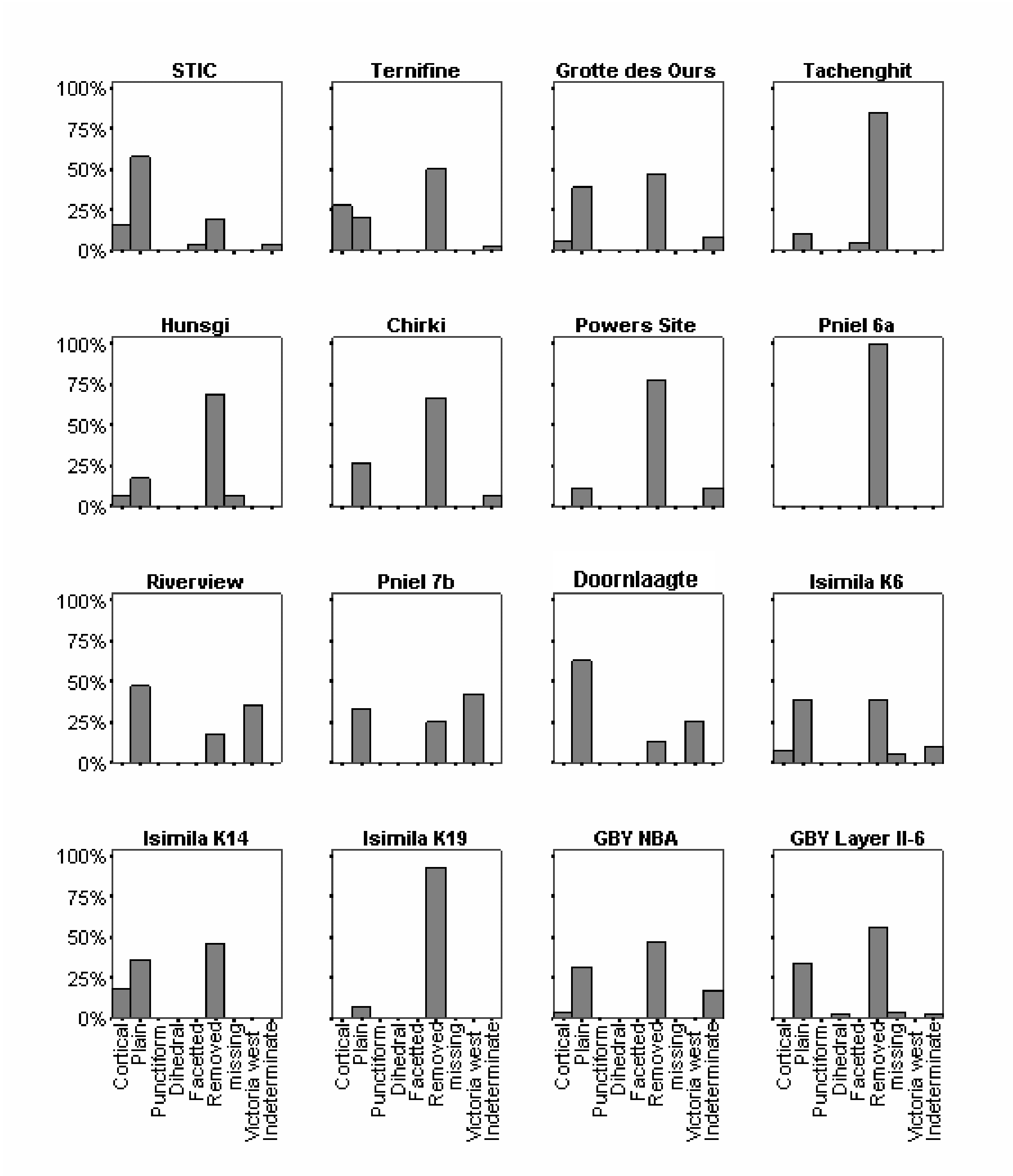

Figure 85. Handaxe striking platform type frequency.

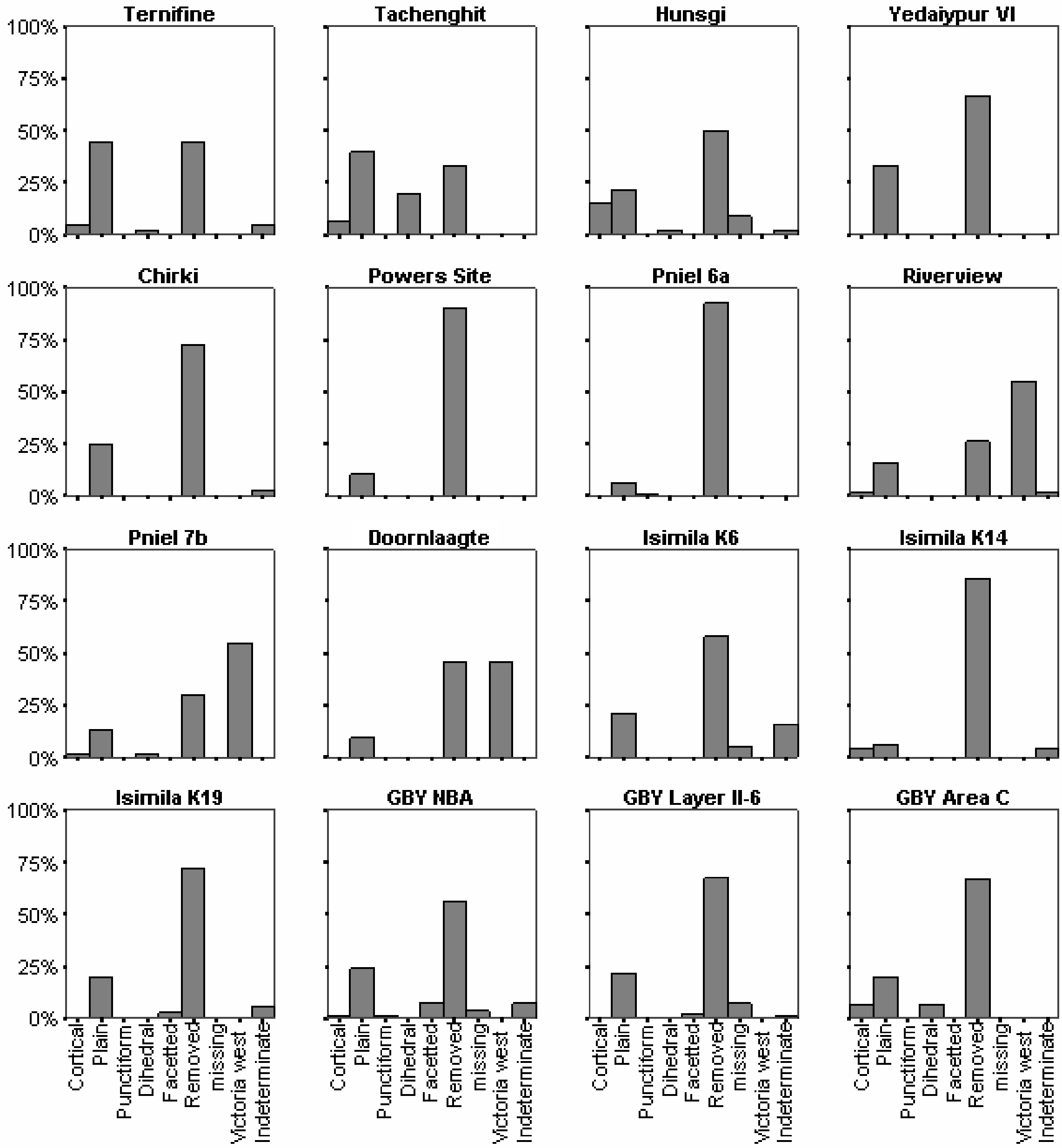

Figure 86. Cleaver striking platform type frequency.

"Removed" and "Plain" Striking Platforms

"Removed" and "plain" striking platforms are the dominant types in all of the sites. Striking platforms are defined as removed when the area on the tool that included the striking platform and the bulb of percussion was removed by retouch during the shaping stage of the blank. This procedure was very frequent in the production of LCTs from flake blanks, as discussed in Chapter 5. Hence, they provide no information regarding the technology applied to the parent giant core. If we eliminate the removed striking platforms, the dominance of plain striking platforms becomes remarkable. Plain striking platforms are recorded when the entire surface of the striking platform consists of a single, non-cortical surface. This means, in most cases, that the blow was applied to a single previous flake scar on the parent core, sufficiently large to form the full surface of the resulting flake striking platform (see below). Although sample sizes are small in some of these assemblages, the pattern is very clear: more than 50% of the striking platforms are plain in most of the sites, and in many cases these constitute over 80% of the assemblage. The South African Vaal River sites are the main exception to this pattern and are discussed below.

The dominance of plain striking platforms can be explained by means of the parent giant core method. Experimental work has shown that in most cases large flakes were removed by directing a blow onto the scar of a previously removed flake, with no further preparation (Madsen and Goren-Inbar 2004). This technique resulted in a plain or, less frequently, a dihedral striking platform on the removed flake. For comparative purposes, the frequencies of striking platform types observed on all flakes experimentally manufactured from basalt giant core No. B-25 in the GBY lithic experiments (Madsen and Goren-Inbar 2004; Sharon 2000) are presented in Table 25. Table 26 presents the striking platform type distribution for flakes larger than 10 cm from the same core (a detailed technological description of Core B-25 is given in Madsen and Goren-Inbar 2004, 30).

Table 25. Experimental data: all Core B-25 flake (>2cm) striking platforms (some of the recorded flakes were fragmented and broken and hence were found irrelevant to this table).

Striking Platform type	N	% of all flakes	% relevant
Indeterminate	4	3.3	4.9
Cortical	11	9.0	13.6
Punctiform	6	4.9	7.4
Plain	**45**	**36.9**	**55.6**
Dihedral	1	0.8	1.2
Faceted	1	0.8	1.2
Missing	4	3.3	4.9
Crushed	9	7.4	11.1
Total	81	66.4	100.0
Fragmented and irrelevant	41	33.6	
Total	122	100.0	

Table 26. Experimental Core B-25: large flake (>10 cm) striking platform types.

Striking Platform	N	% of all flakes	% relevant
Indeterminate	3	11.1	11.5
Cortical	2	7.4	7.7
Punctiform	1	3.7	3.8
Plain	**18**	**66.7**	**69.2**
Crushed	2	7.4	7.7
Total	26	96.3	100.0
Fragmented and irrelevant	1	3.7	
Total	27	100.0	

The experimental data accord with the archaeological data: over 55% of the striking platforms of all the experimental flakes are plain (Table 25). Among the large experimental flakes alone (Table 26), plain striking platforms constitute almost 70%. It has become evident through the experimental knapping of many giant cores that no platform preparation was needed when detaching a large flake. Dihedral and facetted striking platforms, indicating striking platform preparation prior to flake removal, are extremely rare among the smaller experimental flakes (Table 25) and completely absent from the larger ones (Table 26).

Dorsal Face Striking Platforms (Kombewa)

In some flake-based LCTs, a second striking platform can be identified on the dorsal face of the flake, indicating a Kombewa flake (see above). Table 27 presents the frequencies of striking platform types that were observed on the dorsal face of the cleavers included in this study. Data are available only for cleavers, as identifiable handaxe dorsal striking platforms are extremely rare.

The presence of Kombewa flakes is observable in all sites belonging to the Acheulian lithic tradition, since they are to be expected in any knapping procedure that involved large flake production (Dag and Goren-Inbar 2001). Nevertheless, they are rare in most sites. At GBY Layer II-6, the percentage of dorsal face striking platforms is at least three times higher than that of any other site. To some extent, this is due to a somewhat different definition given to the Kombewa flake in the study of this particular assemblage (Goren-Inbar and Saragusti 1996). In the GBY system, a plain (scar-free) dorsal face was seen as the marker of a Kombewa flake. Thinning scars on the dorsal face were interpreted as evidence of a removed striking platform. These removed striking platforms (n=14; 70%) account for the high number of dorsal face striking platforms in the GBY assemblage.

Table 27. Cleaver Face 2 striking platforms.

Site	Indet.		Cortical		Plain		Facetted		Removed		Missing		Victoria West		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Ternifine					3	43	1	14	3	43					7	100
Hunsgi			1	20					3	60	1	20			5	100
Chirki	1	50							1	50					2	100
Power's Site									6	100					6	100
Pniel 6a					1	20			4	80					5	100
Riverview									2	100					2	100
Pniel 7b			1	14	1	14			4	57			1	14	7	100
Isimila K14									2	100					2	100
Isimila K19					1	100									1	100
GBY NBA	2	40			1	20			2	40					5	100
GBY Layer II-6	1	5			4	20			14	70	1	5			20	100
GBY Area C					1	100									1	100
Total	4	6	2	3	12	19	1	2	41	65	2	3	1	2	63	100

Cortical Striking Platforms

As opposed to the dominance of plain striking platforms that is apparent in other assemblages, a high frequency of cortical striking platforms was recorded for the Hunsgi cleavers (n=7; %=37; Table 24) and the Ternifine handaxes (n=11; %=28; Table 23). At Hunsgi, many of the cleavers were produced by the slicing method, in which flakes were struck from the natural (cortical) surface of the slab cores (Fig. 44). At Ternifine, many of the handaxes were produced on *entame* flakes. The results are easily identifiable cortical striking platforms that can be described as "invading" the ventral face of the flake (Fig. 87).

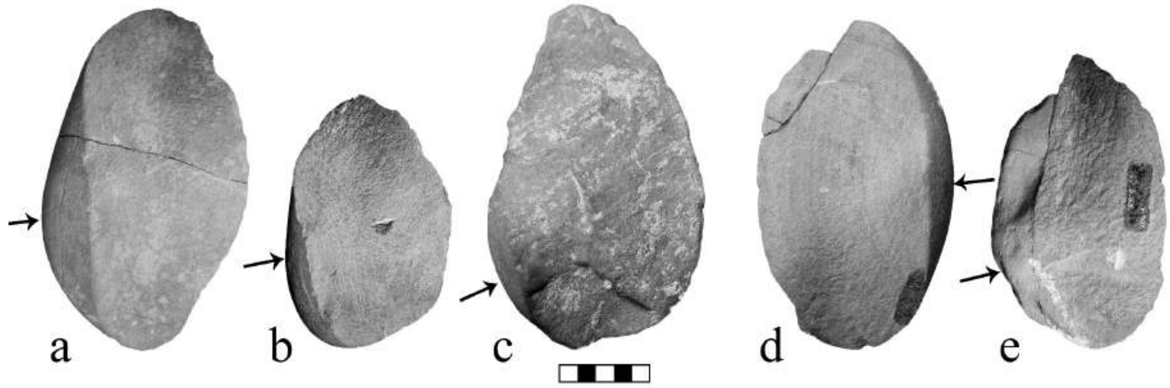

Figure 87. Cortical striking platforms from Ternifine

The low number of cortical striking platforms in all other samples should be emphasized. It suggests that most of the blanks used for the production of cleavers and handaxes were detached during the advanced stages of giant core reduction and not as primary flakes from boulders or outcrops. An illustration of this point can be seen in Core B-25, which was knapped from a cortical basalt boulder. The low number of cortical striking platforms (Tables 23 and 24) is the result of the core method that was used. Core B-25 went through an initial sequence of removals in which the entire cortical mantle was removed by means of a few very large flakes (Madsen and Goren-Inbar 2004). The large blank flakes experimentally produced from Core B-25 all originated in the next stage of core reduction.

Victoria West Striking Platforms

Tables 23 and 24 and Figs. 85 and 86 illustrate the very high frequency of Victoria West striking platforms in the assemblages of Pniel 7 and Riverview. The Victoria West striking platforms were defined through the study of LCTs from Power's Site and Pniel 6a. Analysis of these samples has shown that the typical striking platform, which was classified as “removed”, actually derived from the unique Victoria West core method. Hence, it should be noted that at Power’s Site and Pniel 6a, “removed” striking platforms are the equivalent of “Victoria West”. Core A in Fig. 63 is a Victoria West core from Canteen Koppie, which shows evidence of an unsuccessful blow that resulted in a flake too small to be used as a blank. This unsuccessful removal has provided us with an opportunity to pinpoint the location of the blow on a Victoria West core.

A Victoria West striking platform can be identified by the shallow and bifacial morphology of the scars that it bears. However, its distinction from “facetted” or “removed” striking platforms is not always easy. In the Vaal River Acheulian assemblages, tools were thinned by removing the bulb of percussion through bifacial retouch (26% of the Pniel 7b sample and 30% of the Riverview sample: Tables 23 and 24), thus adding to the difficulty. Fortunately, Victoria West striking platforms are very frequently associated with other typical technological features of the Victoria West flake: a typical scar pattern on the ventral proximal face of the tool and a steep pointed butt (Fig. 88).

Although the Victoria West sites differ from others in their Acheulian assemblages, there is a striking similarity between them in LCT morphology and size.

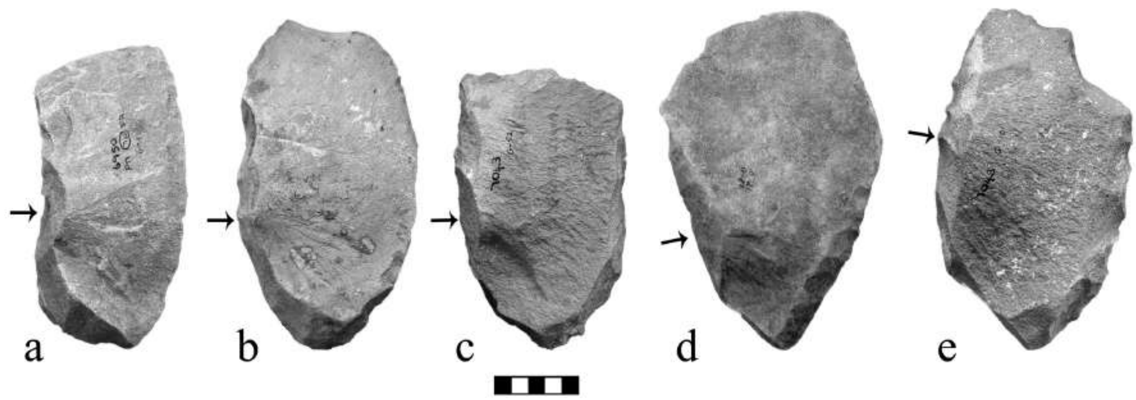

Figure 88. Victoria West cleaver striking platforms from the Vaal River Acheulian sites. Note the steep, pointed butts of the cleavers and the typical scar pattern on the lower part of the ventral faces.

Victoria West and Tabelbala-Tachenghit

From the early stages of Paleolithic research, the Victoria West core technology was equated with the Tabelbala-Tachenghit core method (Alimen 1978; Biberson 1961; Söhnge et al. 1937; van Riet Lowe 1945). Although these two methods do resemble one another, e.g. in the core debitage method (preferential flake), study of their resulting flakes’ striking platforms has illustrated some interesting differences. The Tabelbala-Tachenghit striking platforms were isolated from the core’s surface by retouching the area of the striking platform and creating a concavity on both sides of the point of percussion. A blow was then applied to a medium-sized flake scar that was designed for this purpose. The resulting striking platforms on the removed flake are plain and sometimes almost punctiform (Fig. 89:a, b). This seems to be the most advanced striking platform preparation that was applied in any of the large flake production methods described here. All Tabelbala-Tachenghit flakes in the small sample that was studied here were struck from the same direction (6).

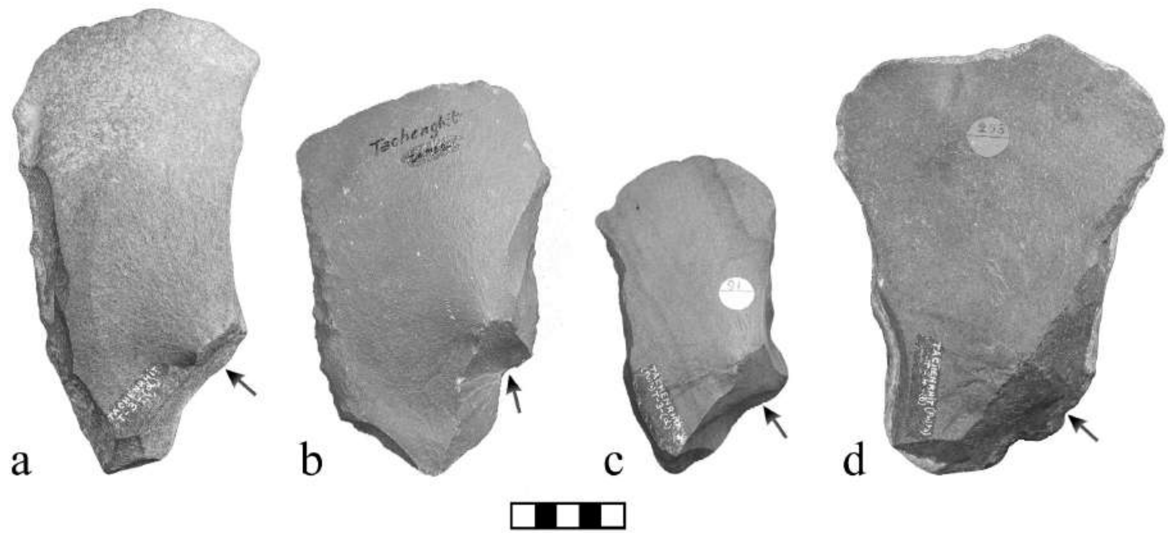

Figure 89. Tabelbala-Tachenghit striking platforms from Tachenghit. Arrows indicate blow direction.

Striking Platform Observations - Summary

The study of striking platforms is one of the most important tools in core method reconstruction and at least five different reduction strategies have been identified through it (plain, Victoria West, Tabelbala-Tachenghit, Kombewa and cortical *entame* flakes). The great majority of flakes used as blanks in the production of LCTS display plain striking platforms. The only exception is the Vaal River South African sites, where the Victoria West core method dominates the assemblages. Plain striking platforms do not indicate that the giant core technology was simple or unsophisticated. The small number of cortical striking platforms implies that large flakes were not detached as opportunistic flakes from boulder or outcrops. Experimental work has demonstrated that plain striking platforms are the most efficient type of striking platform in the production of large flakes, even when using sophisticated core methods (Jones 1994; Madsen and Goren-Inbar 2004). Another significant observation emerging from the above data is that no correlation is apparent between raw material type and the nature of the striking platform that was used.

The Position of Large Flakes as Blanks in the Acheulian

The study of blanks is a key to understanding the LCT *chaîne opératoire*. The blanks used for the production of LCTs were selected by the knapper from several that he had previously collected or made. This act terminated the first stage of a decision-making process dictated by the technological and cultural preferences of the toolmaker. The blanks were large flakes produced from giant cores, naturally available cobbles, nodules, tabular blocks, or any other raw material form. The morphology of the selected blank greatly influenced the morphology of the final tool and its functionality.

Blank types that appear in the samples under study are presented in Tables 28 and 29 and Figs. 90 and 91. In order to determine a blank's type, its original morphological features have to be recognized. These are not always visible, as they tend to be removed or covered by secondary retouch. Consequently, it is easier to determine the type of a blank that has undergone minimal shaping. In the study of LCT types, it is essential to present comparative data from non-LFB Acheulian sites, and this has been done here. Marshall and others (2002) have presented data from UK Acheulian sites and Z. Matskevich (personal communication) has provided information on Tabun Cave. The records from these sites have been grouped with the Ma'ayan Barukh data in order to represent the non-LFB Acheulian.

The different forms of natural blocks that were used as blanks were grouped under the term "chunk". These include flat cobbles and nodules and the relatively rare tabular pieces and flat slabs from the African sites of Olorgesailie and Olduvai. The category "probably flake" is used to indicate tools that bear remnants of flake morphology but lack the definitive striking platform or ventral face that would classify them as flakes. This category only appears within the present study; in other systems of analysis (Marshall et al. 2002; Noll 2000), it is usually subsumed under the heading "indeterminate".

Cleavers differ substantially from handaxes in their blank type frequencies. Even if we adopt a flexible definition of "cleaver", one that includes all cleaver-shaped tools (i.e. Roe's transverse cutting edge and clear meeting point of the bit and margins, including bifacial cleavers), we still find that only 6 out of the 1044 sampled cleavers (0.6%) were definitely made on chunks. Even among the cleavers from the UK site of Broom Pits, 7 out of the 11 specimens were made on flakes and only one was made on a chunk (Marshall et al. 2002). In addition, the number of indeterminate cleaver blanks is small relative to that of indeterminate handaxe blanks. A different classification methodology was employed at Olorgesailie, probably accounting for the high number of indeterminate blanks at the site (Noll 2000).

Handaxe blank type frequency is much more complex. The most obtrusive observation about them is the dominance of indeterminate cases. Unlike cleavers, handaxes were in many cases shaped by extensive retouch of both of their faces. Hence, it is sometimes impossible to determine their blank type, because of an absence of a cortex or ventral face remnants (Goren-Inbar and Saragusti 1996). Noteworthy is the fact that **all** sites in the entire geographical distribution of the Acheulian used flakes as blanks for the production of handaxes, the frequencies varying dramatically. The highest value is 72% at GBY, with many other sites ranging around 60%. However, even at the lower end of the scale, the percentages are over 8% (Table 29). Another notable observation is the small number of chunks that were found among the blanks in most of the sites. None of the assemblages apart from Cuxton had more than 20% definite chunk blanks, and in most cases the percentage was much lower (Table 29). In their study of a large sample of handaxes from South African Acheulian sites, Gamble and Marshall noted that even where cobbles were the main form of raw material, as in the case of Amanzi Springs, large flakes were always by far the most frequently used blank type (Gamble and Marshall 2002, 23, Figs. 2.3, 2.4).

Table 28. Blank types used in cleaver production (Olorgesailie data after Noll 2000)

Site	Flake		Chunk		Indet.		Probably Flake		Total	
	N	%	N	%	N	%	N	%	N	%
Ternifine	44	94					3	6	47	100
Tachenghit	16	100							16	100
Hunsgi	44	90	1	2			4	8	49	100
Yediyapur VI	10	83					2	17	12	100
Chirki	37	77			3	6	8	17	48	100
Power's Site	101	86			6	5	11	9	118	100
Pniel 6a	89	87			2	2	11	11	102	100
Riverview	71	93	1	1	1	1	3	4	76	100
Pniel 7b	90	92			5	5	3	3	98	100
Doornlaagte	10	71			1	7	3	21	14	100
Isimila K6	23	82			3	11	2	7	28	100
Isimila K14	48	87			3	5	4	7	55	100
Isimila K19	38	95			1	3	1	3	40	100
GBY NBA	83	85			2	2	13	13	98	100
GBY Layer II-6	130	96			6	4			136	100
GBY Area C	15	94			1	6			16	100
Olorgesailie DE89B	46	52	4	5	38	43			88	100

Table 29. Blank types used in handaxe production (Olorgesailie data after Noll 2000; Olduvai, Boxgrove, Cuxton and Broom Pits data after Marshall et al. 2002).

Site	Flake		Chunk		Indet.		Probably Flake		Total	
	N	%	N	%	N	%	N	%	N	%
STIC	20	24	11	13	32	39	20	24	83	100
Ternifine	36	63	1	2	9	16	11	19	57	100
Grotte des Ours	26	32	9	11	37	46	9	11	81	100
Tachenghit	17	59	1	3	8	28	3	10	29	100
Hunsgi	25	57	5	11	5	11	9	20	44	100
Chirki	14	35	8	20	12	30	6	15	40	100
Power's Site	8	16	2	4	37	74	3	6	50	100
Pniel 6a	6	15	3	7	24	59	8	20	41	100
Riverview	21	45	5	11	15	32	6	13	47	100
Pniel 7b	12	30	2	5	23	58	3	8	40	100
Doornlaagte	9	53			5	29	3	18	17	100
Isimila K6	44	24	6	3	82	45	52	28	184	100
Isimila K14	11	44	1	4	7	28	6	24	25	100
Isimila K19	13	54	1	4	6	25	4	17	24	100
GBY NBA	46	28	15	9	74	45	29	18	164	100
GBY Layer II-6	232	72	4	1	88	27	-	-	324	100
Ma'ayan Barukh	11	9	21	17	93	74	-	-	125	100
Olduvai HK	81	66	17	14	25	20	-	-	123	100
Olorgesailie DE89B	77	24	30	9	211	66	-	-	318	100
Boxgrove	14	8	12	7	156	86	-	-	182	100
Cuxton	22	11	128	62	55	27	-	-	205	100
Broom Pits	115	48	10	4	117	48	-	-	242	100

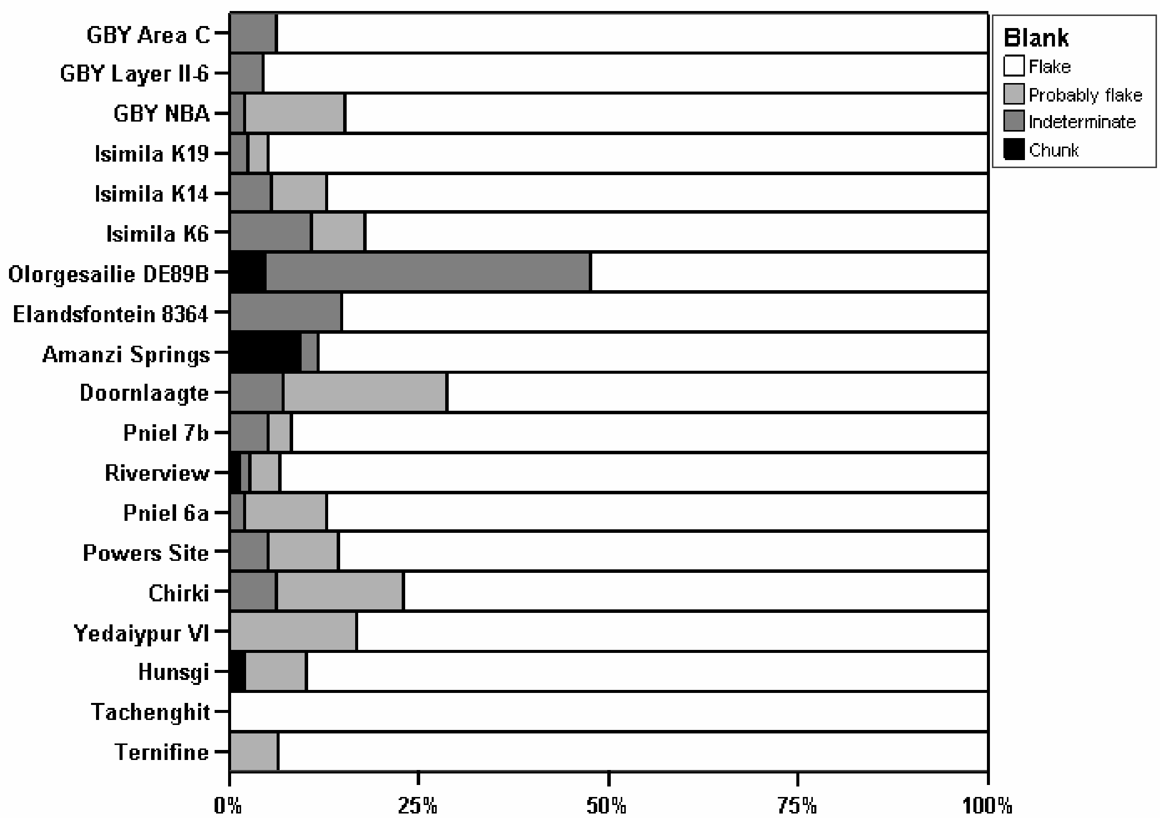

Figure 90. Blank types used in cleaver production.

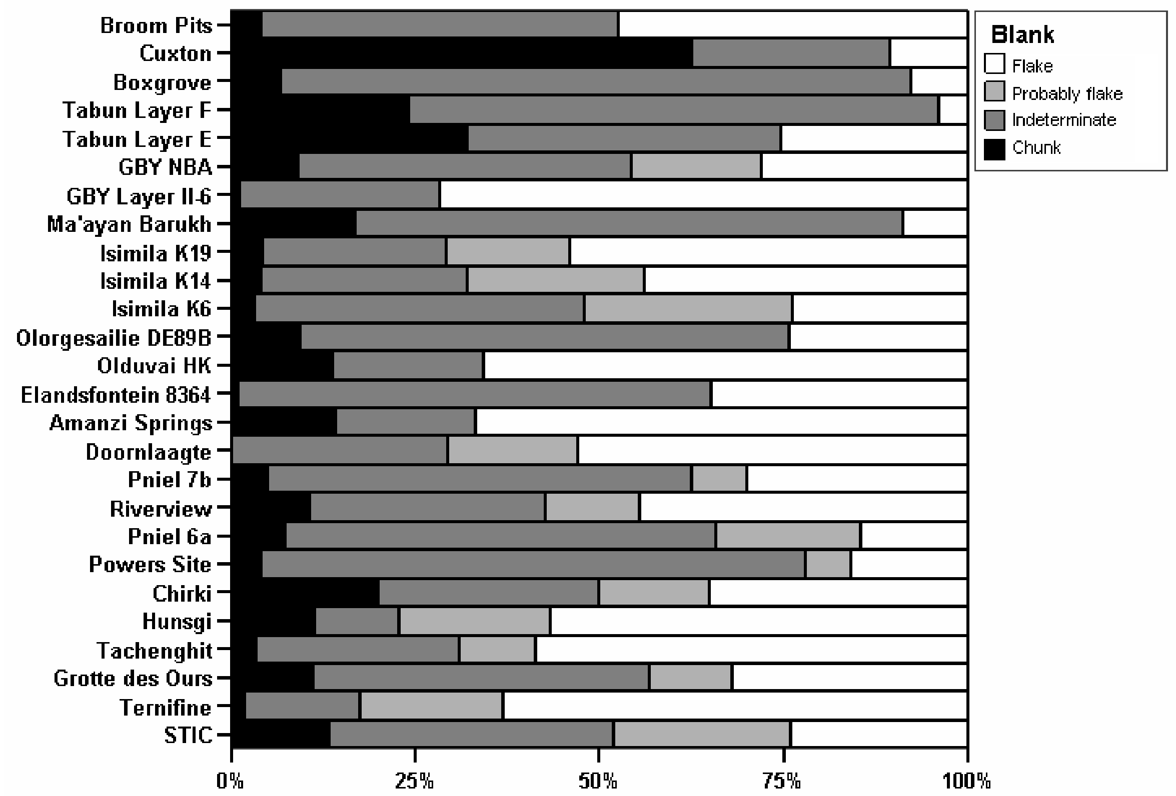

Figure 91. Blank types used in handaxe production.

It is possible that extensive retouch of handaxes in many of the sites has created a bias in which chunk blanks are underrepresented. However, a high frequency of flat cobble blanks was recorded at the site of Cuxton, suggesting that such massive use of cobbles **can** be identified during lithic analysis. A similar example is the handaxe sample from Layer E of Tabun Cave (Matskevich 2006; Matskevich et al. 2002), where out of 179 handaxes 86 (48%) were identified as made on chunks while 84 (47%) were recorded as indeterminate (Matskevich, personal communication). The Cuxton and Tabun Cave handaxes bear cortex remnants on both of their faces and are relatively easily identifiable as chunk blanks.

The handaxes from Ma‘ayan Barukh are dominated by unidentified blanks, due to heavy retouch (Chapter 5). Nevertheless, Ma‘ayan Barukh handaxes differ from those of Tabun Cave Layer E and Cuxton in their frequency of chunk blanks, a difference that seems to be actual and not the result of analysis bias.

It is evident from the above data that large flakes were the preferred blank type in many Acheulian sites. The advantages of flakes over other blank types should now be explained. LCT production stemmed from a need for a sharp, functional and maximally long cutting edge. Jones (1994, 262) articulated the difficulties of producing such a “quality” cutting edge from a rounded pebble:

> "The first approach (using water rounded cobbles as blanks) restricts the tool maker greatly in the type of tools that can be made and their morphology. This is due to the general difficulty of carrying out an extensive, controlled secondary flaking from rounded cobbles' surface, and to the fact that cobbles are generally thick in relation to their length and breadth. Thus, unless a great deal of time and effort is spent shaping and reducing a large cobble, one is restricted to flaking an edge around the perimeter of a small cobble."

In discussing slab blanks at Olduvai, Jones noted that although suitable slabs of quartzite and phonolite are available today at Olduvai, they were rarely used by the Acheulian toolmakers. He maintained that flakes were more suited to be used as blanks due to three factors: 1) Tool manufacture from slabs took longer. 2) The quality, angle and edge length were improved in flake blanks. 3) Flakes have a longer edge in relation to their weight than do slabs (Jones 1994, 268).

A good LCT blank is a block of raw material that meets very specific requirements in a very narrow range of sizes and morphologies. Restriction to the exclusive use of chunk blanks for the production of LCTs would have required a rich resource of flat cobbles, slabs or nodules of good knapping quality that measured more than 20 cm. Yet cobbles in most river systems tend to be rounded and suffer from heavy battering during transportation, and most of the volcanic and metamorphic raw materials that were frequently used by Acheulian knappers did not naturally form into flat slabs or nodules. Some materials, like flint, which can occasionally be found in the shape of flat nodules, were rarely available on the surface (but see an exception in the UK Acheulian sites; White 1995). Moreover, surface raw materials would have suffered from weathering, so only freshly exposed nodules could have been used. A possibility of raw material quarrying in the Final Acheulian has recently been raised (Verri et al. 2005), but this would have entailed expending exorbitant energy. It would seem that in all of the sites under study, when a suitable chunk of proper morphology, size and raw material quality was available, it was willingly and skillfully used (Fig. 92). However, these types of blanks were not very frequently exploited. The production of large flakes from large, boulder-sized blocks of raw material **freed** Acheulian knappers from dependence on a limited source of raw material, opening up a wide range of technological opportunities and new environments.

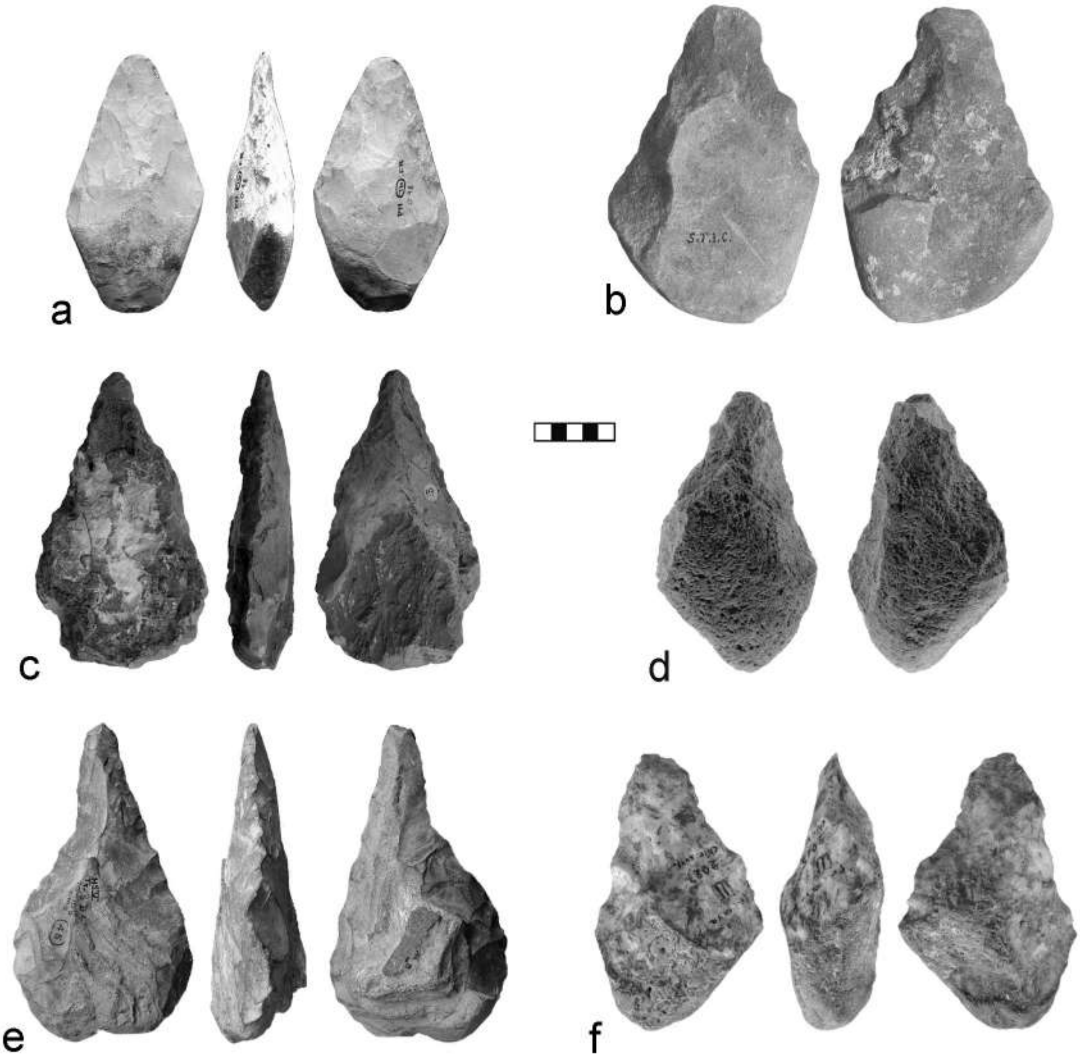

Figure 92. Handaxes made on flat cobbles or chunk blanks. a. Pniel 7. b. STIC. c. Ma‘ayan Barukh. d. GBY NBA. e. Hunsgi. f. Chirki.

Chapter 5: Technological Aspects of Shaping Acheulian LCTs

This chapter is dedicated to the final manufacturing stage in the LFB Acheulian LCT *chaîne opératoire*, namely the shaping of a biface from a selected blank. Three issues relevant to this topic will be addressed: 1) The effect of different raw materials on LCT size and shaping technology. 2) The significance of LCT size as a technological and cultural marker. 3) LCT reduction sequence attribute analysis results and their implications for the morphology of the tools and, on a larger scale, the behavior of Acheulian toolmakers and users.

Raw Material Use in Acheulian LCT Production

Given the diverse geological formations that occur throughout the very large areas that encompassed the Acheulian techno-complex, it is not surprising that widely varying raw material types (e.g. volcanic, sedimentary and metamorphic rocks) were used by the Acheulian knappers for LCT production. Even if it is assumed that some Acheulian hominins transported their raw materials over a few kilometers (see below), the evidence seems to indicate that, on a regional level, toolmakers used those types of rocks that were available in the vicinity of their own sites. In the following section, raw material use strategies will be explored in light of LCTs that were produced from those materials, and will focus on two raw material properties that I have termed "**type**" and "**shape**".

Raw Material Type

Raw material **type** refers to the mechanical properties of each of the rocks that were at the knapper's disposal. These properties comprise a rock's mineralogy and such features as bedding and fissuring (Petraglia et al. 1999). Questions to be answered in this context are:

- What were the rock types in use (mineralogical definitions)?
- What were the physical attributes affecting their knapping qualities (coarse/fine grain, homogeneity, durability, hardness, fragility, sharpness of edges and so on)?
- How frequently were different raw materials used in a specific site and how does this compare with other sites?

- What potentially exploitable raw materials available in the vicinity of a site were **not** used, and why was this the case?

Reports on Acheulian sites do not usually detail raw material availability at a particular site or a site's unexploited resources, and, as mentioned in Chapter 2, detailed mineralogical identification has not been performed for the LCTs under study. Hence, due to a lack of data, some of the above questions will remain unanswered in this study.

Tables 30 and 31 and Figs. 93 and 94 summarize the frequency of use of various raw material types in those sites that have yielded sufficiently large samples (unless otherwise noted, all observations and analyses will focus on samples numbering more than ten tools). With regard to the assemblages sampled in this context, several points are noteworthy:

a) Information based on surface finds does not reflect a raw material's actual frequency of use in a particular site. In the collections from the Vaal River sites, for example, no single assemblage represents a true raw material frequency distribution.

b) Some of the samples presented below were analyzed in order to demonstrate tools made of specific raw materials and their special features. For instance, the small sample from the site of Yediyapur VI served to test some aspects of granite use in large flake production, as they are reflected in an Indian assemblage.

c) The category of "metamorphic rocks" comprises predominantly mylonite tools from Isimila, which were lumped together because the group's subtypes were virtually impossible to identify individually. The term is based on the records of Chicago's Field Museum database.

d) Under the heading "flint", as it refers to Chirki, I have grouped together chert and other types of siliceous rocks that were described by Corvinus (1983b).

e) Although not sampled in the current study, additional raw materials represented by a small number of artifacts, were reported in the sites of Ma'ayan Barukh, Tachenghit and Doornlaagte (Alimen 1978; Mason 1988; Stekelis and Gilead 1966).

Table 30. Raw material use frequency in handaxe production by site (data for Olduvai HK, Boxgrove, Cuxton and Broom Pits after Marshall et al. 2002).

Site		Flint	Limestone	Basalt	Quartz	Quartzite	Sandstone	Granite	Dolerite	Andesite	Hornfels	Chert	Phonolite	Metamorphic Rock	Total
STIC	N					82									82
	%					100									100
Ternifine	N	3	1			48	5								57
	%	5	2			84	9								100
Grotte des Ours	N					81									81
	%					100									100
Tachenghit	N					29									29
	%					100									100
Hunsgi	N		43			1	1								45
	%		96			2	2								100
Chirki	N	3		24	1				13						41
	%	7		59	2				32						100
Power's Site	N					1				48					49
	%					2				98					100
Pniel 6a	N									40					40
	%									100					100
Riverview	N					1				31	14				46
	%					2				67	30				100
Pniel 7b	N	1				2				37					40
	%	3				5				93					100
Doornlaagte	N									16	1				17
	%									94	6				100
Isimila K6	N	1			10			148						26	185
	%	1			5			80						14	100
Isimila K14	N							11						14	25
	%							44						56	100
Isimila K19	N				1			5						17	23
	%				4			22						74	100
GBY NBA	N	49		130											179
	%	27		73											100
Ma'ayan Barukh	N	125													125
	%	100													100
GBY Layer II-6	N	12	7	305											324
	%	4	2	94											100
Olduvai HK	N			1		116				3			3		123
	%			1		94				2			2		100
Boxgrove	N	182													182
	%	100													100
Cuxton	N	214													214
	%	100													100
Broom Pits	N	11										242			253
	%	4										96			100
Total	N	601	51	460	12	361	6	164	13	175	15	242	3	57	2160
	%	28	2	21	1	17	0	8	1	8	1	11	0	3	100

Table 31. Raw material use frequency in cleaver production by site.

Site		Flint	Limestone	Basalt	Quartz	Quartzite	Sandstone	Mudstone	Granite	Dolerite	Andesite	Hornfels	Metamorphic Rock	Total
Ternifine	N	2	9			29	5	2						47
	%	4	19			62	11	4						100
Tachenghit	N					16								16
	%					100								100
Hunsgi	N		49											49
	%		100											100
Yediyapur VI	N	1	1				1		7	2				12
	%	8	8				8		58	17				100
Chirki	N	1		35						12				48
	%	2		73						25				100
Power's Site	N					2					116			118
	%					2					98			100
Pniel 6a	N					2					100			102
	%					2					98			100
Riverview	N										70	6		76
	%										92	8		100
Pniel 7b	N					1					98			99
	%					1					99			100
Doornlaagte	N										14			14
	%										100			100
Isimila K6	N				1				15				12	28
	%				4				54				43	100
Isimila K14	N								31				24	55
	%								56				44	100
Isimila K19	N				1				2				37	40
	%				3				5				93	100
GBY NBA	N	2		96										98
	%	2		98										100
GBY Layer II-6	N		1	135										136
	%		1	99										100
GBY Area C	N			16										16
	%			100										100
Total	N	6	60	282	2	50	6	2	55	14	398	6	73	954
	%	1	6	30	0	5	1	0	6	1	42	1	8	100

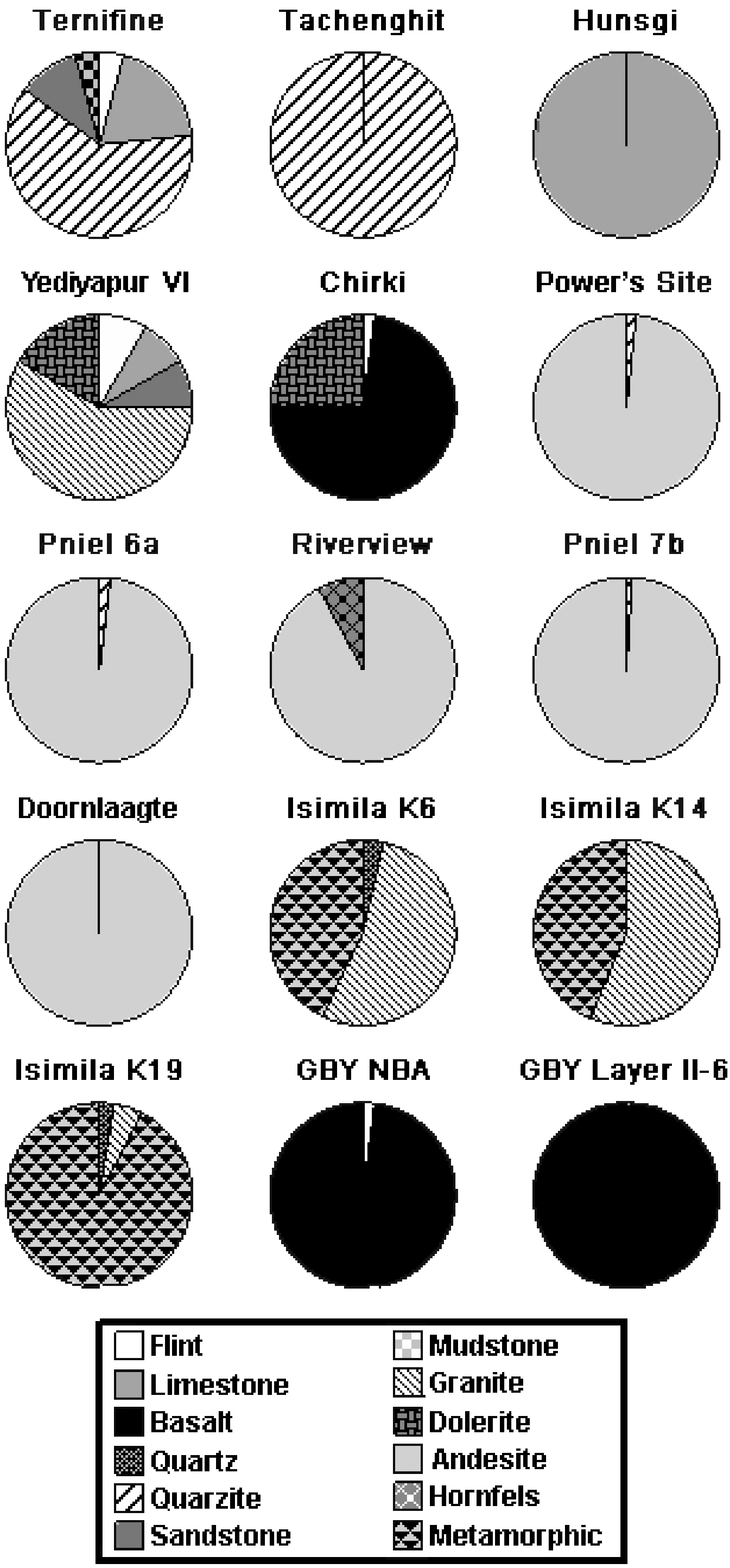

Figure 93. Cleaver raw material type frequency.

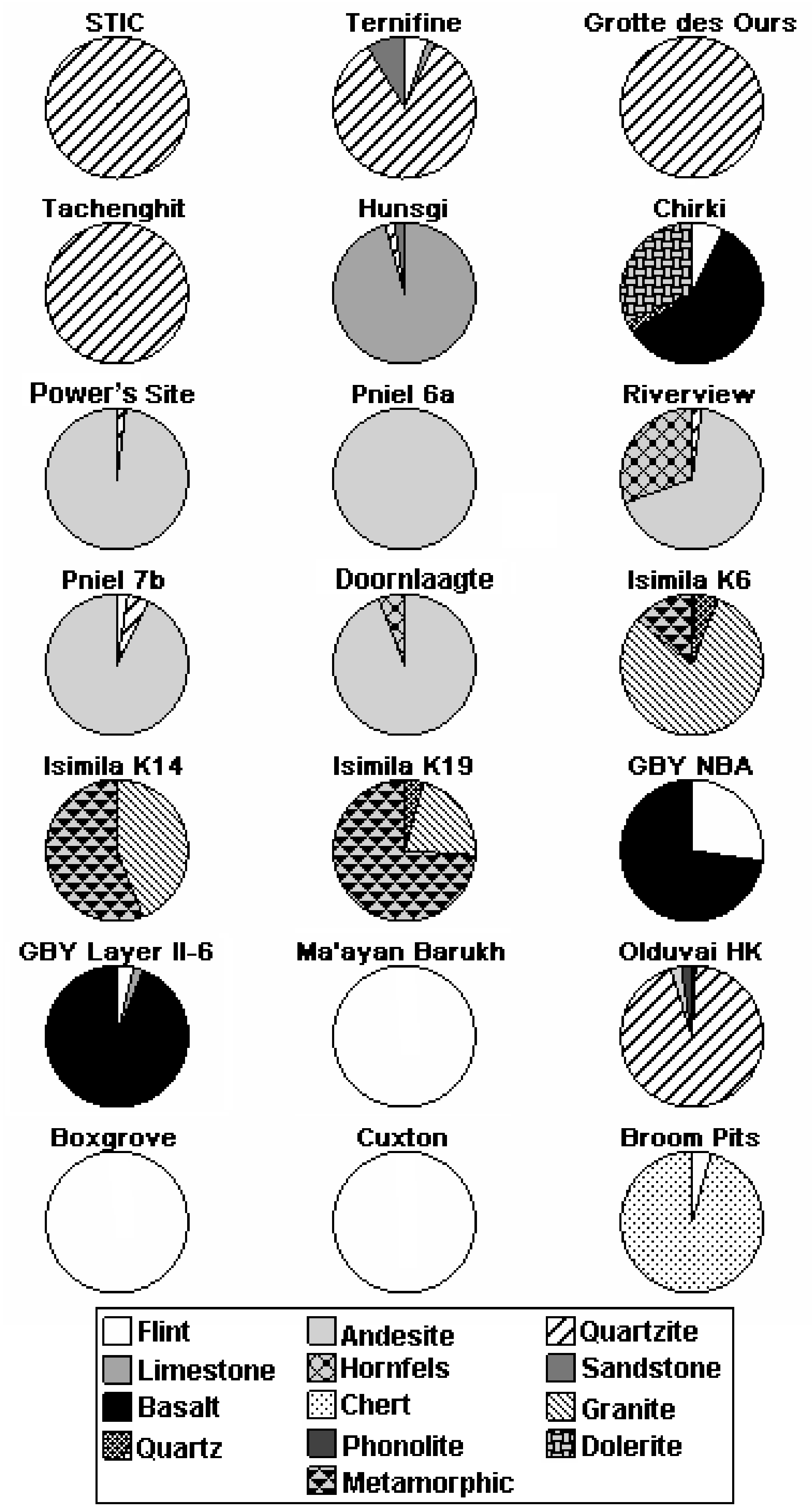

Figure 94. Handaxe raw material type frequency.

Three patterns of raw material exploitation emerge from the data presented above:

a) The dominance of a single type of raw material, as exemplified by the Casablanca sites, Hunsgi, the Vaal River sites (with the exception of Riverview), Ma'ayan Barukh and the UK sites. In all of these a prominent type of raw material was used for the production of LCTs, with other raw materials being either absent or minimally represented.

b) Two types of raw material were in use: one dominant, the other minor. The minor raw material did not normally comprise more than 25% of the entire sample. The assemblages from GBY, Riverview, Chirki and Isimila K14 represent such cases.

c) More than three types of raw materials were used in the cases of Ternifine, Yediyapur, and to some extent Isimila K6 and Olduvai HK.

In order to examine the reasoning behind raw material type selection, let us address some specific sites. The Northern Dead Sea Rift sites (GBY and Ma'ayan Barukh) and the Hunsgi-Baichbal sites (Paddayya 1982, 1991; Petraglia et al. 1999) both represent cases of neighboring sites that exhibit fundamental differences in raw material selection for LCT production. At GBY, basalt was the dominant raw material, whereas at the Late Acheulian site of Ma'ayan Barukh, situated 25 km to the north of GBY in the Hula Valley, flint was used almost exclusively (Stekelis and Gilead 1966). The most diverse area in terms of raw material exploitation for Acheulian biface production was probably the Hunsgi-Baichbal Basin. Here, limestone, granite, dolerite, schist, chert and aplite blocks were all in use. Although more than 200 Acheulian localities have been reported in about 500 km^2 of this drainage basin, in almost all of these sites toolmakers apparently applied a different raw material type strategy (see Chapter 3 for details and references). Another interesting example is the Acheulian site of Berkehat Ram, Golan Heights (Goren-Inbar 1985). Although the site is located in a basalt-rich environment, its inhabitants confined themselves almost exclusively to flint. These facts can lead to conclude that the availability of a certain raw material in the vicinity of a site could not have been the sole, or even the main, consideration in the Acheulian knapper's mind when selecting a raw material type for LCT production.

If we consider our data further, we find that with the exception of the small sample from Yediyapur, raw material selection for cleaver production seems to have been less varied than that of handaxes. In cleaver production, when more than one type of material was used, the dominant type was very pronounced, much more so than its prominence in handaxe production under similar circumstances. The Acheulian toolmaker perceived handaxes in less rigid terms than he did cleavers, a fact that facilitated their manufacture from a larger variety of raw material types and blank shapes. This was probably due to technological factors, as the production of cleavers from large flakes was a very specific process, requiring meticulous raw material selection (see also Texier and Roche 1992). If we trace the different stages of the Acheulian in Israel, as they are represented by the tools of ‘Ubeidiya, GBY and the Late Acheulian sites, different raw material use strategies can be detected in their lithic industry, particularly in their LCT production. It would seem that over the lengthy duration of the Acheulian techno-complex, hominins practised ever-changing raw material use strategies.

Raw Material Grain and Knapping Quality

For the purposes of discussion, I have divided raw material types into a fine-grained group and a coarse-grained group. The former group includes flint, obsidian and hornfels, while basalt, andesite, quartz, quartzite and granite comprise the latter. This partition is based on a rough evaluation of the rocks in terms of such attributes as their homogeneity, lack of intrusions and crystal-size compactness, and is by no means an objective mineralogical definition or a rigid archaeological one. It also renders the knapping qualities of a specific rock a subjective criterion, depending largely on the dexterity and experience of the knapper (Jones 1979; Jones 1994; Madsen and Goren-Inbar 2004; McNabb et al. 2004). Let us take quartz as an example. Mineralogically, this rock has very large crystals, which can definitely produce a sharp edge. Yet in terms of knapping quality most quartz blocks have many intrusions and cracks that make them very hard to control during knapping, especially when producing large tools (Figs. 93, 94). In using this approach, it should be borne in mind that the Rift Valley basalt of GBY is different from the Indian Deccan Trap basalt of Chirki, and that the East African Isimila granite is different from that of Yediyapur. Within Israel itself, flint varies in homogeneity, shape, size and color. The following examples all come from cleaverless, non LFB assemblages. The makers of the Ma‘ayan Barukh handaxes, for example, used flint of the highest quality, while the makers of the handaxes of Rephaim-Baka in Jerusalem exploited brecciated flint of very poor quality (see Gilead 1970 for references). This Mashash formation flint, widely available in the vicinity of Rephaim-Baka, sometimes in the shape of large blocks, is typically very inhomogeneous, with many fissures and inconsistencies that make it very hard to control during knapping.

Other examples originate in the site of the Umm Qatafa Cave in the uplands of the Judean Desert (Gilead 1970; Neuville 1931), where the variety of flint types, some of very low knapping quality, is enormous (Fig. 95). Nevertheless, my suggested partition provides some aid in shedding light on raw material type use strategies.

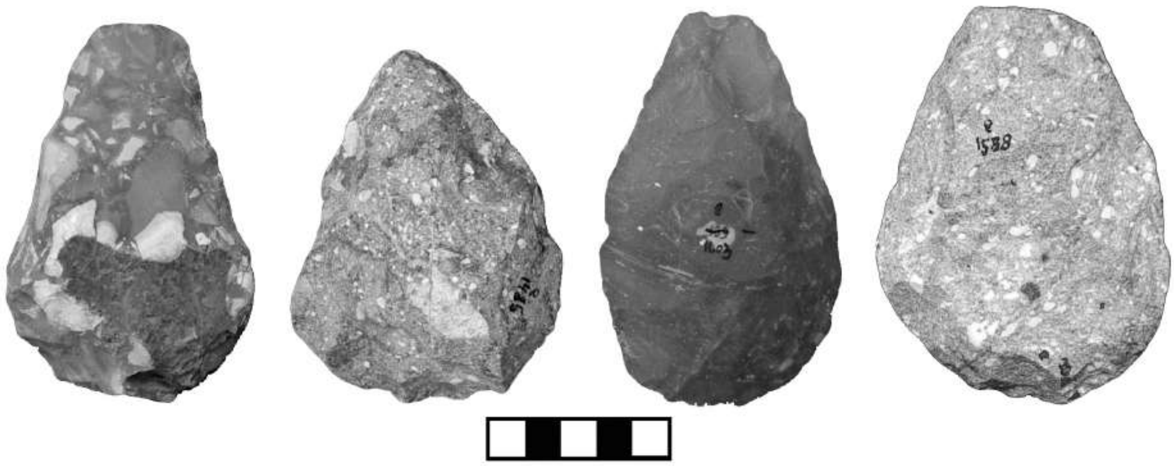

Figure 95. Variety of flint types used for handaxes at Umm Qatafa Cave (collection of the Institute of Archaeology, the Hebrew University of Jerusalem).

Most of the assemblages cited above, in which LCT blanks were produced from large flakes, show that, when presented with a choice, the Acheulian knapper had a preference for coarser-grained material (Tables 3, 31, Figs.93, 94). There are very few examples of Acheulian LFB industries dominated by such fine-grained rocks as flint or obsidian (e.g. Upper Site of Kariandusi, Gowlett 1980). At GBY, basalt was preferred over flint; at the Vaal River sites, andesite was preferred over hornfels; at Chirki, basalt was used more often than dolerite; and in the Acheulian sites of La Rioja, Spain, quartzite was preferred over flint for the production of LCTs, although the latter raw material was found in abundance in the vicinity of the sites (Utrilla and Mazo 1996). Recently, Clark and others (Clark et al. 2003) have reported a similar pattern in the Late Acheulian/MSA transition assemblages of Herto, Middle Awash. At Herto, bifaces were all made on basalt, while flake tools and blades were in many cases made on obsidian. The data from the site of Melka Kunture on the Awash River, Ethiopia, are preliminary, and whether these assemblages belong to the LFB Acheulian is yet to be tested. Yet the data provide some support for this scenario (Chavaillon and Piperno 2004). The hominins of Melka Kunture had access to a large variety of raw materials, including obsidian, which had been extensively used from the earliest occupation levels (Oldowan) of the site. However, when selecting a raw material for

LCT production, knappers demonstrated a complex pattern in which obsidian was not always their first choice. Of 144 LCTs excavated in level B of the Early Acheulian site of Simbiro III, only 12.5% were produced on obsidian. At Gombore II, all cleavers were made on basalt and 85% of the (relatively small) handaxes were made on obsidian. At the Late Acheulian site of Garba I, obsidian was rarely used and most of the LCTs are reported to have been flaked from basalt or trachyte (Chavaillon and Berthelet 2004). Additional regions in which obsidian was common show similar tendencies. The site of Chikini, Southern Georgia is adjacent to very large outcrops of obsidian, yet only one obsidian handaxe was collected amongst the many andesite bifaces originating in this locality (Z. Kikodze, personal communications 2001; but see also Lyubin and Belyaeva 2006).

Raw Material Shape

In Acheulian typology, regional variability has often been attributed to differences in the properties and shapes of the raw material available in each area (Ashton and White 2003; Ashton and McNabb 1994; Clark 1980, 2001; White 1995). Raw material **shape** denotes the original morphology of a block of raw material, as it was available to the prehistoric knapper. This shape could have resulted from the natural formation processes of the rock (e.g. nodules or slabs), or from the weathering processes to which it was subjected after exposure (e.g. rolling into cobbles in river beds or basalt weathering into slabs). Questions to be answered in this context are:

- What were the natural form and size of the raw material that was available to the prehistoric knapper?
- What knapping methods were developed and used by the Acheulians in exploiting the resources of shape and size?

Unfortunately, in the current state of research the first question must remain unanswered with regard to most of the samples under study. Our brief discussion will therefore focus on the second question, through examination of the tools themselves and by reconstructing raw material shape and tracing its effect on LCT technology and morphology.

Much of the debate surrounding the effects of raw material shape on LCT morphology has dealt with the production of handaxes from flint nodules in the British Lower Paleolithic (Ashton and McNabb 1994; Ashton and White 2003; White 1995). Here I will focus on the block of raw material and the role played by its shape in determining the core technology to be applied in large flake extraction. As discussed in detail in Chapter 4, the

Acheulian knappers exploited a large variety of raw material block shapes as cores for large flake production, and the knapping properties of these raw materials presented no limitations. Of course, the shape of the raw material block had to be of sufficient size to allow for large flake production (larger than 10 cm). The Acheulian knappers showed astonishing flexibility in their ability to manipulate an available raw material's shape and size into a large flake core, as exemplified by the Ternifine cobble *entame* flakes and the Hunsgi and GBY sliced slab cleaver flakes.

Raw Materials and LCT Size

Raw material size was a significant factor in LCT knapping, since large flake blanks had to be detached from sufficiently large giant cores. Where no bulky raw material was available, production of large flakes could not have taken place. However, the question of whether LCT size was initially determined by a raw material's knapping properties should be examined. Experimental data suggest that detachment of very large flakes is harder to execute on coarse-grained raw materials (Jones 1979; 1994; Kleindienst and Keller 1976; Madsen and Goren-Inbar 2004). Hence, one would expect that LCTs produced on coarse-grained rock types would be smaller than those produced on fine-grained rocks. Fig. 96 presents maximal dimensions of LCTs in correlation with their raw material type.

Two observations emerge from the above data: a) LCTs from the entire geographical distribution of the Acheulian exhibit the same range of sizes, regardless of their raw material type and their geographical origin (see below). b) Bifaces originating in assemblages dominated by very coarse-grained raw materials are the largest in dimensions. In the Isimila sites, for example, granite and metamorphic rocks were used in the production of the largest LCTs that were studied here. The smallest LCTs seem to have been made on flint and dolerite, which are both relatively fine-grained rock types. It could be suggested that coarse-grained rocks were preferred for LCT production due to their high specific gravity, which made them heavier. Weight could have been an important factor in the use of LCTs. Fig. 97 presents tool weight distribution in correlation with tool raw material.

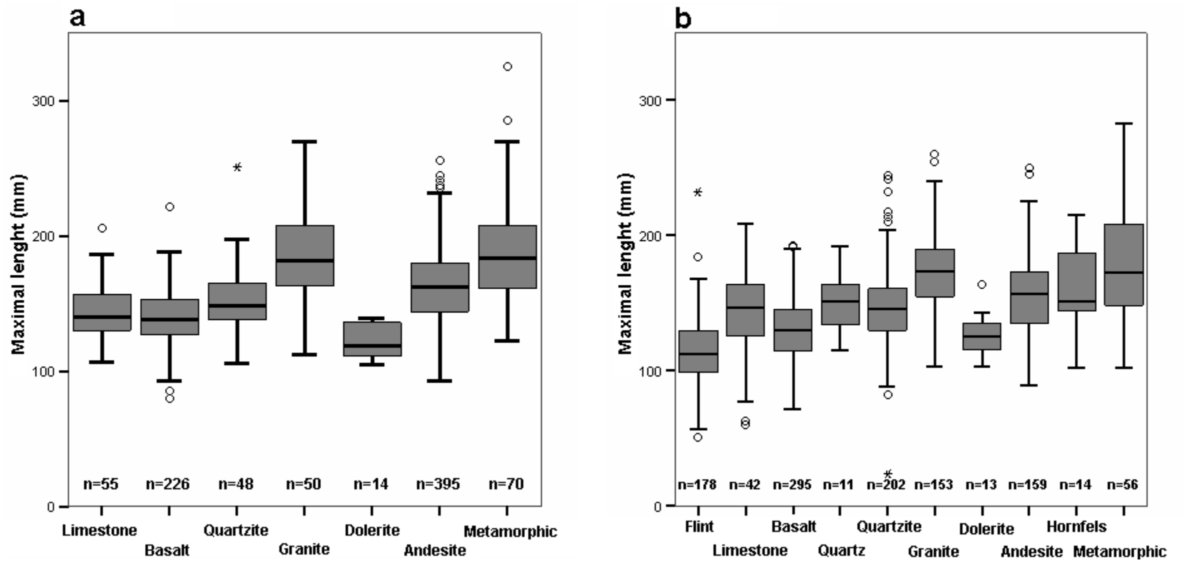

Figure 96. LCT sizes (maximal length in mm) in correlation with raw material type (complete tools only). A. Cleavers. b. Handaxes.

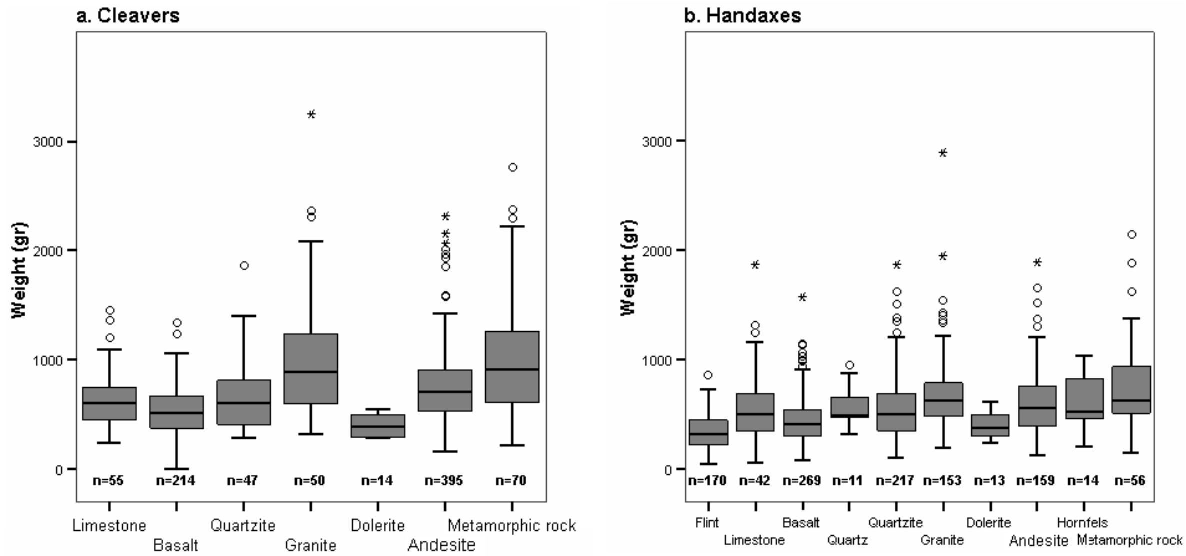

Figure 97. Weight (gr) of LCTs by raw materials. a. Cleavers. b. Handaxes.

As can be observed, the range of weights is quite limited, with the marked exception of the very large (granite and metamorphic rock) tools of Isimila. There is no evidence that any raw material type was selected because of its higher specific gravity. Exceptionally large LCTs are also the heaviest (Jones 1994).

Intra-assemblage Size and Raw Materials

In some sites, such as Olorgesailie, the size of LCTs made of a particular material differed from those made of other materials (Noll 2000). Fig. 98 presents the circumferences (a good indication of overall tool size) of LCTs in individual sites, in correlation with their raw material type.

Most of the sites show no significant size differences between tools made of various raw material types. LCTs produced on minor raw material types (Figs. 93, 94) fall well within the size range of those made from a dominant raw material. There was no single raw material that was preferred for the production of larger tools, with the exception of the GBY assemblage, where larger handaxes were made of basalt and smaller ones of flint and limestone. Nevertheless, technological observation has demonstrated that large flakes were produced from flint at GBY to be used as handaxe blanks. Moreover, flint large-flake handaxes were produced by a core technology similar to that of basalt handaxes, and by the same shaping method (Fig. 99). It may be concluded, therefore, that neither raw material size nor technological constraints presented any limitations to the GBY knappers. The reason behind the production of GBY's smaller flint and limestone handaxes probably relate to the size of the cobbles available in the vicinity of the site.

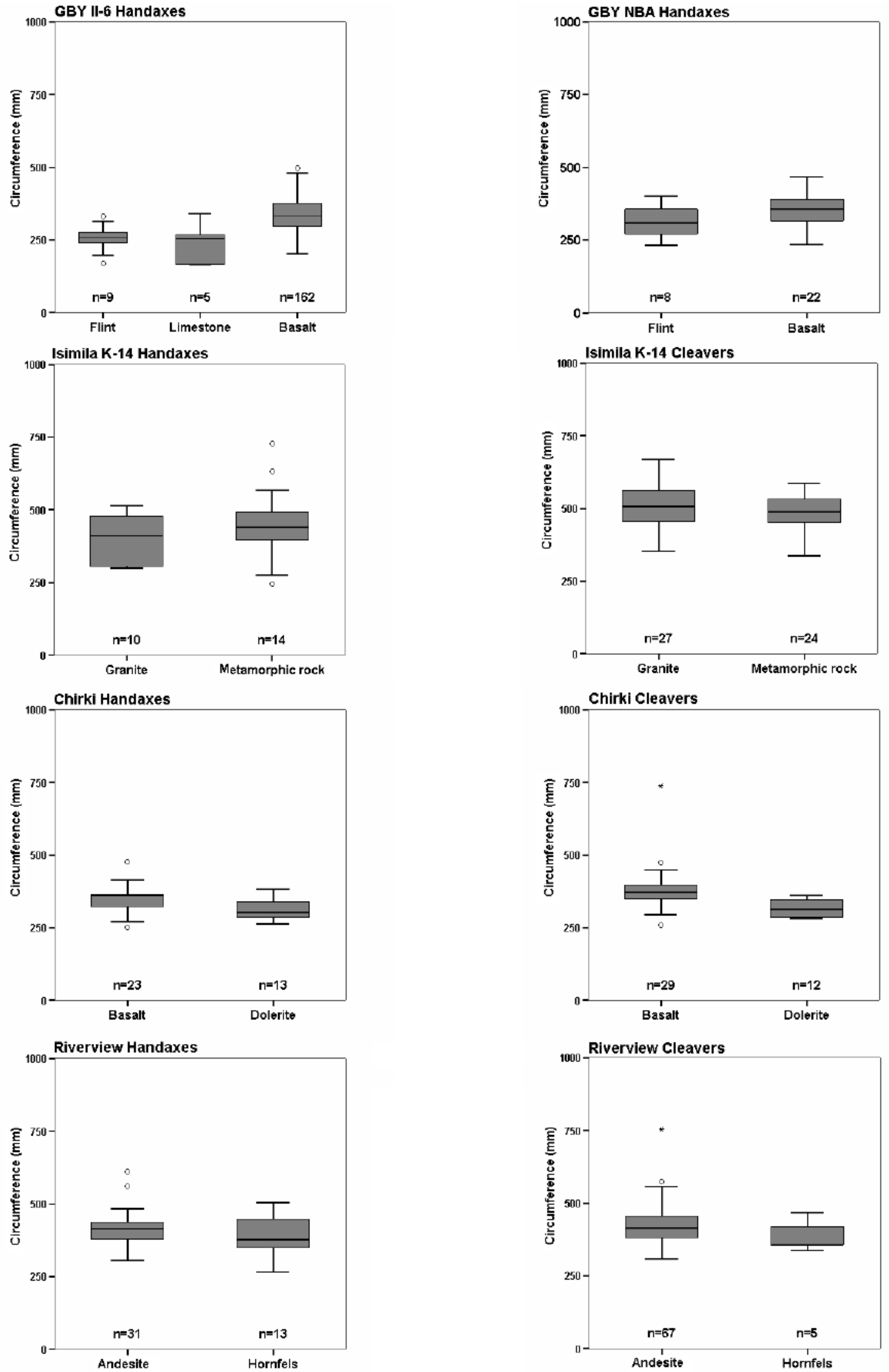

Figure 98. LCT Circumference (mm) by raw materials. Sample sizes >5 (GBY NBA and GBY Layer II-6 yielded samples of non-basalt cleavers that were too small).

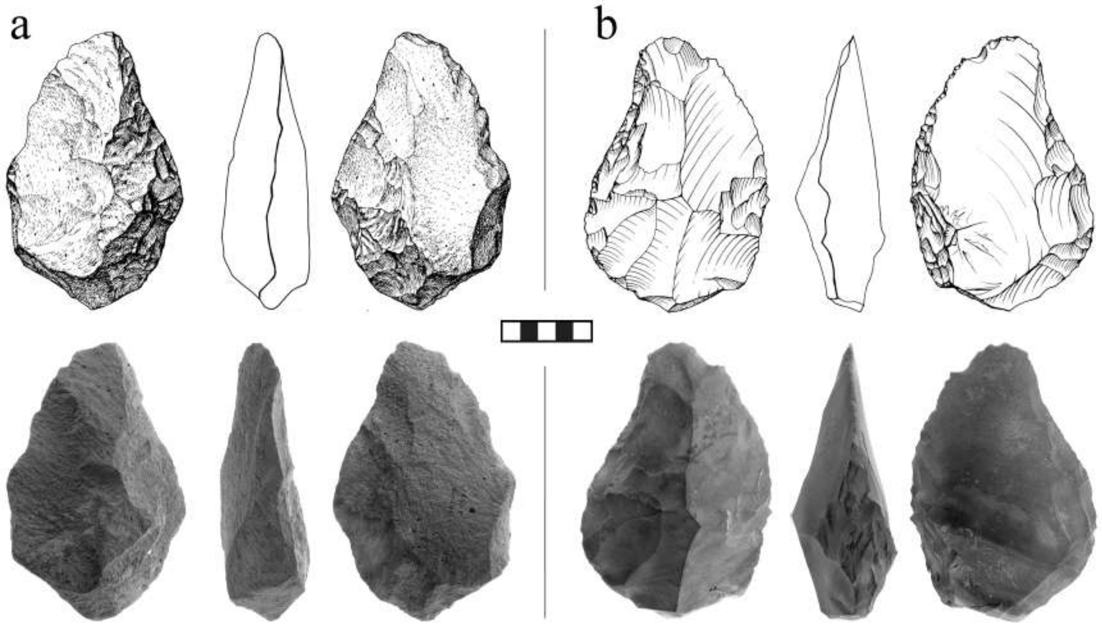

Figure 99. Handaxes made on large flakes from GBY NBA. a. Basalt. b. Flint (note the similarity in size and morphology).

Raw Material Observations - Summary

The role of raw materials in dictating LCT size, technology and morphology has been the subject of much research and debate in recent years. Up to this point, we have attempted to describe the benefits that the Acheulian knappers reaped from the qualities of raw materials, as well as the difficulties that they faced during the reduction sequence of large flake production and LCT shaping. The following general aspects of raw material **type** (mineralogical definition and knapping qualities and constraints), **shape** (form of raw material blocks) and size were addressed.

It is evident that in most sites more than one raw material type was in use, although a single type was usually preferred over others. Cleavers were less varied than handaxes in raw material use, even within the same site, although handaxes were produced on large flakes by a method similar to that of cleavers.

The toolmakers of the LFB Acheulian industries had a preference for coarse-grained rock types in the production of LCTs. Even at sites where fine-grained raw material was widely available, large flakes were produced on hard-to-control, poor-quality rocks. Though hard to knap, rocks like granite and basalt were extensively exploited and preferred over more easily knappable materials (from a modern perspective) like flint or obsidian.

Moreover, the largest flakes (and larger LCTs) were produced on coarse-grained material. The specific gravity of the rock types was not observed to play a role in raw material use strategies.

The conclusion to be drawn from these facts is that a raw material's availability, type, shape and technological constraints were not the primary factors dictating its strategy of use, leading to the possibility that the main consideration guiding the Acheulian knapper was a functional/cultural preference. It should also be noted that in the Levant of the Late (non-LFB) Acheulian, handaxes were produced exclusively on flint, testifying that there were chronological differences between LFB industry preferences and those of later handaxe industries.

The Size of Large Cutting Tools

Opening Remarks

Most researchers perceive the different aspects of LCT size as central to any discussion on these tools' technology, typology and function. The more influential typological classification methods are based on indexes of the various aspects of tool size (Bordes 1961; Roe 1968, 1994), as are new approaches to the study of LCTs (McPherron 1999; Saragusti 2003; Wynn and Tierson 1990). Almost any overview of Acheulian variability and inter-assemblage relations is largely based on such metrical data (Gilead, 1970a; Isaac 1977; Kleindienst 1962), as are the numerous discussions on intra-assemblage variability (see Goren-Inbar and Sharon 2006 for many recent examples).

In this study, different aspects of LCT size will be compared on a complete-assemblage scale, without using sophisticated statistical manipulation. The discussion will then be expanded to include regional and global perspectives. Two points are relevant to this issue: a) All size measurements pertain only to complete artifacts. b) Occasionally, small samples (generally of cleavers) are discussed, although they cannot be taken to represent a site's full range of data. Rather, they serve to illustrate interesting aspects of a given assemblage that could not otherwise have been presented.

Intra-site Size Variability

The LCTs in this study were examined at the level of the site, although significant variations in size have been observed within single localities, such as the Isimila localities, Olorgesailie (Isaac 1977) and other sites (Clark 2001; Leakey and Roe 1994). This puts into question the validity of using this level. However, the archaeological resolution of GBY has yielded a conclusive answer to this, which is represented in Figs. 100 and 101. Here we presented the maximal length of handaxes and cleavers from GBY, Area B, Layer II-6 (comprising 7 sub-layers) and Area C, Layers V-2 to V-6 (Goren-Inbar et al. 2000; see also Chapter 2), both samples possibly preserving evidence reflecting a span of millennia of human presence at GBY (Goren-Inbar et al. 2000).

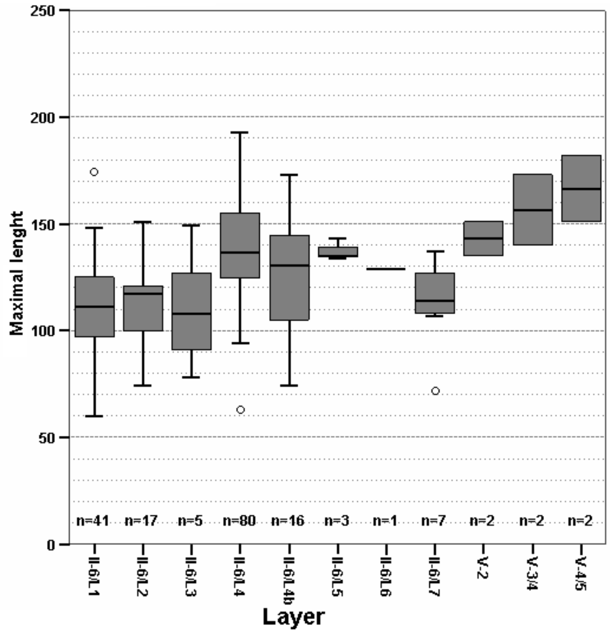

Figure 100. Maximal length of GBY handaxes by sub-layer.

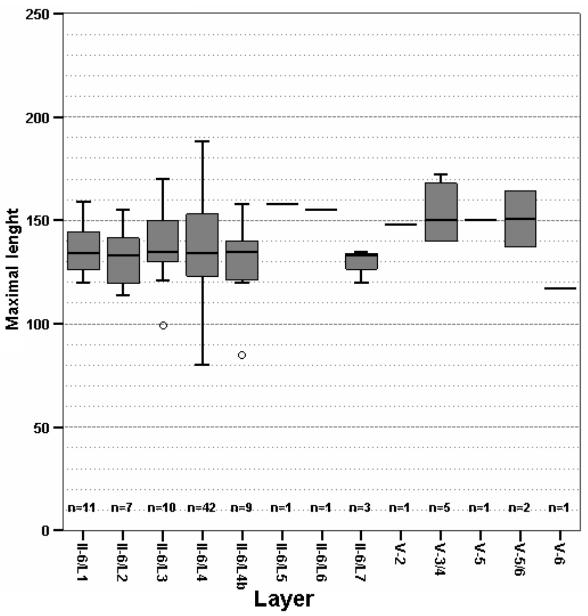

Figure 101. Maximal length of GBY cleavers by sub-layer.

It is evident from the above graphs that GBY handaxes and cleavers originating in different layers all fall within the same size range, regardless of their material and technology of manufacture. The similarity in size between all of the Layer II-6 cleavers is astonishing. Handaxes, on the other hand, are much more varied in size. Area C handaxes and cleavers are slightly larger than Layer II-6 LCTs (note that the sample size is very small), but these fine differences are negligible. Hence, the GBY data demonstrate a general similarity of size between the different layers of the site, estimated to represent 100,000 years of archaeological habitation, supporting the validity of grouping Acheulian LCTs from different layers into a single assemblage.

LCT Size Metrical Data

Tables 32 and 33 present descriptive metrical statistics for all complete LCTs in the assemblages under study, which have been subdivided under the headings of "cleavers", "handaxes" and "handaxes from large LFB assemblages" (including the GBY sites, the Isimila sites, Doornlaagte, the Pniel sites, Power's Site, Riverview, Chirki, Hunsgi, Tachenghit and Ternifine). Regardless of their technology of manufacture, I have integrated the size measurements of handaxes from all available datasets (Marshall et al. 2002; Noll 2000) into general handaxe columns (n=2925) and have isolated the LFB assemblage handaxes for purposes of comparison with non-LFB handaxe assemblages. Of particular interest are the handaxes from Tabun Cave, as discussed below. Table 32 presents length, width and thickness, with Table 33 indicating weight and circumference. According to the SPSS software guide, these are the meanings of the different statistical measurements:

> "**5% Trimmed Mean** - The arithmetic mean calculated when the largest 5% and the smallest 5% of the cases have been eliminated. Eliminating extreme cases from the computation of the mean results in a better estimate of central tendency, especially when the data are non-normal.
>
> **Interquartile Range** - A measure of the spread of the data. The distance between the third quartile (75th percentile) and the first quartile (25th percentile) values.
>
> **Skewness** - A measure of the asymmetry of a distribution. The normal distribution is symmetric, and has a skewness value of zero. A distribution with a significant positive skewness has a long right tail. A distribution with a significant negative skewness has a long left tail. As a rough guide, a skewness value more than twice its standard error is taken to indicate a departure from symmetry.
>
> **Kurtosis** - A measure of the extent to which observations cluster around a central point. For a normal distribution, the value of the kurtosis statistic is 0. Positive kurtosis indicates that the

observations cluster more and have longer tails than those in the normal distribution and negative kurtosis indicates the observations cluster less and have shorter tails."

The following graphs present the maximal length (Figs. 102, 103) and circumference (Figs. 104, 105) of LCTs by site. The circumference of a tool was measured around its perimeter, adjacent to the cutting edge. One difficulty with this type of measurement is that tools with a less homogenous shape (such as Micoquian shapes or bifaces with notches along their edges) yield results that are higher in value than those of more regularly shaped tools. Fortunately, heavily notched and irregular shapes are quite rare among the assemblages under study.

Table 32. Descriptive statistics (length, width and thickness) pertaining to all complete LCTs.

		Cleavers (n=1056)		**Handaxes (n=2925)**		**Handaxes from Large-flake Assemblages (n=881)**	
		Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Length	Mean	159.26	.96	134.37	.71	145.88	1.17
	5% Trimmed Mean	157.89		133.14		145.12	
	Median	156.50		132.60		143.00	
	Variance	967.123		1477.661		1202.348	
	Std. D.	31.10		38.44		34.67	
	Minimal	80		47		57	
	Maximal	325		295		283	
	Range	245		248		226	
	Interquartile Range	40.75		53.34		45.00	
	Skewness	.774	.075	.439	.045	.361	.082
	Kurtosis	1.550	.150	.073	.091	.269	.165
Width	Mean	95.41	.58	81.35	.34	83.87	.52
	5% Trimmed Mean	94.54		81.02		83.66	
	Median	94.00		81.00		84.00	
	Variance	354.565		328.661		238.015	
	Std. D.	18.83		18.13		15.43	
	Minimal	35		32		34	
	Maximal	209		170		155	
	Range	174		138		121	
	Interquartile Range	21.00		24.00		19.00	
	Skewness	.986	.075	.274	.045	.324	.082
	Kurtosis	3.371	.150	.128	.091	1.387	.165
Thickness	Mean	43.86	.30	40.38	.21	42.62	.33
	5% Trimmed Mean	43.37		39.99		42.30	
	Median	43.00		39.90		42.00	
	Variance	92.441		126.533		96.643	
	Std. D.	9.61		11.25		9.83	
	Minimal	19		13		15	
	Maximal	102		104		104	
	Range	83		91		89	
	Interquartile Range	11.00		15.00		12.00	
	Skewness	1.040	.075	.587	.045	.760	.082
	Kurtosis	3.156	.150	.773	.091	2.527	.165

Table 33. Descriptive statistics (weight and circumference) pertaining to all complete LCTs.

		All complete cleavers n=888		**All complete handaxes N=2322**		**Complete handaxe large-flake assemblages n=753**	
		Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Weight	Mean	731.34	13.65	436.92	6.18	545.25	11.15
	5% Trimmed Mean	689.39		410.36		519.08	
	Median	648.50		371.00		500.00	
	Variance	165408.12		88784.310		93697.202	
	S.D.	406.70		297.97		306.10	
	Minimal	131		22		60	
	Maximal	4082		2893		2893	
	Range	3951		2871		2833	
	Interquartile Range	438.75		347.00		325.00	
	Skewness	2.330	.082	1.650	.051	1.893	.089
	Kurtosis	10.027	.164	4.884	.102	7.376	.178
Circumference	Mean	414.09	2.57	327.45	1.77	375.69	2.85
	5% Trimmed Mean	410.93		325.35		373.98	
	Median	411.00		322.30		373.00	
	Variance	5871.836		7246.050		6137.690	
	S.D.	76.63		85.12		78.34	
	Minimal	215		112		166	
	Maximal	770		727		727	
	Range	555		615		561	
	Interquartile Range	102.00		117.22		104.00	
	Skewness	.710	.082	.352	.051	.357	.089
	Kurtosis	1.575	.164	.065	.102	.564	.178

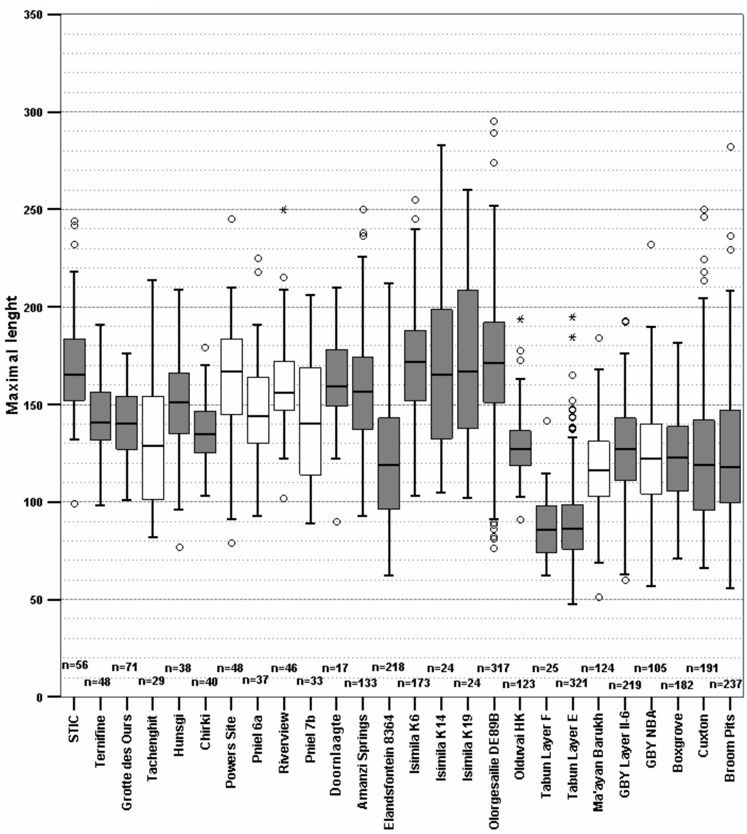

Figure 102. Length (mm) of complete handaxes by site. White boxes represent assemblages that originated in unexcavated contexts, i.e. surface collection.

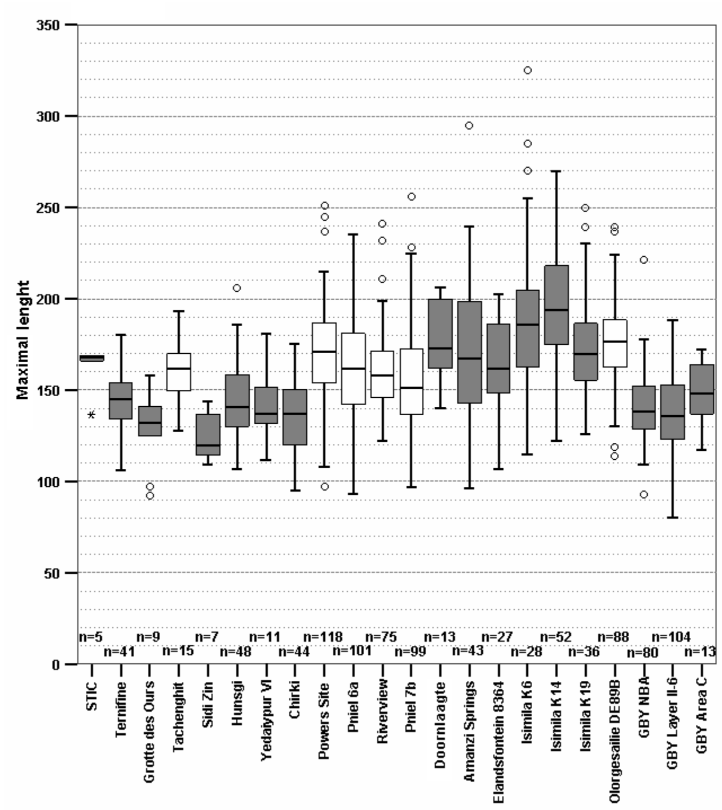

Figure 103. Length (mm) of complete cleavers by site. White boxes represent assemblages that originated in unexcavated contexts, i.e. surface collection.

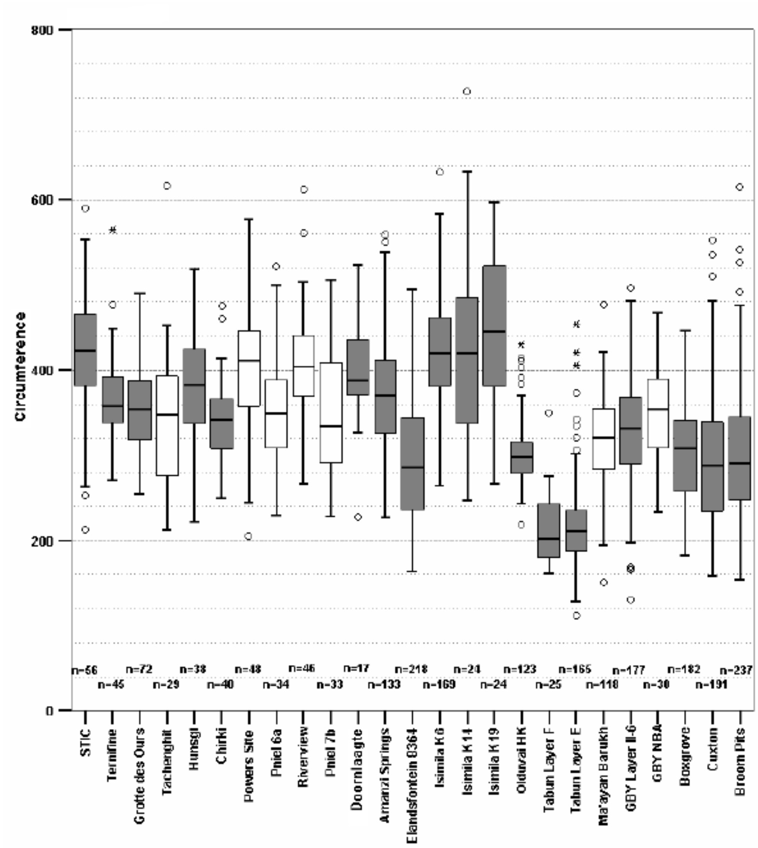

Figure 104. Circumference of complete handaxes by site. White boxes represent assemblages that originated in unexcavated contexts, i.e. surface collection.

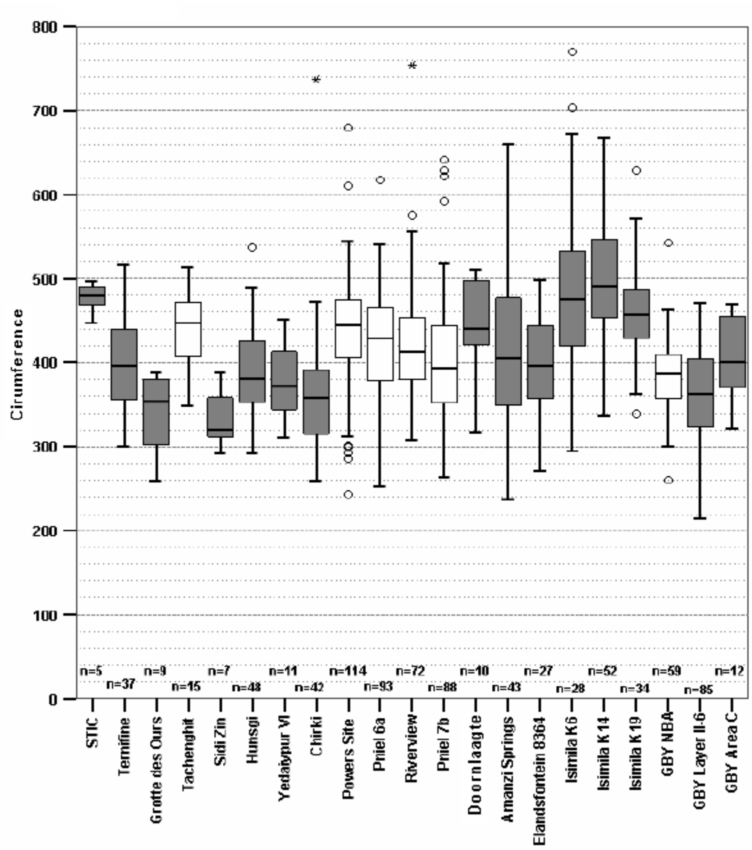

Figure 105. Circumference of complete cleavers by site. White boxes represent assemblages that originated in unexcavated contexts, i.e. surface collection.

LCT Maximal Dimensions

From a global perspective, the most striking observation emerging from the above data is that 90% of all LCTs from all regions of the Acheulian distribution fall within a 100 mm length range. It is evident that almost all bifaces in all assemblages are between 100 and 200 mm in maximal length (or between 300 and 500 mm in circumference), with a surprisingly small number of outliers. Moreover, 50% of the handaxes fall within the 53 mm interquartile range and 50% of the cleavers fall within the 41 mm interquartile range (Table 32).

Recent studies of Acheulian sites in the Levant (Brande and Saragusti 1996; Gisis and Ronen 2006; Marder et al. 2006) have been very fruitful in terms of identifying variability between layers in the same site or in the same region. The present study's global perspective emphasizes the great **similarity** in size between assemblages from the entire Acheulian geographical distribution. It also stresses such pronounced exceptions as the small Tabun handaxes and less prominent deviations like the large Isimila K14 LCTs (Figs. 102, 103). The possible meaning of these deviations will be discussed below.

LCT Width

The distribution of maximal width for handaxes and cleavers is presented in Figs. 106 and 107. The variability is the smallest among all the measurements presented here (kurtosis value of 3.371 for cleavers and 0.128 for handaxes, see Table 32). After Wynn and Tierson (1990) developed the polar coordinates system for handaxes, Vaughan (2000) tested the corrected coefficient of variation (the standard of deviation was expressed as a percentage of the mean). His results support the above conclusion: "… the width of handaxes is considerably less variable than any of the other variables describing handaxe morphology" (Vaughan 2000, 148).

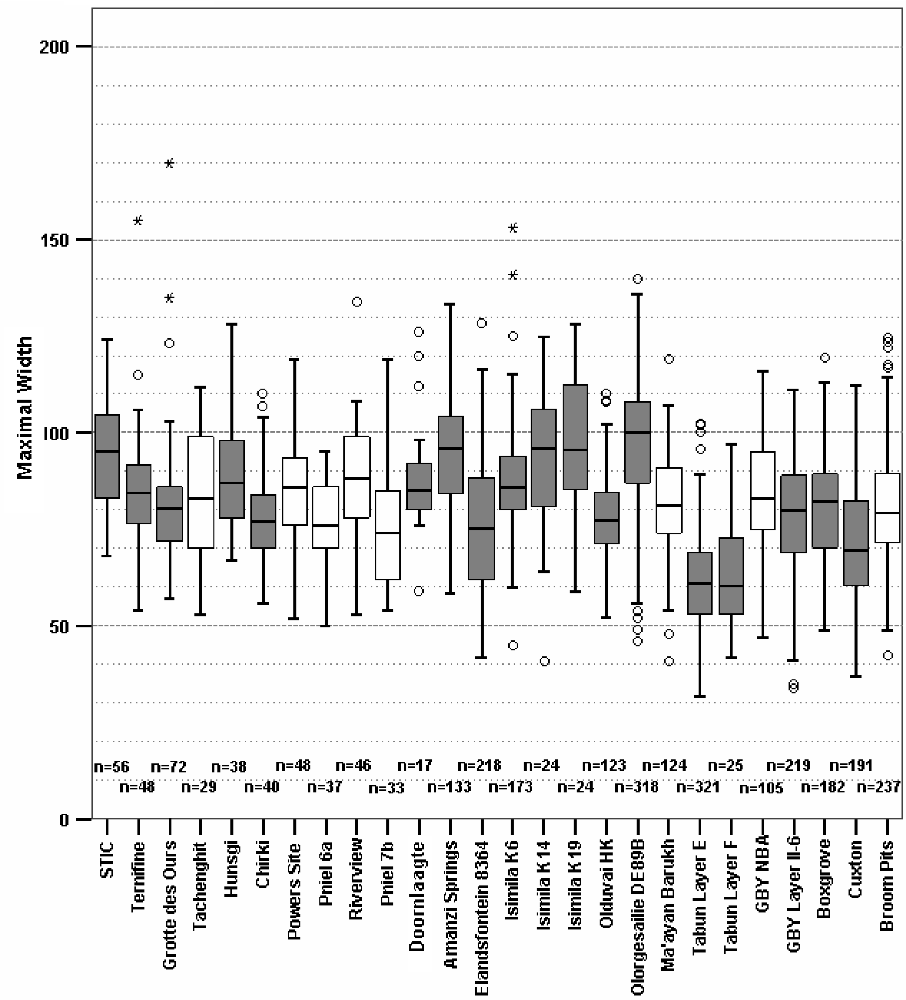

Figure 106. Maximal width of handaxes by site.

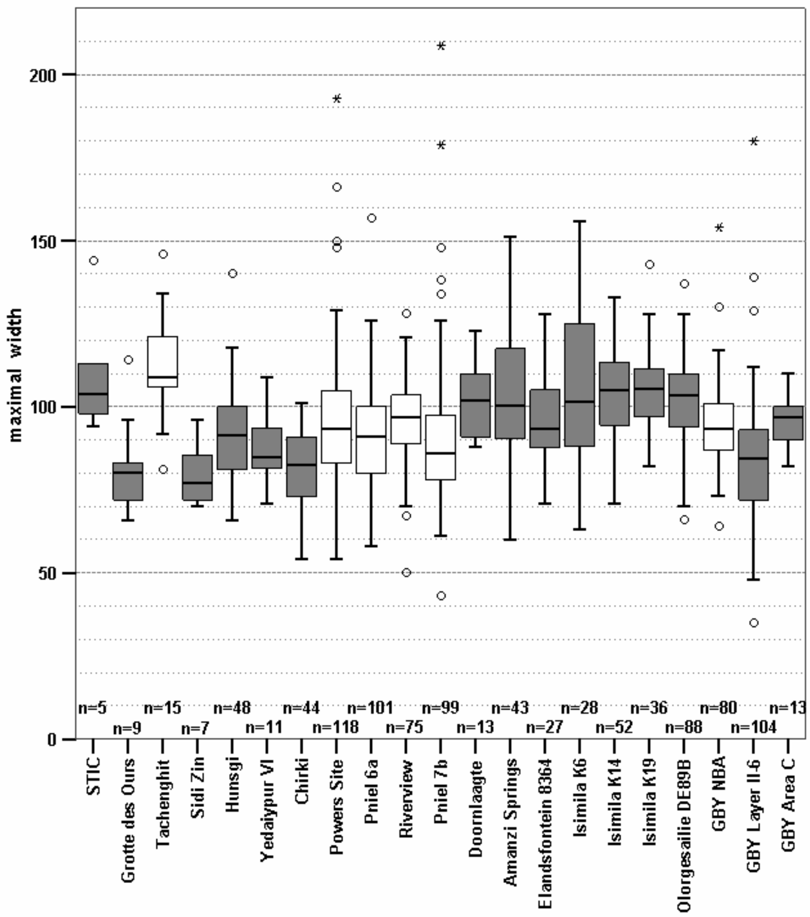

Figure 107. Maximal width of cleavers by site.

LCT Thickness

LCT thickness distribution as it is reflected by sufficiently large assemblages is presented in Figs. 108 and 109. Because cleavers were subject to much less intensive retouch than handaxes during shaping (see below), they closely preserve the thickness dimensions of the original blank.

The notable thickness of cleavers from Amanzi Springs and Isimila K6 cleavers has yet to be fully explained. These sites contain a relatively small number of cleavers, together with many *ficron*-type handaxes (see Chapter 6) that may suggest a specific technological or stylistic preference. The small sample of thin cleavers from Sidi Zin may suggest a different strategy, in which cleavers were much more extensively worked. However, more data are needed before any further observations can be made.

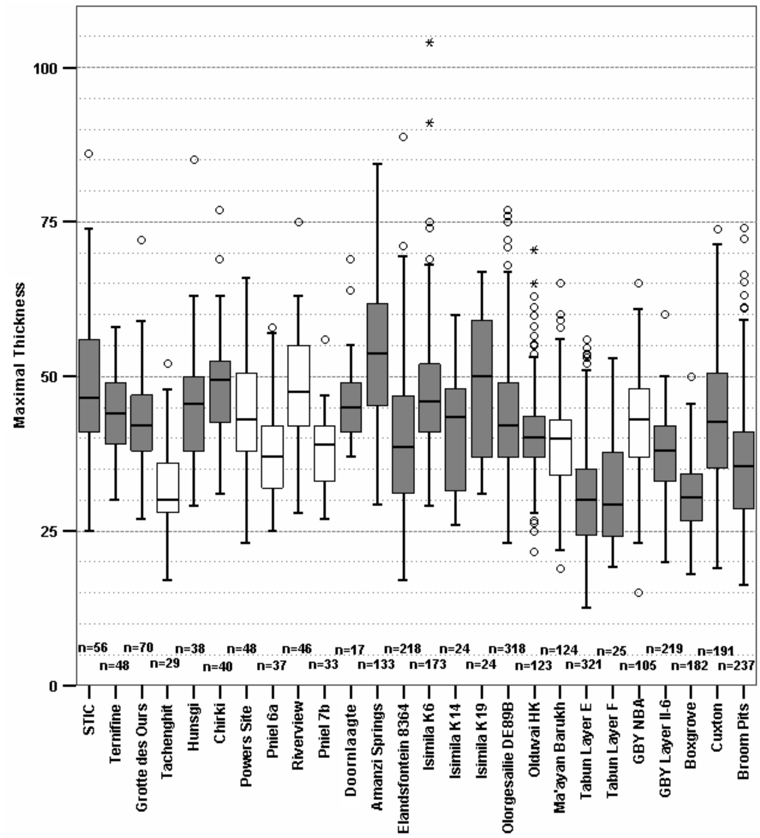

Figure 108. Handaxe thickness by site.

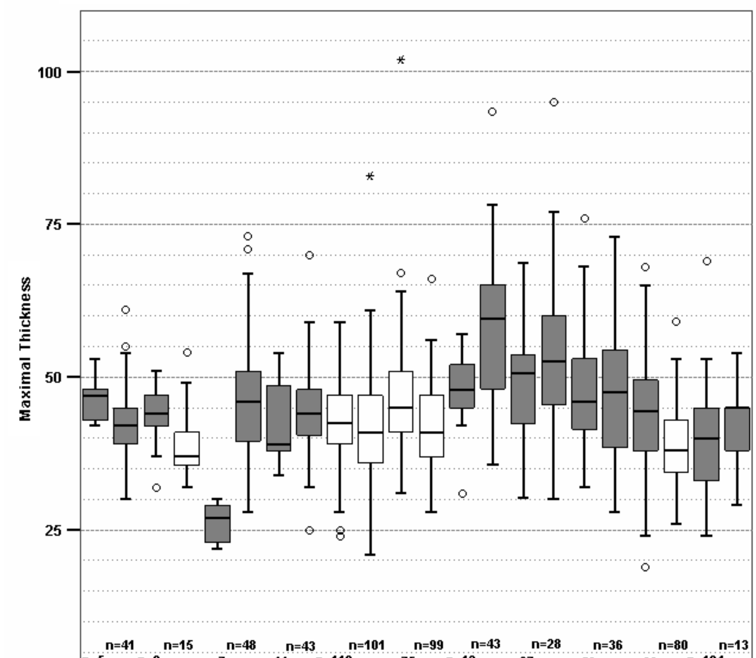

Figure 109. Cleaver thickness by site.

As for handaxes, sites like Amanzi Springs, STIC and Isimila K19 display very high thickness values, which are not observable in the other size measurements of the assemblages. There is some evidence that Isimila K19, STIC and possibly Amanzi Springs (see also Gamble and Marshall 2002), as well as the small sample from Doornlaagte, share many characteristics of a workshop site (see below).

Thinner handaxes were recorded at Isimila K14 and K6 and Tabun Cave. The former are on the large end of the scale, while the latter are on the small side (Figs. 102, 103). In length and width, the Tabun handaxes are significantly smaller than those of other assemblages, and yet they are similar in thickness to the much larger handaxes from Boxgrove, Tachenghit, and to a lesser degree Broom . A possible explanation for this thinness is the high level of workmanship applied to the handaxes' manufacture. If the aim was to reduce the mass of the tool while maintaining its overall size and cutting edge length, reduction of the tool's thickness was the only means of doing so (Jones 1994). Thinning a handaxe (Newcomer 1971) required the highest degree of skill in the handaxe knapping process and entailed the removal of long, thin flakes, which at the very least crossed the middle of the tools' breadth (Newcomer 1971). If a knapper mis-aimed a blow, the resulting flake could have been too thick, compelling the knapper to reduce the size of the handaxe dramatically in order to obtain a usable size-to-edge ratio. Another problem that could have arisen was the "phenomenon of end shock which occurs when shock waves within a long and narrow piece of stone coincide at some point and snap it in two" (Jones 1994, 270). Large, thin handaxes were especially prone to these knapping accidents. Thus, it is possible to evaluate and appreciate a knapper's dexterity through his ability to produce as thin a handaxe as was compatible with a usable size-to-cutting-edge-length ratio. The thickness data presented in Figs. 108 and 109 suggests that the knappers of Ma'ayan Barukh, Boxgrove and Tachenghit achieved the best thinness results. In his study of the Olorgesailie LCTs, Isaac (1977) addressed the issue of relative thickness in bifaces, which was also discussed by Roe (2001, 494) in relation to the "refinement" of the Kalambo Falls LCTs:

> "It has long been argued that, in so far as one can pick out general morphological criteria which distinguish later handaxes and cleaver industries from earlier ones, increasing flatness of the implement seem important. It is rare to find a very flat handaxe or cleaver (except perhaps on some tabular raw material) on which the flaking is rough and irregular, or thick one (other then a specialised type) on which the flaking is of high quality."

LCT Weight

LCT weight distribution is shown in Figs. 110 and 111. The weight range of handaxes is between 200–800 gr, and that of cleavers 400–1000 gr. Generally speaking, cleavers are heavier and less varied than handaxes. The range of weight values is larger than that of other metrical measurements. Because the tools under study were produced on a large variety of rock types, each with a different specific gravity, a tool's weight does not automatically reflect its size. Recent studies of bifacial tool allometry (Gowlett and Crompton 1994; Gowlett et al. 2001) have demonstrated that the weight of a tool increases dramatically with each minor increase in its size. P. Jones (1994, 271) has demonstrated that "…tool mass increases at roughly six times the rate of edge increase". When LCTs increase in size, the ratio of tool edge to mass becomes a crucial factor. The fact that, worldwide, the great majority of LCTs weigh less than 1 kg and tools over 2 kg are extremely rare strongly supports the view that a functional need had to be met by the toolmakers.

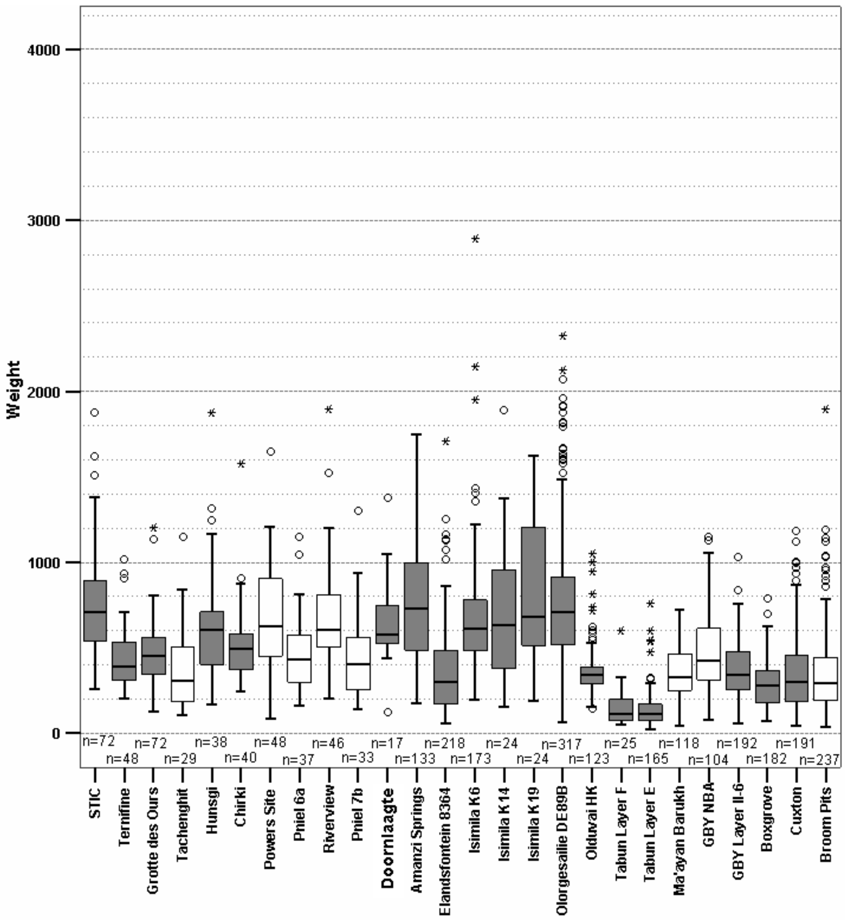

Figure 110. Weight (gr) of handaxes by site.

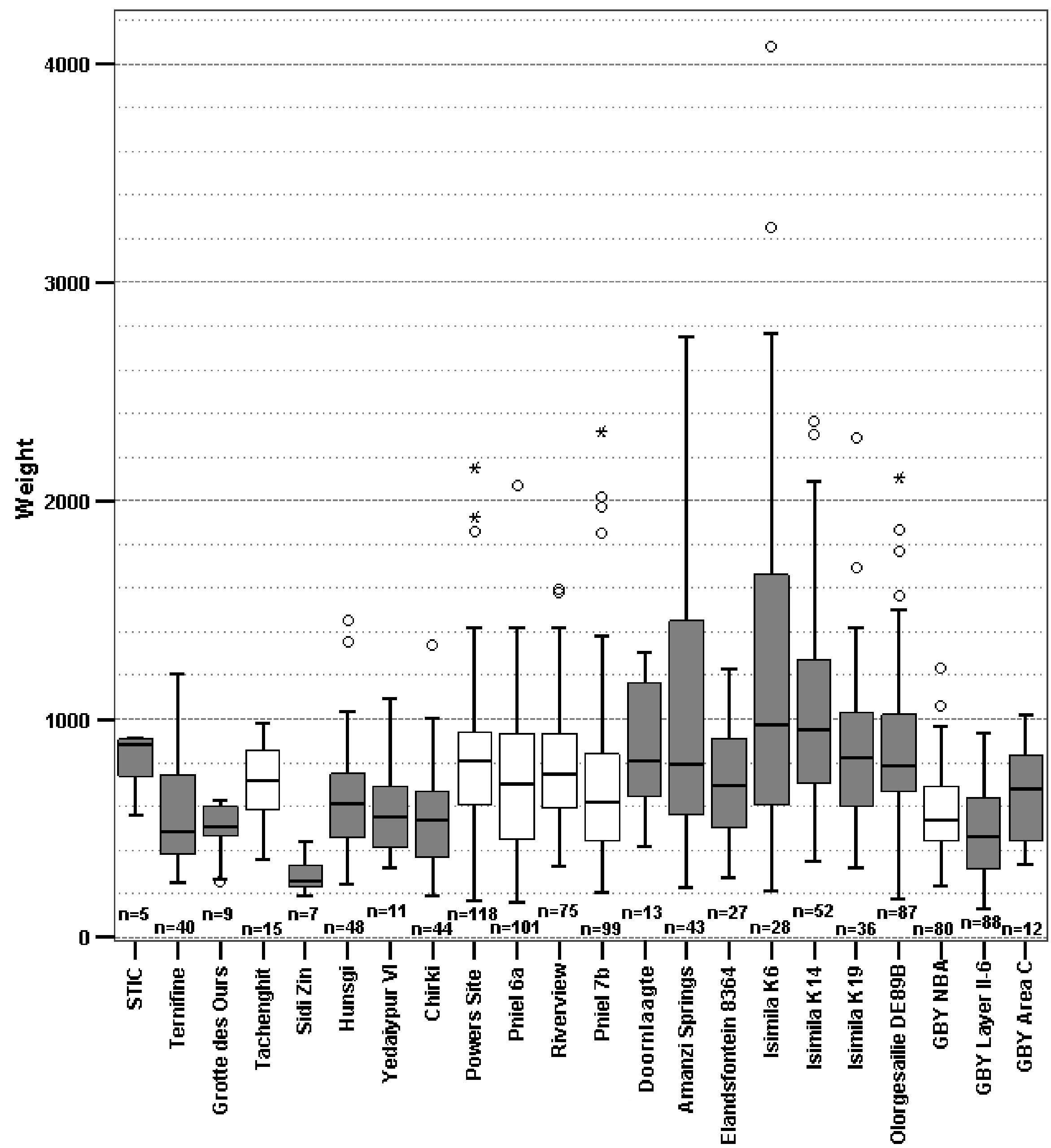

Figure 111. Weight (gr) of cleavers by site.

Cleaver Size *Versus* Handaxe Size

The maximal length, width and thickness of handaxes as opposed to cleavers (in sites that contain adequate sample sizes) are presented in Figs. 112–114.

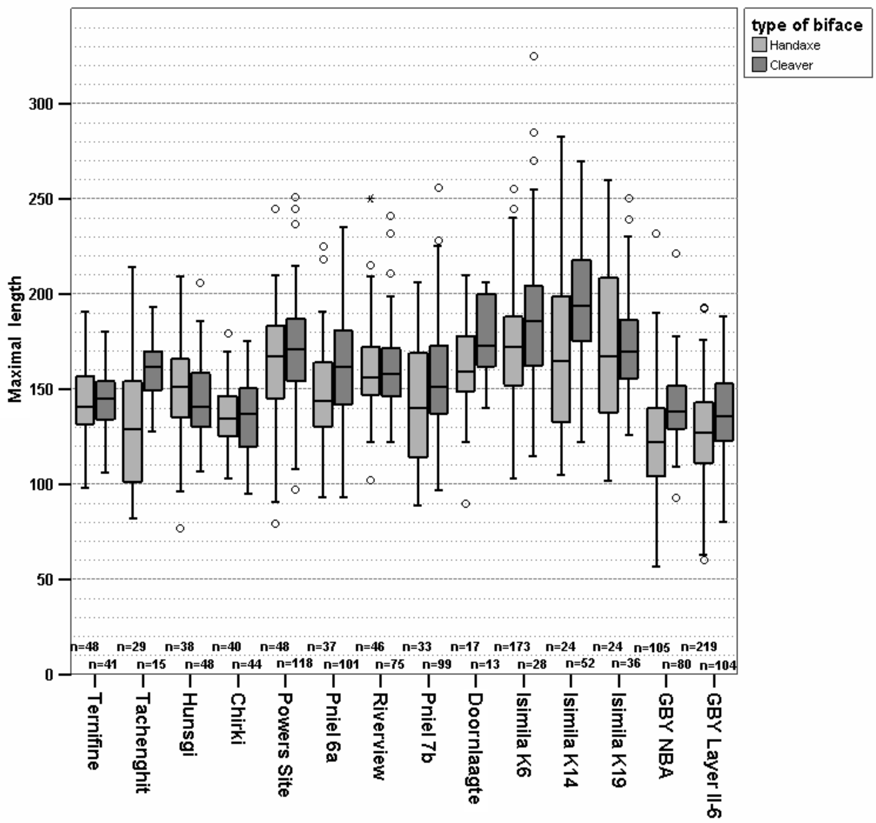

Figure 112. Maximal length, handaxes vs. cleavers, by site.

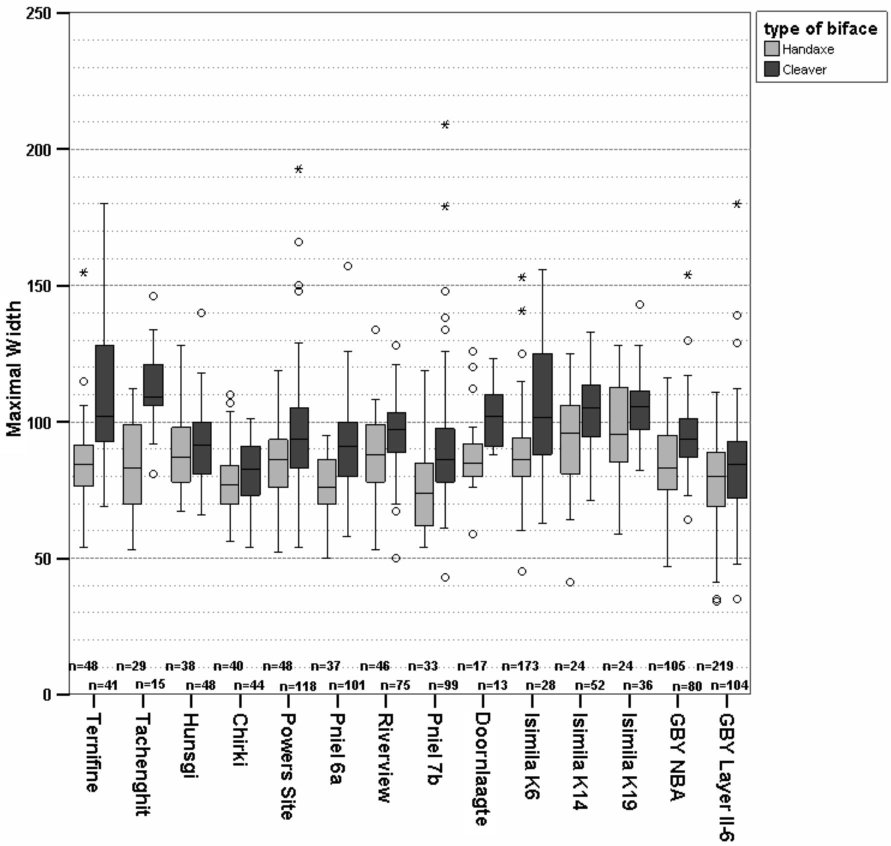

Figure 113. Maximal width, handaxes vs. cleavers, by site.

The data in Figs. 112-114 suggest that cleavers are larger tools than handaxes or, to be more precise, that the cleaver group lacks the small size component that is observable in handaxes. In most sites, handaxes show a larger length range than do cleavers, which are rarely smaller than 10 cm. Table 32 and 33 shows that while the kurtosis value of handaxe length is 0.073 (and 0.269 for large-flake assemblages), that of cleavers is 1.55. The only exceptions are the Chirki cleavers, which exhibit larger size variability than do handaxes. It should also be noted that in assemblages where handaxes are large in size, cleavers are also large, and *vice versa*. The Isimila assemblages, for example, encompass both large handaxes and large cleavers.

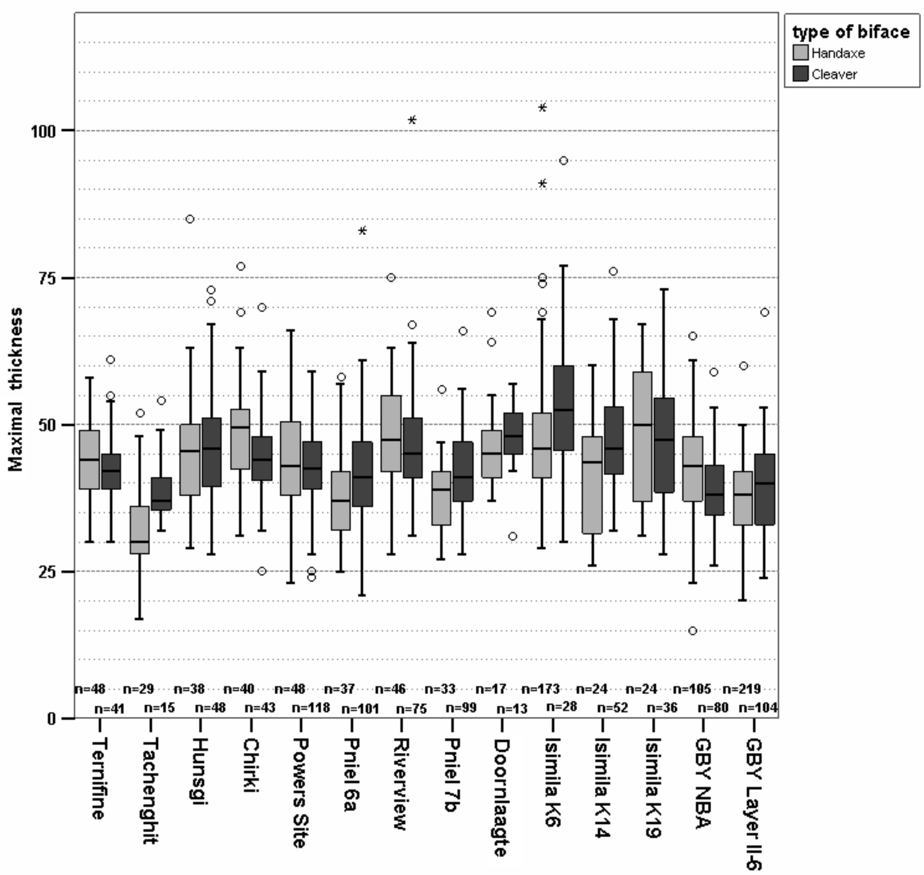

Figure 114. Maximal thickness, handaxes vs. cleavers, by site.

Cleavers also seem to be wider than handaxes (Fig. 113), an attribute dependent on blank selection. Although both handaxes and cleavers required blanks in a similar thickness range, wider flakes were selected for cleaver blanks, possibly in order to ensure a sufficiently transverse cutting edge. Alternately, handaxe width was determined by the much greater intensity of retouch (see below) applied to these tools during shaping.

The Small Handaxes from Tabun and Raw Material Size

As demonstrated above, the effect of raw material on a large cutting tool's size seems to have been minimal. The observable similarity of size between UK handaxes, made mainly on flint nodules (White 1995), and many LFB assemblages worldwide clearly supports this. Nevertheless, the opposite has been claimed, for example in the case of the small Tabun flint handaxes, whose size was deemed to have been affected by the small size of the raw material available in the vicinity of the site. Although this cannot be totally ruled out, the presence of larger forms of raw material from more distant sources was also noted for the Tabun Acheulian assemblage (Druck 2004). The knappers of the very small Tabun handaxes had access to larger flint cobbles. Moreover, it has been shown that some of the raw material used at the cave was quarried from underground sources, an activity that required a substantial investment of time and labor (Verri et al. 2005). The Tabun Cave hominins showed a propensity toward the production of small handaxes, because of either functional needs or lithic tradition preferences.

Very Large LCTs

A cluster of sites in Southeast Africa is characterized by many large LCTs. This pattern comprises Isimila, Olorgesailie – the large sample of over 550 LCTs from the Catwalk Surface, in which the largest handaxe is over 30 cm in length and the average handaxe length is 216 ± 6 mm (Isaac 1977, 134) – and the site of Isenya (Roche et al. 1988; Texier and Roche, 1992). Very large bifaces, measuring at least 250 mm, are present in other sites as well (Figs. 102, 103). Nevertheless, this is a rare phenomenon in most Acheulian sites and may be due to functional requirements or the region's lithic tradition.

LCT Size - Summary

The following observations were demonstrated and described above:

1. The overall size range of the bifaces that are presented in this study is 100–200 mm in maximal length (50% of the handaxes fall within the 53 mm interquartile range and 50% of the cleavers fall within the 41 mm interquartile range). Moreover, most LCTs, the world over, range in size from 130 to 170 mm.
2. Cleavers show smaller variability in size than do handaxes and are not represented in the smaller size range (< 100 mm).
3. Exceptions to the abovementioned size range cannot be explained by means of raw material constraints or by the Acheulian knappers' technological limitations. It is likely that they represent behavioral patterns, by which toolmakers preferred larger or smaller LCTs for reasons of function or lithic tradition.
4. LCT width is the least variable size attribute.
5. LCT thickness is relative and seems to reflect work expenditure and knapper dexterity. Skilled workmanship resulted in a thinner tool, while thick tools may represent unfinished tools from workshop sites.
6. LCT weight ranges between 200 and 800 gr for handaxes and 400 and 1000 gr for cleavers. Tools weighing over 1.5 kg are rare.
7. LCT weight was not significantly affected by a raw material's specific gravity.
8. LCT weight does not seem to present a different pattern from other size attributes and cannot be considered a significant factor in determining the preferred size of a bifacial tool.
9. Cleavers are larger than handaxes in most samples. Very few cleavers are under 100 mm in length. The main size difference between handaxes and cleavers is their width, cleavers being the wider.

10. Assemblages containing large handaxes also contain large cleavers and vice versa.

11. Some of the observable variability between the tools can be explained in terms of the knapping activity practiced at the various sites. Some of the assemblages originated in workshop sites, where large and thick preforms formulated the majority of tools. In other sites, well-made, thin handaxes are present in relatively high frequencies (see also discussion below).

The great majority of bifacial tools fall within a size range of a few centimeters, with exceptions being rare. The low variability in size and weight of the tools is probably due to the fact that they were used for the same tasks everywhere and were hand-held. A prominent deviation from this size range is exemplified in the small handaxes from Tabun Cave. The Tabun assemblage probably belongs to the final Acheulian lithic tradition (Bar-Yosef 1998; Gisis and Ronen 2006; Goren-Inbar 1995). While it can be suggested that small-sized handaxe assemblages (average length <100 mm) should be attributed to a post-Acheulian context, much more study is needed.

It should also be noted that the size of an LCT in a given assemblage is probably not a good chronological marker for determining its age. Many researchers have tried to establish such a size-age linkage. The suggestion that LCTs decreased in size with the advance of the Acheulian era is the most popular of these views (Gilead 1970). Yet, the very large Isimila LCTs and the very small Tabun Cave handaxes both come from late Acheulian stages. The data presented above have demonstrated that on the large scale all Acheulian LCTs are in the same size range, regardless of their chronology. This pattern may have changed only in such post-Acheulian industries as the Yabrudian or the Sangoan cultures.

The Technology of Shaping Handaxes and Cleavers

The Number of Scars

Finished (or discarded) tools bear scars that reflect different aspects of the LCT knapping process. Problems and dilemmas relating to the scar count were discussed in Chapter 3. Tables 34 and 35 contain descriptive scar count statistics by site, as they pertain to the faces of complete tools.

Table 34. Flake scar counts: handaxes.

Site		Number of Scars Face I (ventral)	Number of Scars Face II (dorsal)	Total Number of Scars
STIC	Mean	12.46	12.28	24.80
	N	70	71	70
	S.D.	6.46	6.28	11.34
	Minimal	1	1	8
	Maximal	33	41	74
Ternifine	Mean	9.90	9.21	19.10
	N	48	48	48
	S.D.	6.51	7.55	10.45
	Minimal	0	0	3
	Maximal	27	29	56
Grotte des Ours	Mean	10.66	11.58	21.61
	N	64	59	51
	S.D.	5.91	5.65	9.92
	Minimal	2	1	8
	Maximal	24	29	50
Tachenghit	Mean	21.85	31.00	52.96
	N	27	29	27
	S.D.	10.08	7.19	13.35
	Minimal	6	17	23
	Maximal	39	45	77
Hunsgi	Mean	9.68	12.37	22.05
	N	38	38	38
	S.D.	6.90	6.44	10.32
	Minimal	2	1	8
	Maximal	34	29	54
Chirki	Mean	8.05	13.55	21.60
	N	40	40	40
	S.D.	4.82	4.42	7.26
	Minimal	1	6	10
	Maximal	19	24	41
Power's Site	Mean	21.00	21.00	41.72
	N	47	46	46
	S.D.	6.15	7.18	9.74
	Minimal	6	2	19
	Maximal	34	37	68
Pniel 6a	Mean	24.69	23.09	47.69
	N	36	35	35
	S.D.	8.40	6.90	13.07
	Minimal	9	7	19
	Maximal	43	35	75
Riverview	Mean	28.98	32.00	60.98
	N	46	46	46
	S.D.	17.61	15.92	29.54
	Minimal	1	2	3
	Maximal	80	65	145
Pniel 7b	Mean	27.31	32.59	60.24
	N	29	27	25
	S.D.	14.12	9.47	21.58
	Minimal	6	15	31
	Maximal	75	51	121
Doornlaagte	Mean	14.12	19.69	32.47
	N	16	16	15
	S.D.	11.24	7.86	16.40
	Minimal	0	8	13
	Maximal	35	37	72
Isimila K6	Mean	26.43	29.78	56.36
	N	166	167	165
	S.D.	15.37	15.00	28.20
	Minimal	4	5	12
	Maximal	75	78	150

Site		Number of Scars Face I (ventral)	Number of Scars Face II (dorsal)	Total Number of Scars
Isimila K14	Mean	34.79	39.50	74.29
	N	24	24	24
	S.D.	21.57	24.91	41.41
	Minimal	2	5	17
	Maximal	87	101	167
Isimila K19	Mean	17.29	27.58	44.87
	N	24	24	24
	S.D.	9.37	11.76	16.55
	Minimal	7	9	22
	Maximal	46	53	92
GBY NBA	Mean	15.68	17.60	33.28
	N	95	95	95
	S.D.	9.95	8.25	17.36
	Minimal	4	5	14
	Maximal	79	66	145
Ma‘ayan Barukh	Mean	22.99	23.23	46.22
	N	124	124	124
	S.D.	6.61	6.11	10.86
	Minimal	8	8	23
	Maximal	41	44	85
GBY Layer II-6	Mean	11.59	14.35	25.98
	N	204	206	203
	S.D.	6.49	5.81	11.24
	Minimal	3	4	8
	Maximal	40	31	70
Tabun Layer E	Mean	19.46	18.16	37.62
	N	179	179	179
	S.D.	7.06	7.41	13.09
	Minimal	5	5	10
	Maximal	40	52	92

Table 35. Flake scar counts: cleavers.

Site		Number of Scars Ventral Face	Number of Scars Dorsal Face	Total Number of Scars
Ternifine	Mean	6.55	8.10	14.74
	N	40	39	38
	S.D.	3.80	4.80	6.61
	Minimal	1	1	4
	Maximal	15	20	28
Tachenghit	Mean	11.87	21.47	33.33
	N	15	15	15
	S.D.	6.98	7.66	10.41
	Minimal	1	9	16
	Maximal	27	37	52
Hunsgi	Mean	7.59	11.38	18.59
	N	41	47	41
	S.D.	5.70	6.49	7.67
	Minimal	1	1	4
	Maximal	24	26	50
Yediyapur VI	Mean	4.36	13.18	17.55
	N	11	11	11
	S.D.	2.11	4.83	6.09
	Minimal	1	6	9
	Maximal	8	20	27
Chirki	Mean	5.61	10.93	16.77
	N	41	43	40
	S.D.	3.92	5.21	7.29
	Minimal	1	2	3
	Maximal	19	23	39
Power’s Site	Mean	13.68	19.67	33.52
	N	115	113	112
	S.D.	7.26	6.92	11.70
	Minimal	1	5	14
	Maximal	38	44	75
Pniel 6a	Mean	16.82	21.35	38.17
	N	100	101	100
	S.D.	10.11	8.96	14.96
	Minimum	1	3	5
	Maximum	52	45	88
Riverview	Mean	17.72	23.52	41.37
	N	75	73	73
	S.D.	12.12	12.89	20.74
	Minimal	1	1	2
	Maximal	55	66	94
Pniel 7b	Mean	17.27	26.66	43.38
	N	96	91	89
	S.D.	10.04	12.27	19.04
	Minimal	1	4	6
	Maximal	53	60	88
Doornlaagte	Mean	11.62	17.08	29.08
	N	13	12	12
	S.D.	9.13	6.91	14.05
	Minimal	1	6	7
	Maximal	30	30	56
Isimila K6	Mean	20.54	30.14	50.68
	N	28	28	28
	S.D.	13.58	13.52	24.53
	Minimal	1	7	19
	Maximal	63	58	121
Isimila K14	Mean	28.81	39.46	68.27
	N	52	52	52
	S.D.	14.98	17.86	26.24
	Minimal	1	3	4
	Maximal	68	90	122

Site		Number of Scars Ventral Face	Number of Scars Dorsal Face	Total Number of Scars
Isimila K19	Mean	11.64	21.67	33.31
	N	36	36	36
	S.D.	6.59	10.54	13.63
	Minimal	1	3	10
	Maximal	28	45	70
GBY NBA	Mean	14.69	9.66	24.35
	N	80	80	80
	S.D.	10.44	6.93	14.86
	Minimal	2	1	6
	Maximal	90	36	126
GBY Layer II-6	Mean	8.56	13.66	22.37
	N	91	97	91
	S.D.	4.41	5.32	7.62
	Minimal	1	4	8
	Maximal	22	32	46
GBY Area C	Mean	6.85	15.00	21.85
	N	13	13	13
	S.D.	3.65	3.87	4.96
	Minimal	1	10	16
	Maximal	14	23	32

Overall Number of Scars

Fig. 115 shows the frequency of the overall number of scars per biface by site (handaxes and cleavers separately).

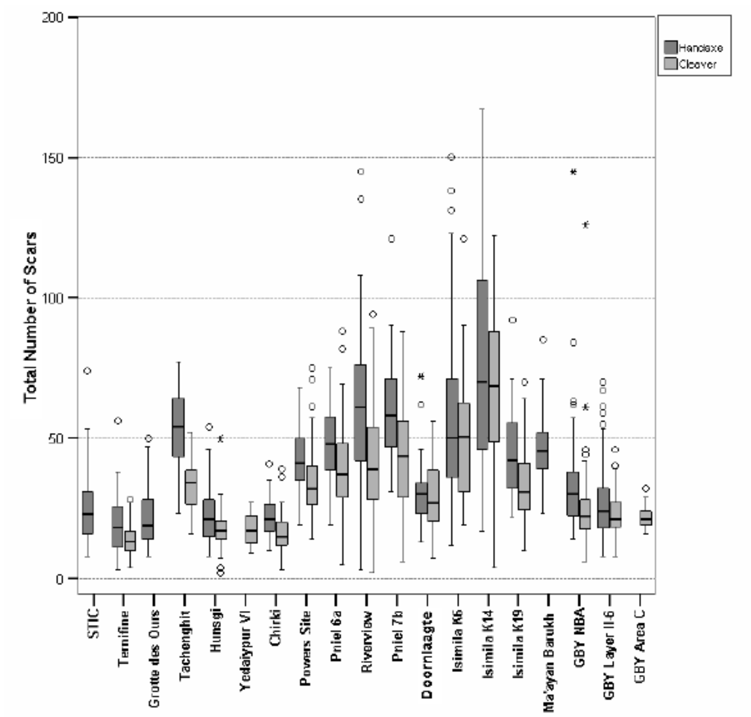

Figure 115. Total number of handaxe and cleaver scars by site.

Unlike the size attributes presented above, the assemblages under study show great variability in their scar counts. The mean number of Isimila handaxe scars is 74.3, while that of Chirki is only 21.6 (Table 34). The flint handaxes of Ma‘ayan Barukh have a lower scar count than the granite and metamorphic handaxes of Isimila. Raw material quality was not the cause of this variability, as the same raw material could bear very different scar counts in various assemblages. Other possible explanations are presented below.

Handaxes generally bear more flake scars than do cleavers. Exceptions to this rule are the Doornlaagte LCTs, which are probably not “living site” tools, but rather unfinished workshop preforms, and the Isimila K19 bifaces, which bear a relatively low number of scars in comparison to the LCTs of other Isimila sites, hence suggesting that Isimila K19 was also a workshop (see below).

Sites that demonstrate a high handaxe scar count usually demonstrate a relatively high cleaver scar count and *vice versa*. The Tachenghit handaxes and cleavers, which comprise a small sample from surface collection, are an exception, with the Vaal River sites presenting a similar, though less pronounced, pattern. In both of these areas, there is inconsistency between handaxe and cleaver scar counts, which can be attributed to their flake blank core technologies. Both the Victoria West and the Tachenghit-Tabelbala core methods were engineered with cleaver production in mind (Chapter 4). In order to shape handaxes from these “cleaver” blanks, much work had to be expended, leaving many flake scars on the tools.

Scar Numbers and Tool Size

When examining scar counts on LCTs, one has to evaluate the effect of a tool’s size on the number of scars. Tables 36 and 37 present Pearson correlation results between LCT type, size and scar count.

Table 36. Pearson Correlation for handaxe size and scar count.

		Width	Thickness	Circumference	Total Number of Scars
Length	Pearson Correlation	.698	.579	.871	.382
	Sig. (2-tailed)	.000	.000	.000	.000
	N	1133	1131	1005	1060
Width	Pearson Correlation		.463	.733	.210
	Sig. (2-tailed)		.000	.000	.000
	N		1131	1005	1060
Thickness	Pearson Correlation			.553	.113
	Sig. (2-tailed)			.000	.000
	N			1003	1060
Circumference	Pearson Correlation				.328
	Sig. (2-tailed)				.000
	N				956

** Correlation is significant at the 0.01 level (2-tailed).

Table 37. Pearson Correlation for cleaver size and scar count.

		Width	Thickness	Circumference	Total Number of Scars
Length	Pearson Correlation	.640	.572	.702	.506
	Sig. (2-tailed)	.000	.000	.000	.000
	N	878	877	839	845
Width	Pearson Correlation		.392	.543	.147
	Sig. (2-tailed)		.000	.000	.000
	N		877	839	845
Thickness	Pearson Correlation			.407	.274
	Sig. (2-tailed)			.000	.000
	N			838	844
Circumference	Pearson Correlation				.313
	Sig. (2-tailed)				.000
	N				812

** Correlation is significant at the 0.01 level (2-tailed).

In Retouch Index I, which traces the effect of tool size on scar count, Saragusti (2003) divided a tool's total number of scars, attributing each face to an evaluated surface size of the tool (Length X; Maximal Width X 2). Handaxe and cleaver values by site are given in Fig. 116. The results are very similar to those appearing in Fig. 115.

Both the results of the Pearson correlation and the similarity between the distribution graphs in Figs. 115 and 116 show that the size of a tool had a marginal influence on scar count. Scarring reflects craftsmanship and behavioral/functional preferences. This observation is further supported by the handaxe scar counts of Tabun Cave, Layer E (see Table 34; data after Matskevich et al. 2002, Matskevich 2006 and personal communication). As demonstrated above, the Tabun handaxes are significantly smaller than any others originating in a Levantine assemblage. Nevertheless, their scar counts (mean number of scars: 37.62) are much higher than those of the much larger GBY, North African and Indian handaxes.

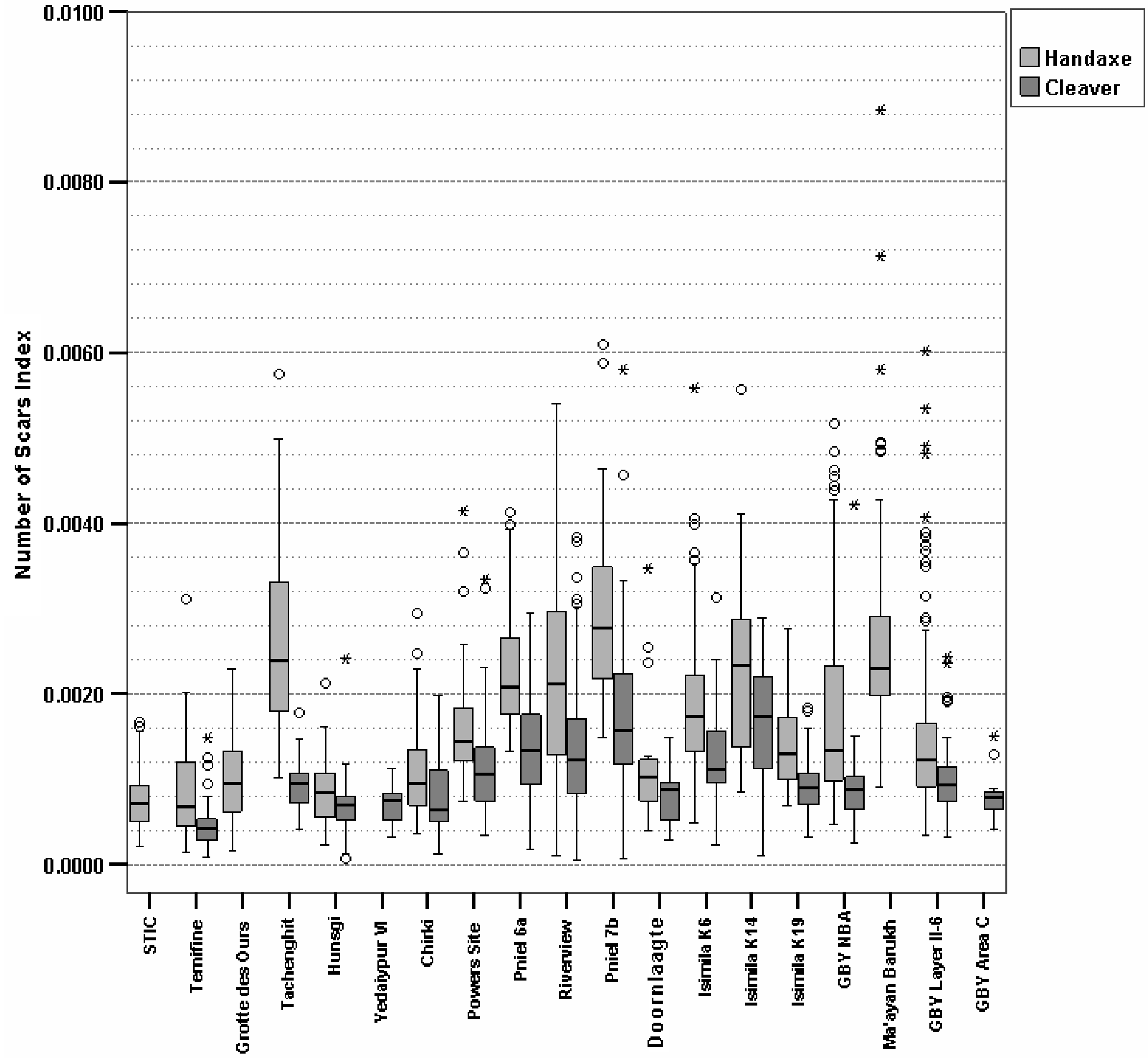

Figure 116. Handaxe and cleaver scar number (retouch) –Index I – by site (after Saragusti 2003).

Scar Numbers by Tool Face

The different tool faces are designated Face 1 (dorsal) and Face 2 (ventral); see Chapter 2. In some cases, especially with regard to handaxes, each face is totally covered by scars and the nature of the face (or the original blank) cannot be determined with certainty. Nevertheless, all complete tools are presented here. The distribution by site of handaxe and cleaver scar numbers on the ventral and dorsal faces is presented in Fig. 117.

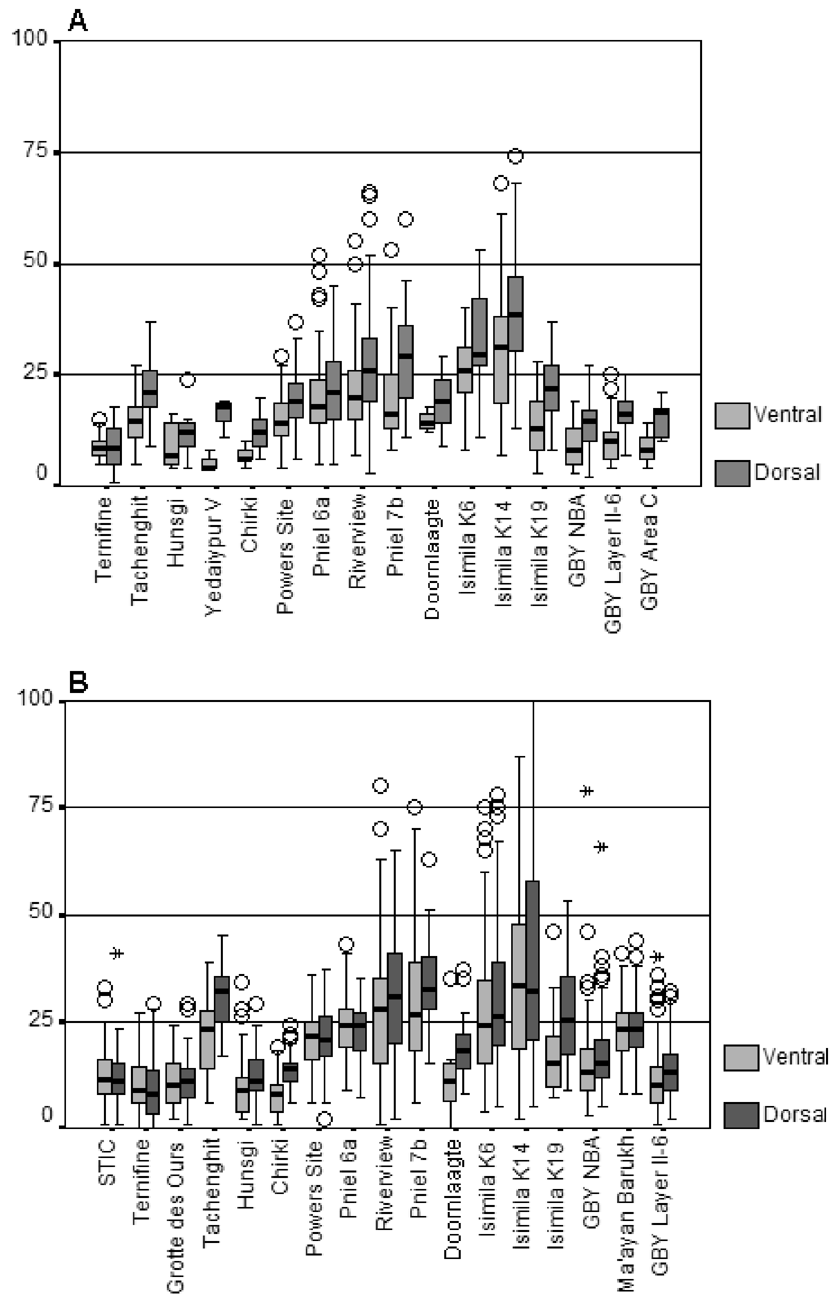

Figure 117. Cleaver (a) and handaxe (b) scar number, by face.

Because cleavers were made on flakes that were minimally retouched on their ventral face, they show a much higher number of scars on their dorsal face. The larger dorsal face scars were formed during giant core preparation and not in the actual process of shaping the cleaver. The difference in scar counts between cleaver faces is the result of their blank technology and the minimal work invested in their manufacture.

Handaxes bear many more scars, which are distributed rather evenly between their two faces. However, in the Indian sites of Hunsgi and Chirki, very large differences between the dorsal and ventral faces are apparent. The handaxes at these sites are less intensively worked than those in other assemblages, and the morphological features of the original blanks were maintained. In contrast, the North African sites of STIC, Ternifine and Grotte des Ours exemplify the same low scar numbers as the Indian tools, but without a disparity between the faces. Another interesting comparison can be made between the handaxes of Tachenghit and Ma‘ayan Barukh, where the scar counts are in the same high range. The Ma‘ayan Barukh handaxes show no difference between the faces, while the Tachenghit handaxes were minimally retouched on the ventral face.

Surface Coverage by Retouch

The percentage of a tool’s face that that was covered by retouch scars is estimated in Fig. 118. For a comprehensive view of tool retouch, the discussion of this attribute should be combined with observations appearing in the “Location of Retouch” section below.

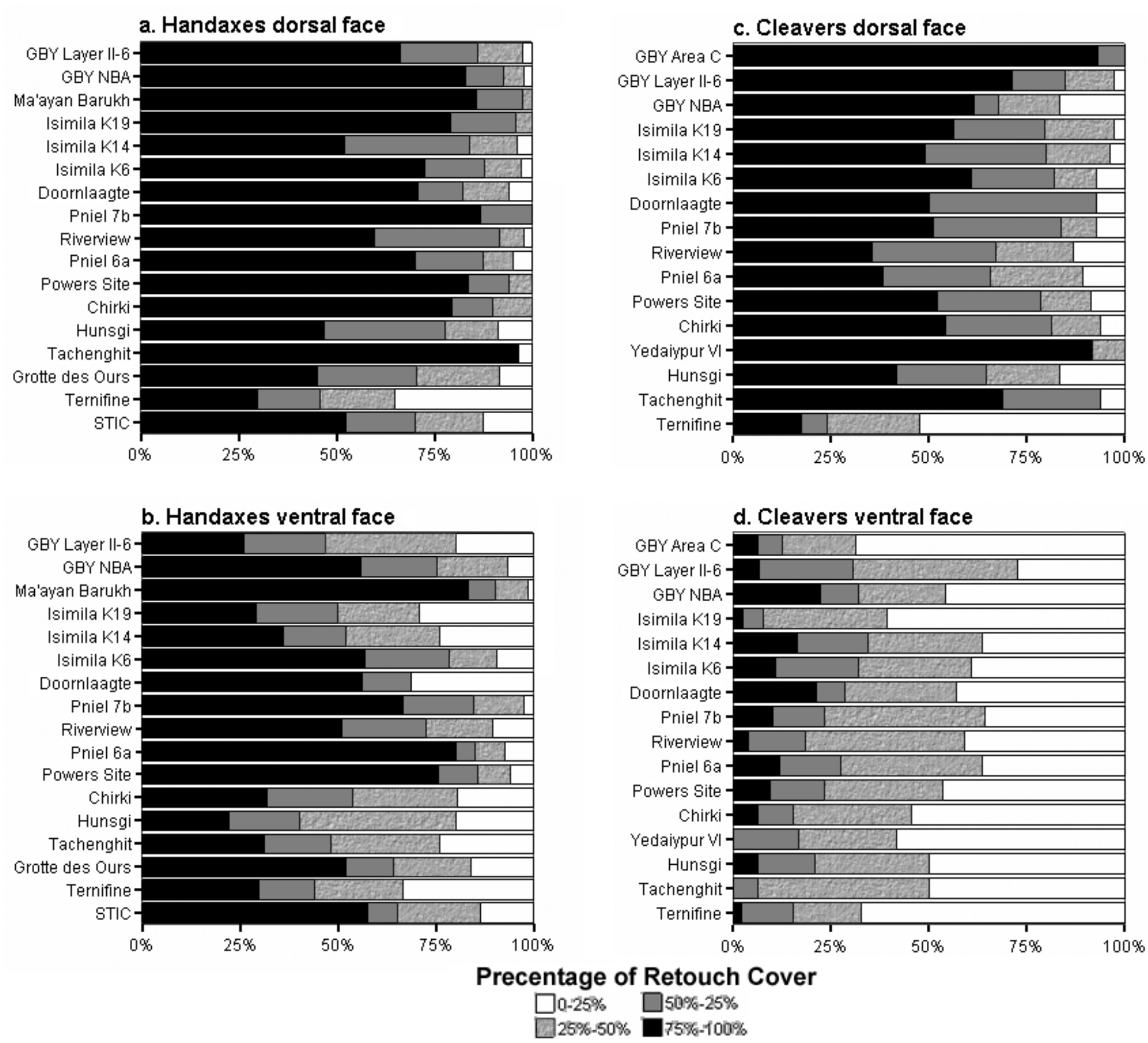

Figure 118. Percentage of LCT retouch covering face by site

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As seen in Fig. 118, the sample from Ma‘ayan Barukh presents the highest degree of ventral face surface coverage, perhaps because it is the only sample in which large flakes did not constitute the dominant blank type. On the other hand, while the Vaal River LCTs of Pniel 6, Pniel 7 and Power’s Site are indeed based on large flakes, the technology of handaxe blank production has left a high frequency of scar coverage on the ventral face. This may be because the large flakes derived from the Victoria West core method, which preserved some of the parent core scars on the ventral face (Chapter 4). In other words, the high ventral face scar values at Ma‘ayan Barukh may indicate high investment of labor in handaxe face shaping, as opposed to the LFB samples, in which the ventral face was subjected to minimal work. However, other non-LFB sites should be examined to substantiate this suggestion.

Location of Retouch on LCT Faces

Tool retouch location is presented in Figs. 119 and 120. For purposes of conciseness, the full list of options (see appendix) have been summarized under the following headings: *Distal and Side* includes: *distal and right side*, *distal and left side*, and *distal and both sides*. The same principle applies to combinations of *Proximal and Side*. *Others* encompasses less common combinations of retouch location (e.g. *Convergent and Proximal*), recorded in very few cases.

It is clear that cleavers are less extensively retouched than handaxes. Although the dorsal face of the cleaver is often completely covered by scars (shown by black bars) in a similar frequency to handaxes, the ventral face of the cleaver shows a much lower intensity of retouch (see also discussion of quantity of retouch above). All assemblages demonstrate a clear dominance of the *Proximal and Side* location (shown by gray bars) on the ventral face, which was produced by a common technological procedure in cleaver production: the thinning of the bulb of percussion. As demonstrated in the discussion of flake blank blow direction (Chapter 4), most bulbs of percussion were located on the proximal and lateral margins of the cleaver blank. When a blank was shaped into a cleaver, the only retouch that was needed on the ventral face was the reduction of the flake’s thickest part – the bulb of percussion. The Acheulian knapper normally applied only minimal (fewer than 10) blows, removing the striking platform and a significant part of the bulb to ensure a good balance between the cleaver’s sides. Some examples from the different regions of Acheulian distribution are given in Fig. 121. Goren-Inbar and Saragusti (1996) have demonstrated this technological LCT characteristic with regard to Layer II-6 Level 4 at GBY. Isaac claimed that in the LCTs of Olorgesailie, the first, and in many cases the only, secondary retouch is very frequently "… directed at the removal of the platform vestige" (Isaac 1977, 117).

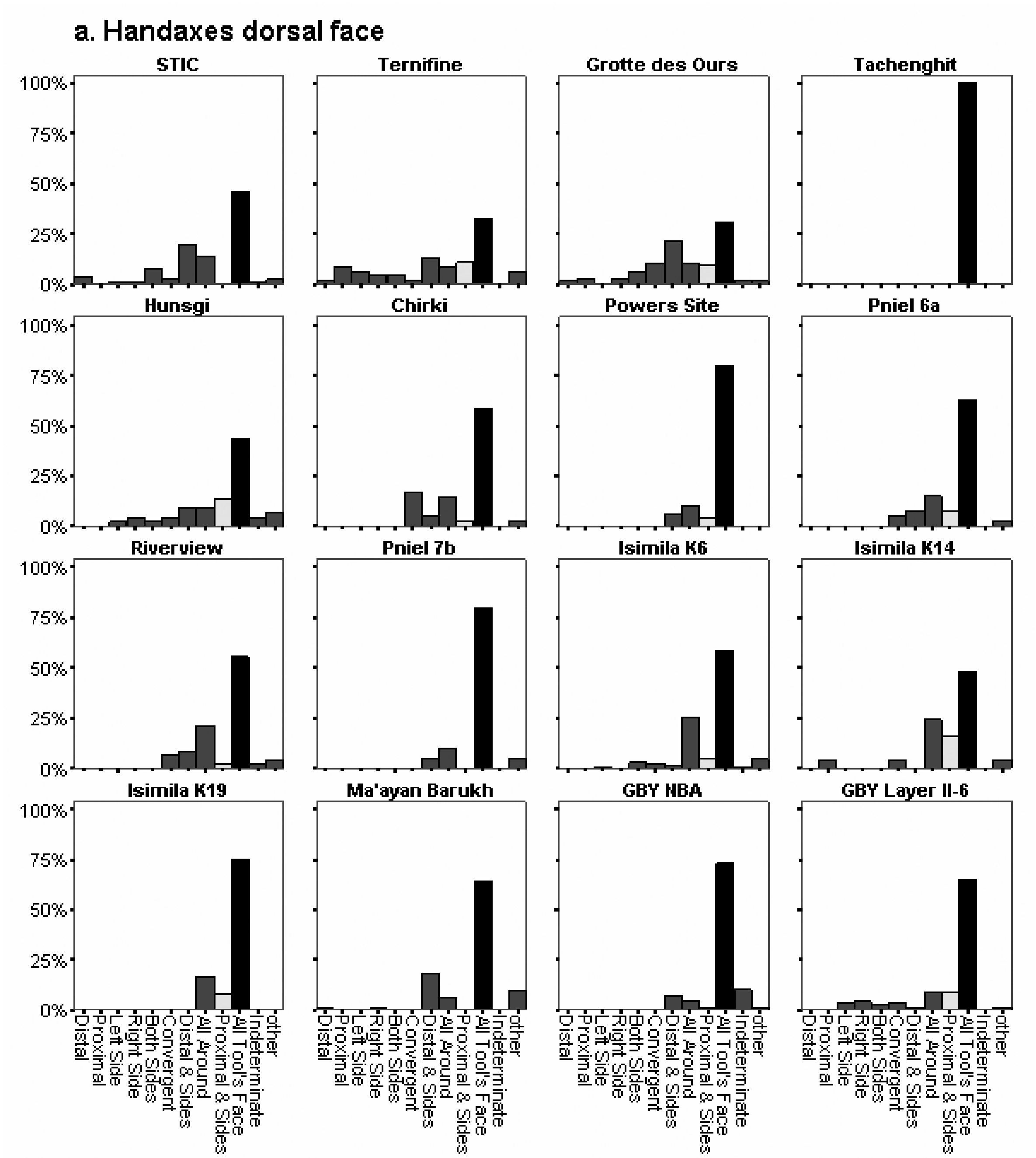


Figure 119a. Handaxe retouch location Face 1 (dorsal).

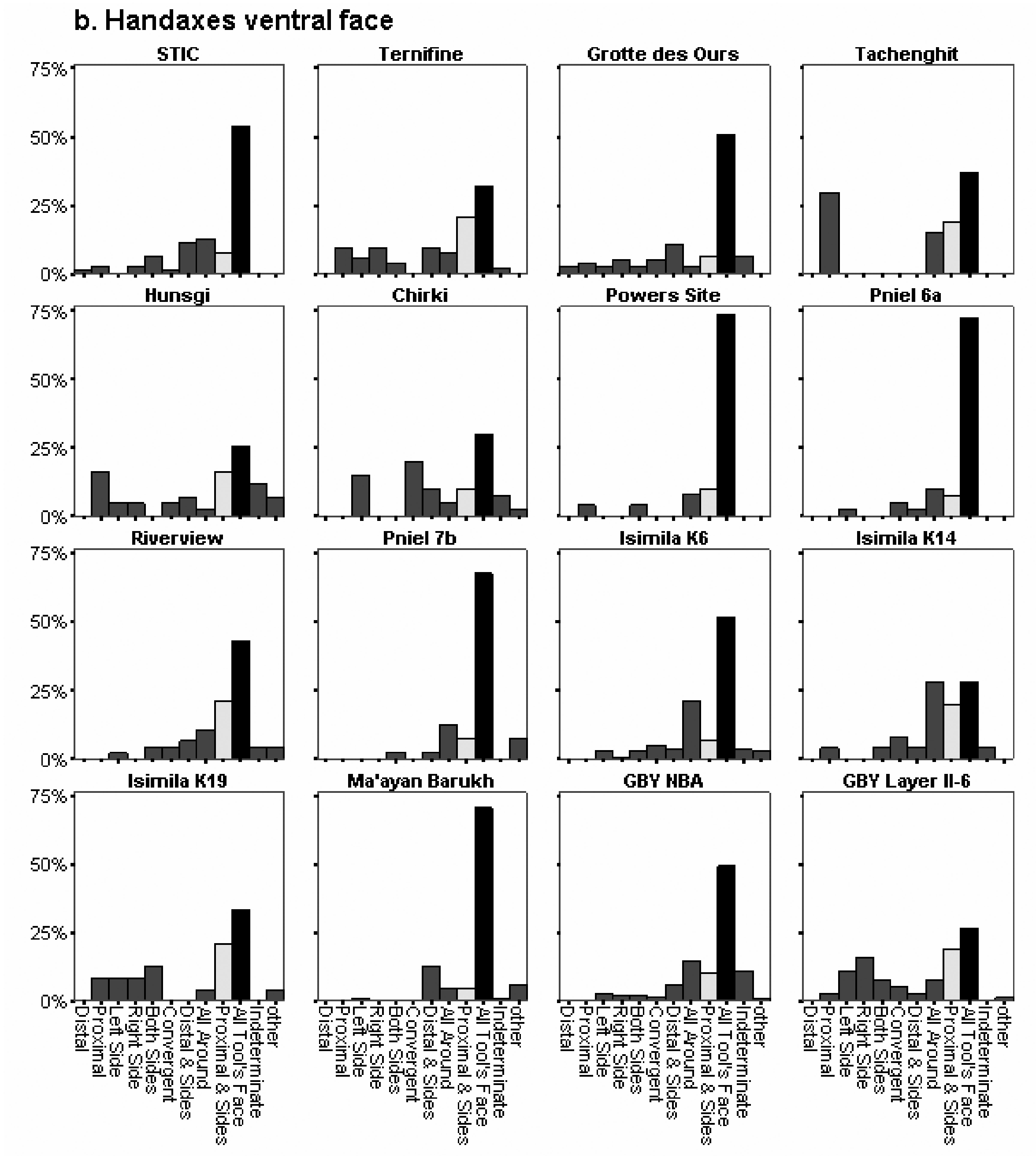


Figure 12019b. Handaxe retouch location Face 2 (ventral).

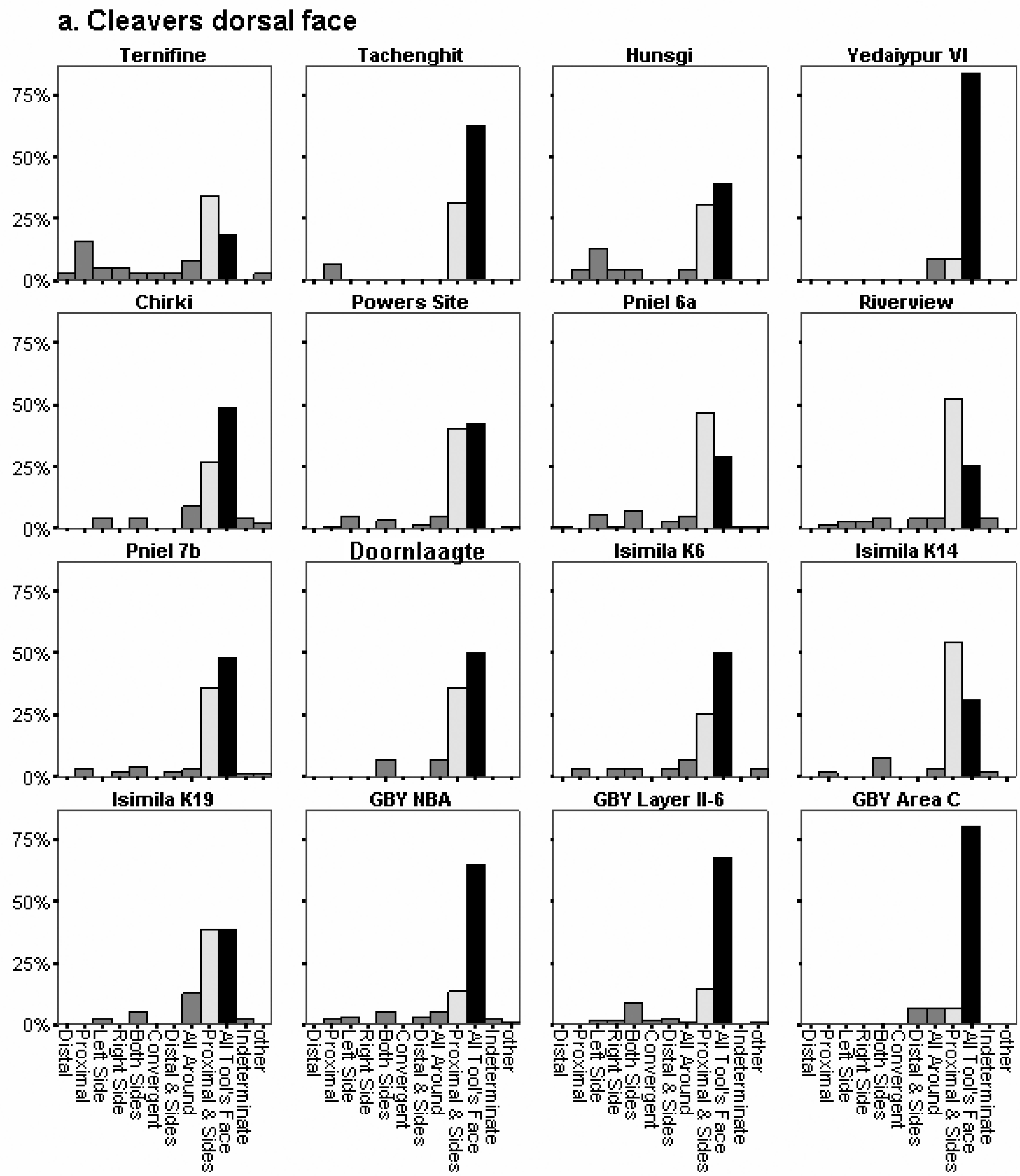


Figure 120a. Cleaver retouch location Face 1.

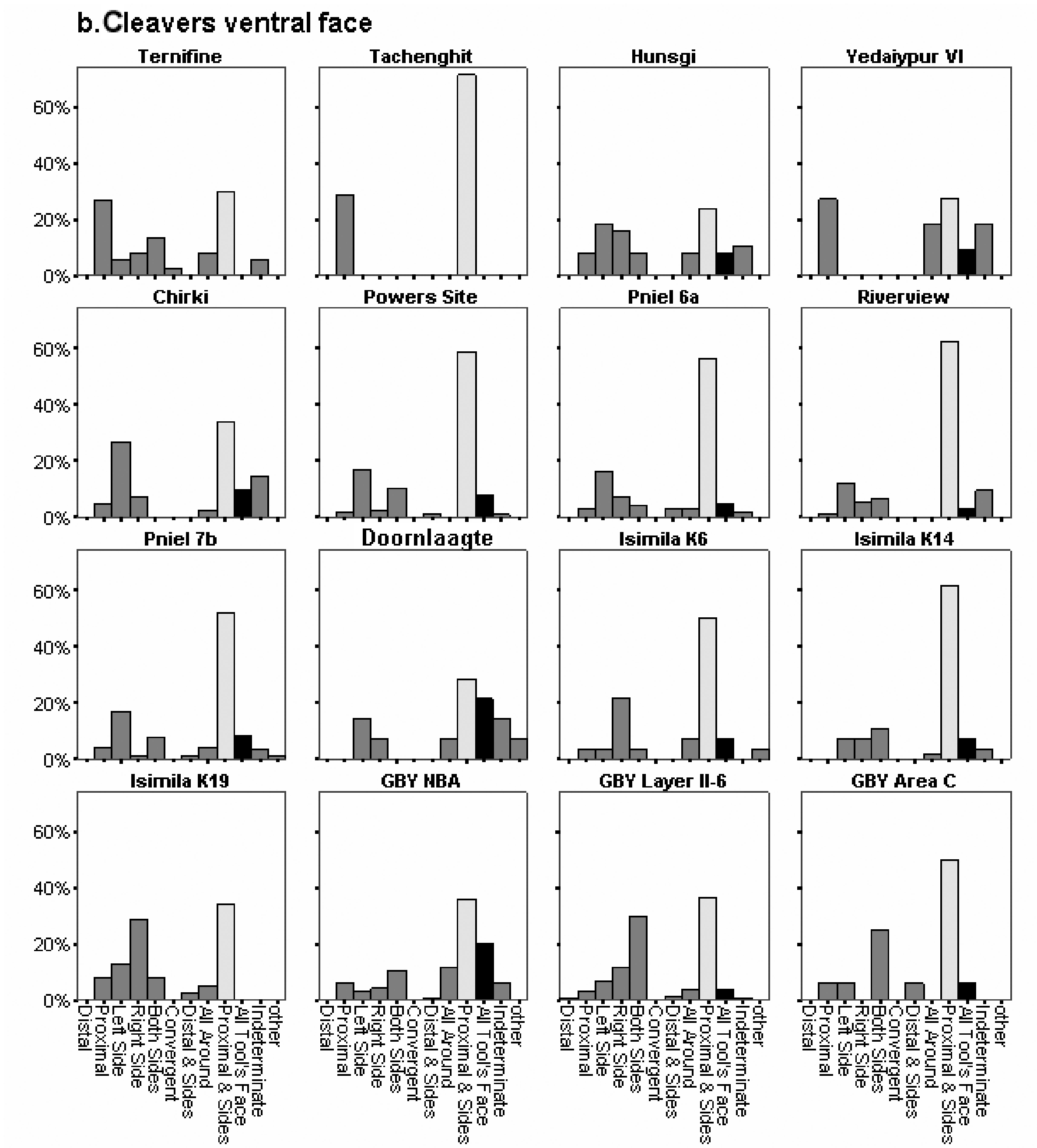


Figure 1210b. Cleaver retouch location Face 2.

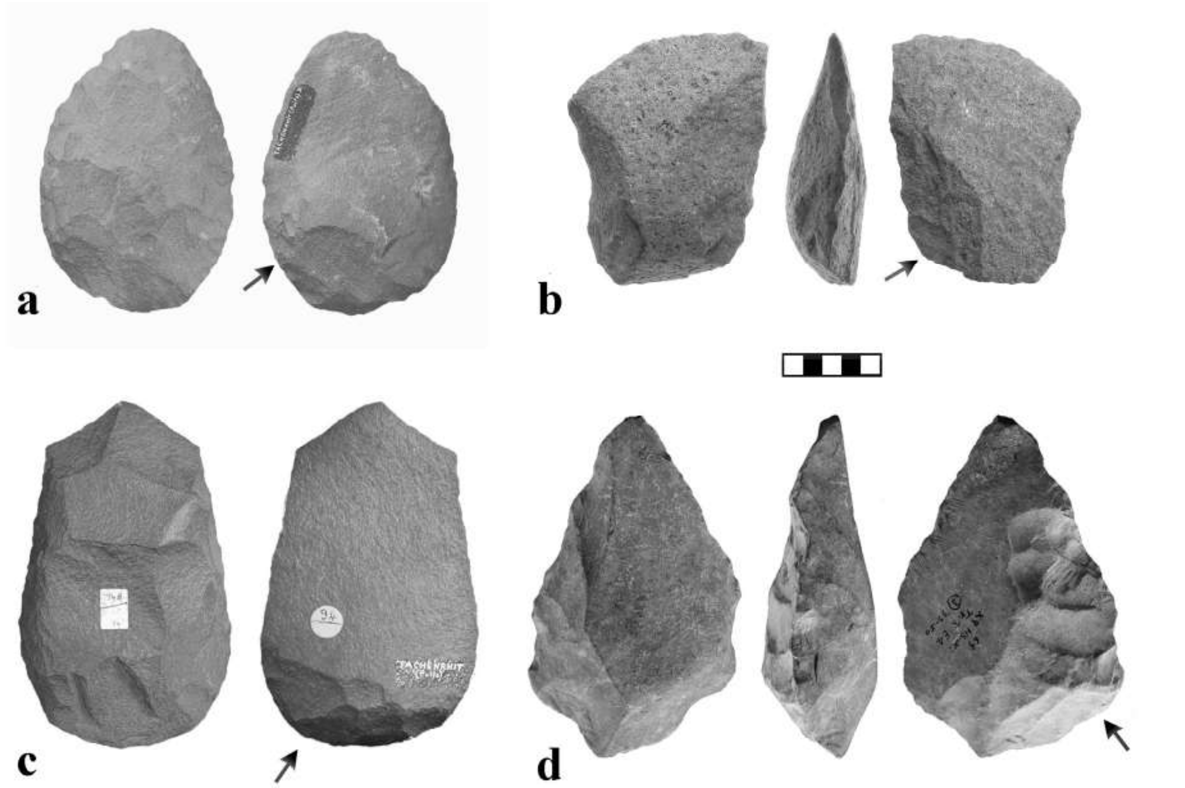


Figure 121. Thinning the bulb of LCTs. a. Handaxe, Tachenghit. b. Cleaver, GBY NBA. c. Cleaver, Tachenghit. d. Handaxe, Hunsgi. Arrows indicate probable blow direction.

The dominance of *Proximal and Side* and *Side* in Fig. 120b is also relevant to the high frequency of removed striking platforms in cleavers (Chapter 4, Tables 23 and 24). The striking platform was often located at the proximal end of the flake blank (Figs. 82 and 83, blow directions 4, 5 and 6) or at its side (Figs. 82 and 83, blow directions 3 and 7). Handaxes and cleavers that were minimally retouched after removal from the parent giant core would have probably been classified as partial tools in the Bordesian typology (Bordes 1961). However, as noted by Texier and Roche (1992), these LCTs are very well balanced and finished.

To sum up, I would like to emphasize the following:

1. The difference between handaxes and cleavers lies in the labor invested in them and their shaping strategy. Handaxes required more work on their blanks, thus granting greater control over their final shape. In cleavers, it was the blank shape itself that dictated the morphology of the tool.
2. Cleaver ventral faces were minimally retouched. It should be noted, however, that in LFB Acheulian industries a minimally retouched ventral face and a thinned bulb of

percussion are also typical of handaxes. The latter was the most frequent procedure in LCT shaping, whose probable purpose was to ensure balanced tools.

These two technological features may serve to define the LFB industries and differentiate them from other stages of the Acheulian techno-complex.

LCT Edges

Handaxe Edge Location

In his study on bifacial tools from Olduvai Gorge, Jones (1994) perceived the length of the cutting edge as a central factor in dictating the shape and size of LCTs. While this approach is very useful for the understanding LCT morphology (Chapter 6), Jones's premise was that the cutting edge of a handaxe surrounded its perimeter. While this is true for many handaxes, others show a very different cutting edge continuum along their margins. Furthermore, the definition and identification of a handaxe cutting edge is problematic and, in many cases, subjective. The term "cutting edge" itself bears functional connotations, which are imprecise. Many retouched LCT edges are not sharp and were probably used for such tasks as scraping and prising. Moreover, much of the edge may reflect its use as a striking platform for flake thinning or bulb removal. I have therefore chosen to use the simple term "edge". The varying levels of abrasion in the samples under study add difficulty in identifying the edge, which is recognized as a margin that has been flaked by retouch. In other words, the cortex, striking platforms, natural surfaces and breakage surfaces are not deemed an edge. Other researchers (Isaac 1977; McNabb 2001) have applied other methodologies, which are similar in principle. Fig. 122 presents the ratio of handaxe edge length to handaxe circumference (edge length/circumference; an edge around the entire perimeter =1).

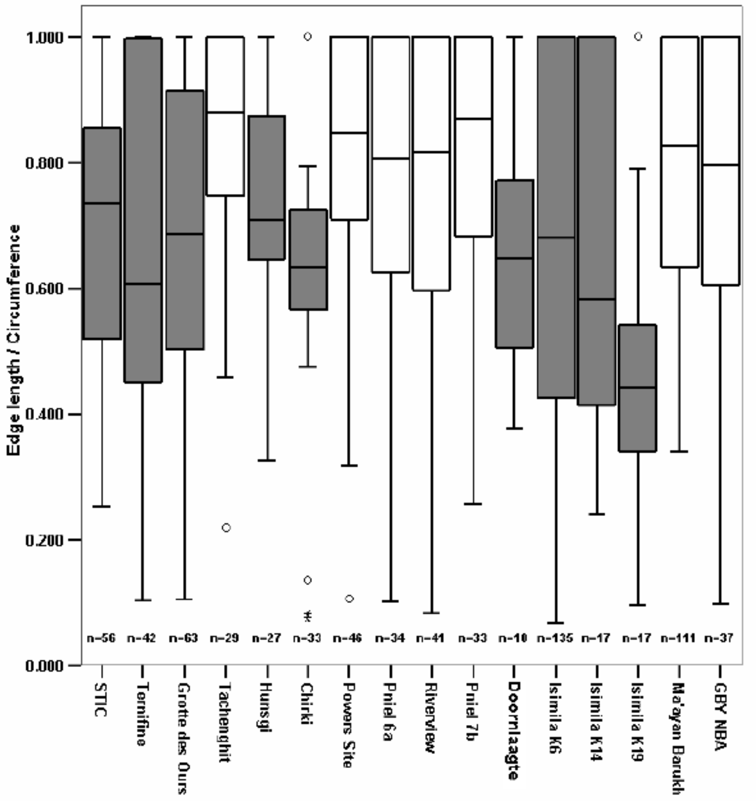


Figure 1222. Ratio of handaxe cutting edge to handaxe circumference. Shaded boxes originate from excavated sites while the other assemblages are surface collections.

Low ratios of edge length to circumference are found in the sites of STIC, the Indian sites (mainly Chirki) and Doornlaagte; lowest are in Isimila K19. It has been maintained that STIC, Isimila K19 and Doornlaagte represent workshop sites (see below), in which finished tools are under-represented and the majority of handaxes are actually preforms. The data presented in Fig. 122 seem to support to this hypothesis. Some researchers have suggested that a high edge-to-perimeter ratio indicates a higher degree of handaxe finish. However, this cannot be taken as a direct reflection of finish level at a site, because all samples range over several values. In Isimila K6 and K14, many handaxes have an edge around their entire perimeter (1 in Fig. 122), but there are many whose edge is limited to the tip of the tool. In STIC (and possibly Grotte des Ours), Doornlaagte and Isimila K19, however, the low values (in comparison to other sites in the same regions as well) indicate a lower degree of handaxe finish, supporting the hypothesis that many of the tools in these sites are actually preforms. The case of Isimila K19 is the most striking. As opposed to other Isimila localities, not one of the handaxes in this site has a value of 1. As regards the low values of the Indian sites, particularly Chirki, a workshop environment cannot be ruled out, but other explanations, such as knapping preferences, should also be considered (see below).

The similarity between samples with high edge-to-perimeter values should also be noted. In Ma'ayan Barukh, the handaxes are not LFB and it has been suggested that cobble blanks were in primary use. Fig. 122 shows that the Ma'ayan Barukh knappers removed all cortical remnants from most of their tools and had a preference for an all-around retouched edge. It is hoped that future study will enable the comparison of the data presented above with data from such sites as Tabun and Misliya Caves, where it was maintained that the focus of handaxe manufacture was the tip of the tool (Gisis and Ronen 2006; Matskevich et al. 2002; Zaidner et al. 2006). The results may well prove interesting.

Further clarification of into the nature of the cutting edge can be achieved by examining the site distribution of handaxe edge location, shown in Fig. 123.

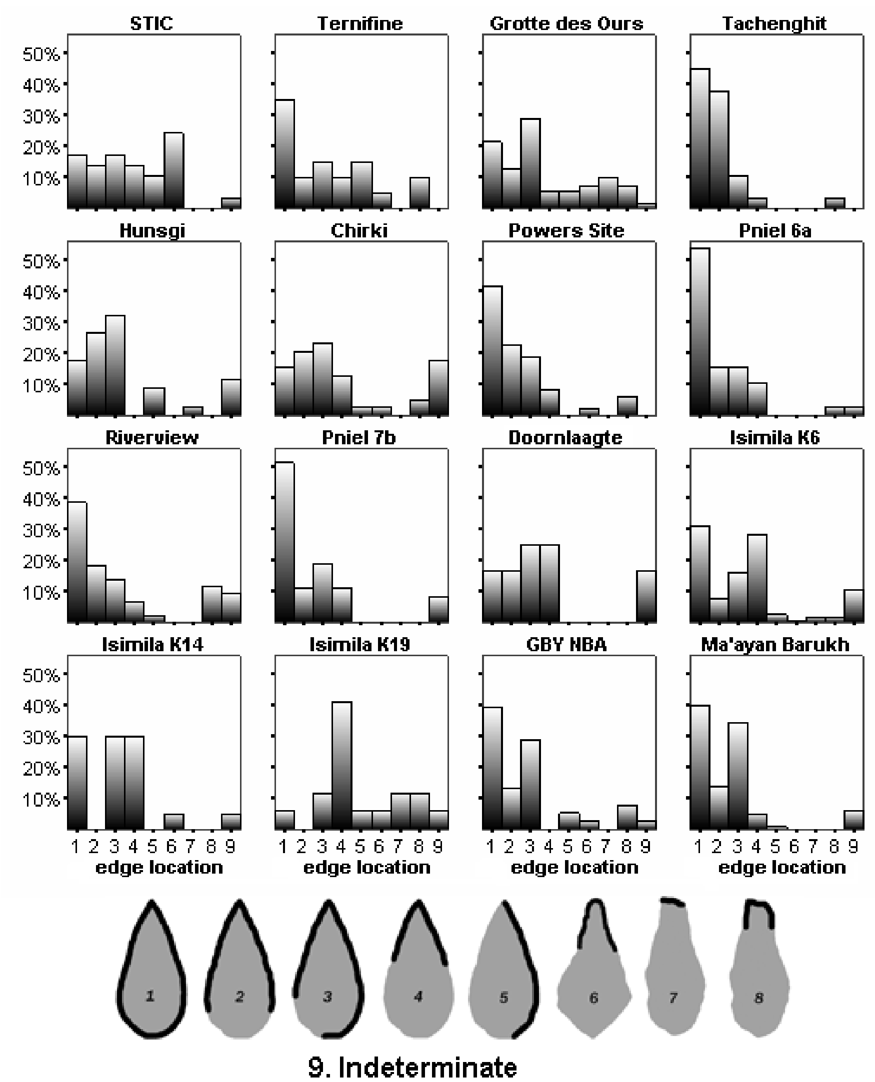


Figure 123. Handaxe cutting edge location by site. Sample sizes – STIC: 29. Ternifine: 20. Grotte des Ours: 70. Tachenghit: 20. Hunsgi: 34. Chirki: 39. Power's Site: 48. Pniel 6a: 39. Riverview Estate: 44. Pniel 7b: 37. Doornlaagte: 12. Isimila K6: 165. Isimila K14: 20. Isimila K19: 17. Ma'ayan Barukh: 117. GBY NBA: 38.

As is evident in Fig. 123, all sites display a variety of edge location. Some sites (STIC, Grotte des Ours, Chirki and Hunsgi) show no particular preference for one location. In others, mainly the Vaal River sites and Ternifine, a preference for an all-around edge is indicated. The rest of the sites exhibit a more complex nature. Isimila K6 and Isimila K14 show high values of both an all-around edge (location 1) and a tip-located edge (location 4). At Isimila K19, location 4 is by far the most dominant, a dominance shared by handaxes from the site of STIC, although the latters' tool edges are knapped in a more limited and Micoquian manner (location 6). This edge location may exemplify a tool that was unsuccessfully shaped and therefore abandoned at its workshop site. At Tachenghit, Ma'ayan Barukh and GBY NBA, one side of the butt, which was left without a cutting edge, registers high values. This may be explained by technological or functional needs, or even suggest significant use of cobble blanks in some of these sites.

The data presented for handaxe edge and location suggest that the Acheulian knapper applied a sophisticated edge manufacturing strategy in which clear traits are apparent. In some sites, the special emphasis given to a tool's tip suggests that it is an unfinished preform. Alternatively, recent studies of Acheulo-Yabrudian handaxes from Tabun Cave (Matskevich et al. 2002) and Misliya Cave (Zaidner et al. 2006) have demonstrated that the tip of the handaxe at these sites was the main focus of its manufacture, the other parts frequently exhibiting minimal investment of time and energy. However, this retouch strategy does not explain the differences between the Vaal sites and the site of Doornlaagte, which is technologically similar, nor does it reflect the variability of the Isimila site. This particular difference was observed through the presence or absence of finished handaxes in these assemblages. The Final Acheulian–Yabrudian handaxes add another dimension and demonstrate the part played by the cutting edge in the history of a handaxe's reduction sequence and morphology.

In the sites of STIC and Isimila K6, there are rare cases in which the shaping of a handaxe resulted in a cortical tip (Fig. 124). These cases demonstrate that the Acheulian knapper did not always perceive the handaxe tip as a cutting edge; the marginal edges of these handaxes could have been used and the tools were probably functional.

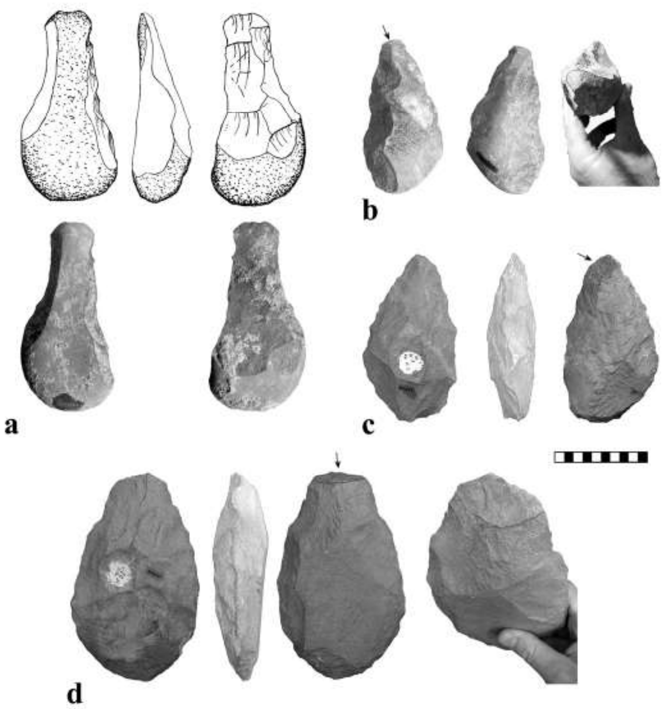


Figure 124. Cortex tip handaxes (marked**) from STIC (a–b) and Isimila K6 (c–d).**

Cleaver Cutting Edge

Cleaver cutting edges are very different from those of handaxes in their location and technology of manufacture. As opposed to handaxes, it seems safe to define the edge opposite the butt of the cleaver as a cutting edge, since it is uniform in all cleavers and is typified by a sharp, thin and unretouched morphology. LCT cutting edges were shaped by two main methods: 1) Retouch of blank margins; bifacial retouch was usually used to create a handaxe's cutting edge, giving the knapper control over the shape of the resulting edge (straight, concave, convergent, etc.), its location along the tool's perimeter and its nature and qualities (sharp, blunt, steep, etc.). 2) Use of naturally sharp edges that were formed when a flake was removed from its core. The absolute majority of cleaver edges were produced by this method.

The debate on the definition of cleavers, particular bifacial cleavers, was summarized in Chapter 1. Tixier (1957) defined a cleaver's cutting edge as having never been shaped by retouch. In order to test this definition, the cleavers under study were divided into two categories: a) Those whose edge was determined prior to the detachment of the cleaver blank. b) Those whose edge was shaped by secondary retouch after the detachment of the cleaver blank. Cleavers that could not be categorized were classified as "indeterminate'. The results are presented in Table 38.

Table 38. Cleaver edge shaping.

Edge Shaping	Prior to Blank Detachment		Subsequent to Flake Detachment		Indeterminate		Total
	N	%	N	%	N	%	N
Ternifine	32	78.0	8	19.5	1	2.4	41
Tachenghit	12	80.0	3	20.0	-	-	15
Hunsgi	40	85.1	6	12.8	1	2.1	47
Yediyapur VI	8	72.7	3	27.3	-	-	11
Chirki	35	85.4	6	14.6	-	-	41
Power's Site	109	94.8	-	-	6	5.2	115
Pniel 6a	94	94.9	3	3.0	2	2.0	99
Riverview	71	94.7	3	4.0	1	1.3	75
Pniel 7b	78	90.7	5	5.8	3	3.5	86
Doornlaagte	11	91.7	1	8.3	-	-	12
Isimila K6	23	82.1	4	14.3	1	3.6	28
Isimila K14	44	88.0	6	12.0	-	-	50
Isimila K19	30	88.2	3	8.8	1	2.9	34
GBY NBA	66	75.9	17	19.5	4	4.6	87
GBY Layer II-6	82	66.7	10	8.1	31	25.2	123
GBY Area C	11	78.6	-	-	3	21.4	14

The great majority of cleaver edges were formed prior to blank detachment from the core. In the GBY assemblage, there is a high number of indeterminate cases, since complete LCTs are fully represented in this assemblage (in the other sites under study, indeterminate cases yielded fewer data and were therefore less frequently selected for analysis). The relatively high percentage of "subsequent to flake detachment" cleaver edges in GBY NBA may be due to their taphonomic history; i.e., there may be post-depositional "retouch" as a result of the high-energy depositional environment of some of the site's levels (Chapter 3). In any case, the number of cleavers in which the cutting edges were created after the flake blank was detached is extremely low. It cannot be ruled out that some of these edges were formed through use, breakage (Fig. 125:c) or secondary retouch of what was originally the "true" cleaver edge (Fig. 125:b).

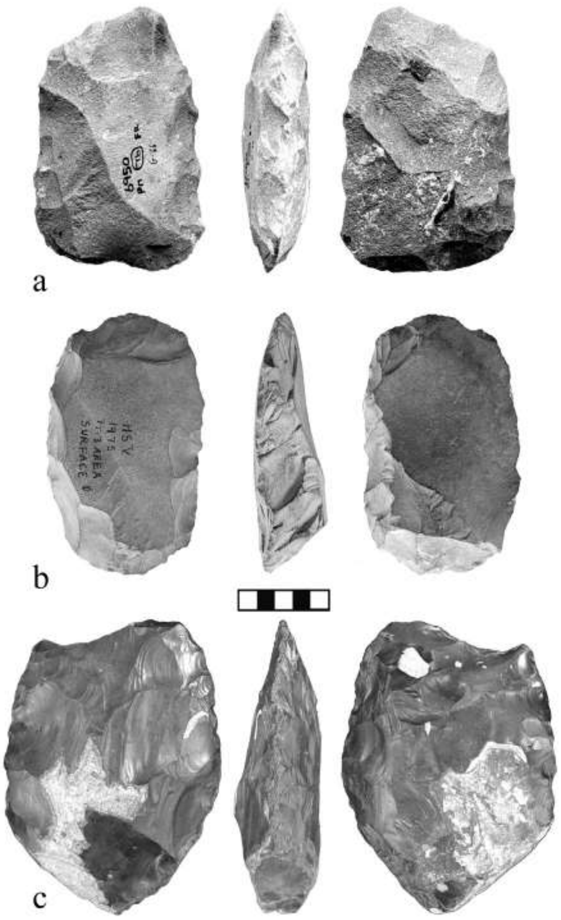


Figure 125. Retouch-shaped cleaver cutting edge. a. Pniel 7b. b. Hunsgi V. c. GBY NBA.

The main advantage of the unretouched cleaver cutting edge over the bifacially knapped handaxe cutting edge was its sharpness (and probably its thinness). An alternate way of achieving a sharp broad edge was the removal of a tranchet flake (see Goren-Inbar and Sharon 2006 for recent discussion) from the tip of the tool, as widely discussed for the UK Acheulian (Roberts et al. 1997) and the Acheulian of the Eastern Levant (Rollefson et al. 2005). This might provide a basis for defining many European LCTs as cleavers (see, however, White 2006). Some scholars perceive the tranchet removal as evidence of a resharpening procedure applied to blunt LCT cutting edges. An additional approach sees these removals as "work accidents" that occurred because of missed blows during tool shaping, or as use wear (see discussion in Goren-Inbar and Sharon 2006). Some of the cleavers under study show probable tranchet scars (Fig. 126; dorsal face of cleavers from Pniel 7b), although this is rare. It should be noted that, since the examples in Fig. 126 were all produced from Victoria West cores, the scar that creates the cleaver edge could have been removed during the previous core preparation stage.

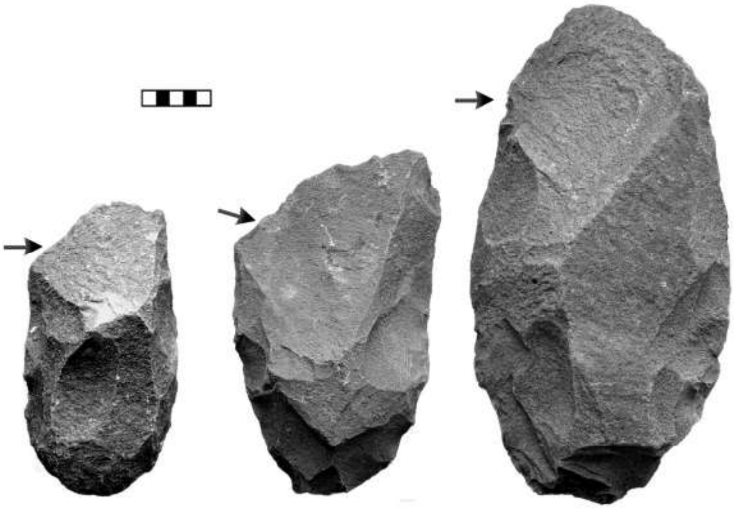


Figure 126. Cleavers with cutting edge shaped by large tranchet blow. All are from Pniel 7b; note that all of these cleavers were produced by the Victoria West method.

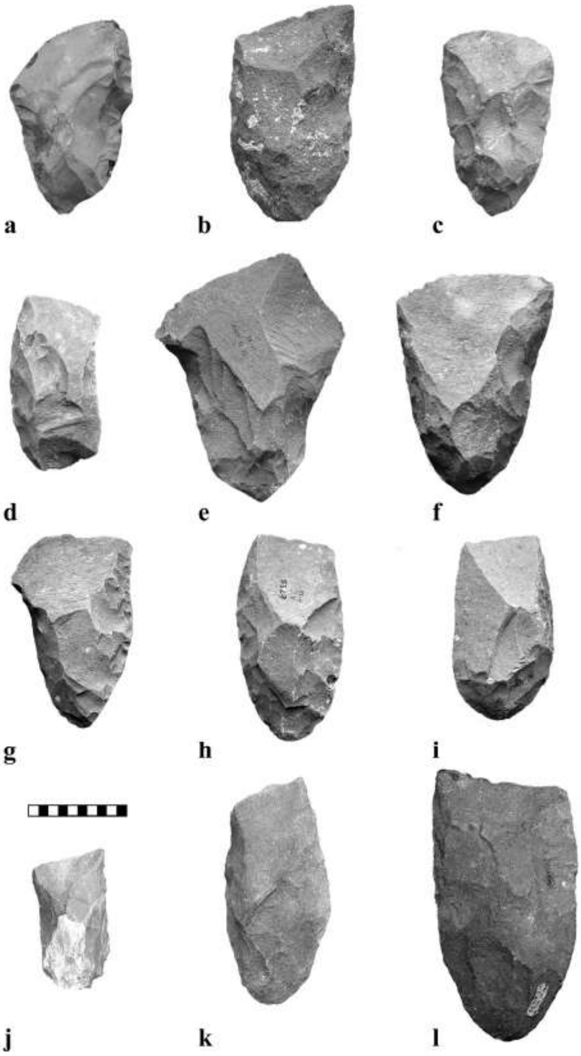


Figure 127. South African cleavers with predetermined cutting edge. a–c. Riverview Estate. d–f. Pniel 7b. g–h. Pniel 6a. j–l. Isimila K14.

A major benefit of many large core methods was that they enabled the knapper to pre-plan a scar pattern on the large core and thus predetermine the flake blank's dorsal scar pattern. Kombewa, Levallois, Victoria West and slab cores are all core methods that facilitated control over the blank dorsal face and the cutting edge (Texier and Roche 1992). Note that in side-struck or special side-struck flakes, the cutting-edge dorsal scar could be designed to appear either at the distal edge of the tool, or at a 45^{o} or 90^{o} angle to the flaking axis. Examples of cleavers with predetermined cutting-edge scars are shown in Figs. 127 and 128. The junction of this scar with the ventral face formed the cleaver's edge (see recent overview in Mourre 2003).

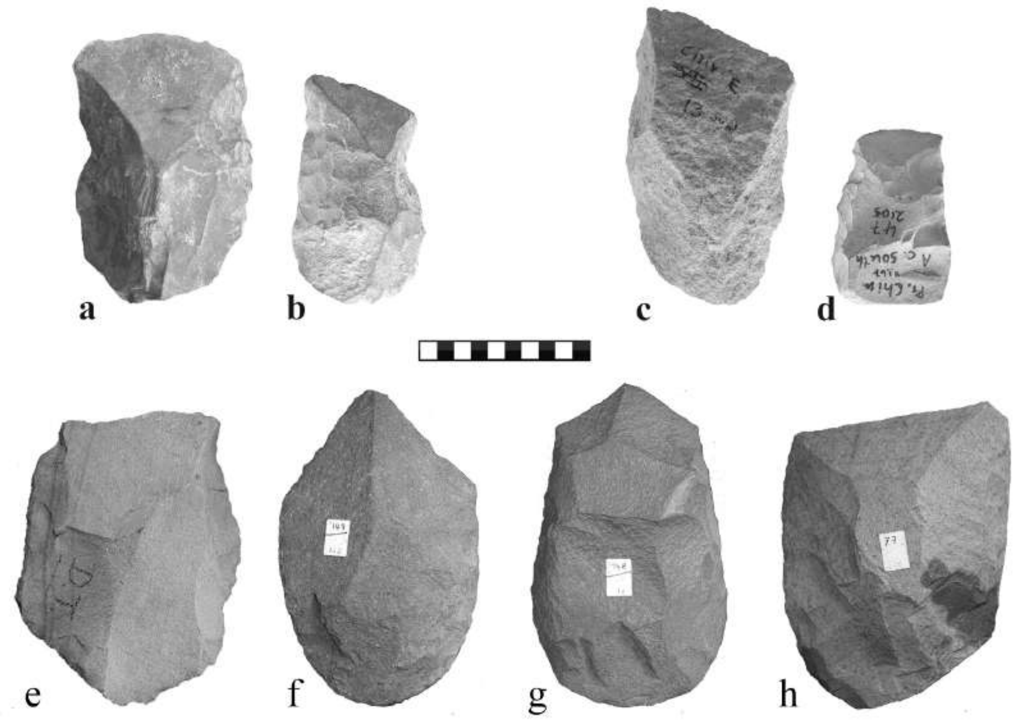


Figure 128. Cleavers from India and Tachenghit (North Africa) showing cutting edge predetermination. a–b. Hunsgi V. c–d. Chirki. e–h. Tachenghit.

In some cases, a cortical distal dorsal edge was used as a cutting edge. These cortical edges suggest the use of primary opening flakes from giant cores, cobbles or outcrop exposures as blanks for cleaver production. Although these cortical blanks (Fig. 129) do occur in the assemblages under study, they are quite rare, probably because the edge quality of the cortex is low. Exceptions are the cortical Ternifine entame flakes, as described in Chapter 4.

Figure 123. Cortical cleaver edges. a. GBY NBA. b. Hunsgi V. c. Pniel 7b. d. Riverview Estate. See also the Ternifine *entame* cleavers in Fig. 4.12.

LCT Workshop Sites

Among the various sites under study, the Isimila K19 biface assemblage best exemplifies a group of samples that are typified by certain common technological characteristics. These may be summarized as follows:

1. The handaxes from Isimila K19 are very large in all size attributes (Figs. 102-111), particularly when compared to Isimila sites K14 and K6. Most striking is the width of the Isimila K19 handaxes, which is greater than that found in all other sites. In contrast, although the cleavers from Isimila K19 are on the large side of the scale, they do not differ greatly from those of Isimila K6 or Isimila K14. The scar counts of the Isimila K19 handaxes and cleavers are at the lowest end of the scale, both in their total (Tables 34 and 35, Fig. 115) and as they appear on individual tool faces (Fig. 117).
2. When examining the ratio of handaxe cutting edge to circumference, the results for Isimila K19 are dramatically lower than those of any other site. None of the Isimila K19 handaxes have a cutting edge that surrounds the handaxe's perimeter (Fig. 122), and, in contrast to any other site, these handaxes are dominated by the "tip only" mode (edge location 4; Fig. 123).
3. The present study of the Isimila K19 assemblage has also revealed the following observations. There appear to be many large flakes (larger than 10 cm) in the assemblage (Fig. 130). These are either unfinished biface blanks or, more frequently, rough-out or large thinning flakes produced in the process of handaxe manufacture (terminology after Newcomer 1971). The assemblage of Isimila K19 contains many

preform-type tools. These have rough, thick, sometimes pick-like shapes, as shown in Fig. 131.

4. In terms of workmanship, the bifacial tools from Isimila K19 are rougher than those of the other Isimila localities under study. The site is characterized by large, thick handaxes, which bear a small number of deep and widely spaced scars and have a limited cutting-edge length compared to their circumference, located at the tip of the tool.

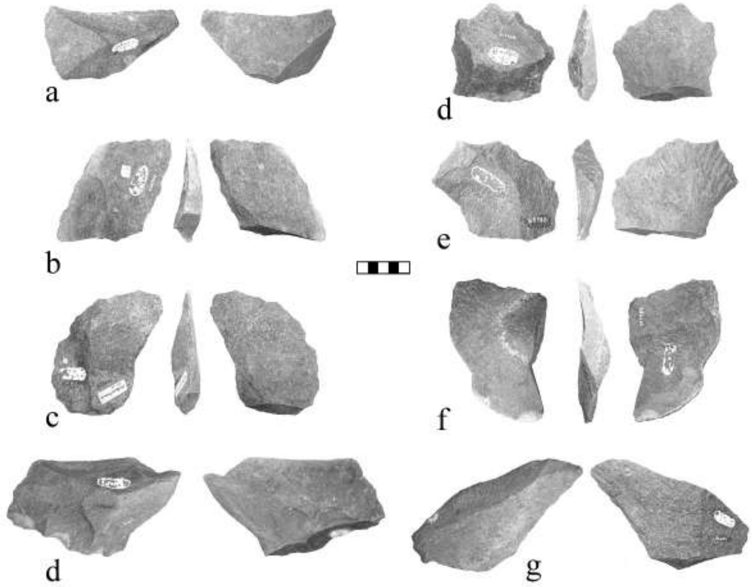


Figure 130. Isimila K19 large flakes.

There are at least two other sites that exhibit characteristics similar to Isimila K19: the STIC quarry of Casablanca and Doornlaagte, in the vicinity of the Vaal River, South Africa. There is some technological and typological resemblance between the assemblages of each of these sites and others in their regions. Nevertheless, their own particular tools are rough, large and especially thick. They have low scar counts and generally seem to represent preforms. Fig. 132 presents some large biface manufacturing flakes from the STIC quarry, which exhibit similarity to the large flakes from Isimila K19 (Fig. 130).

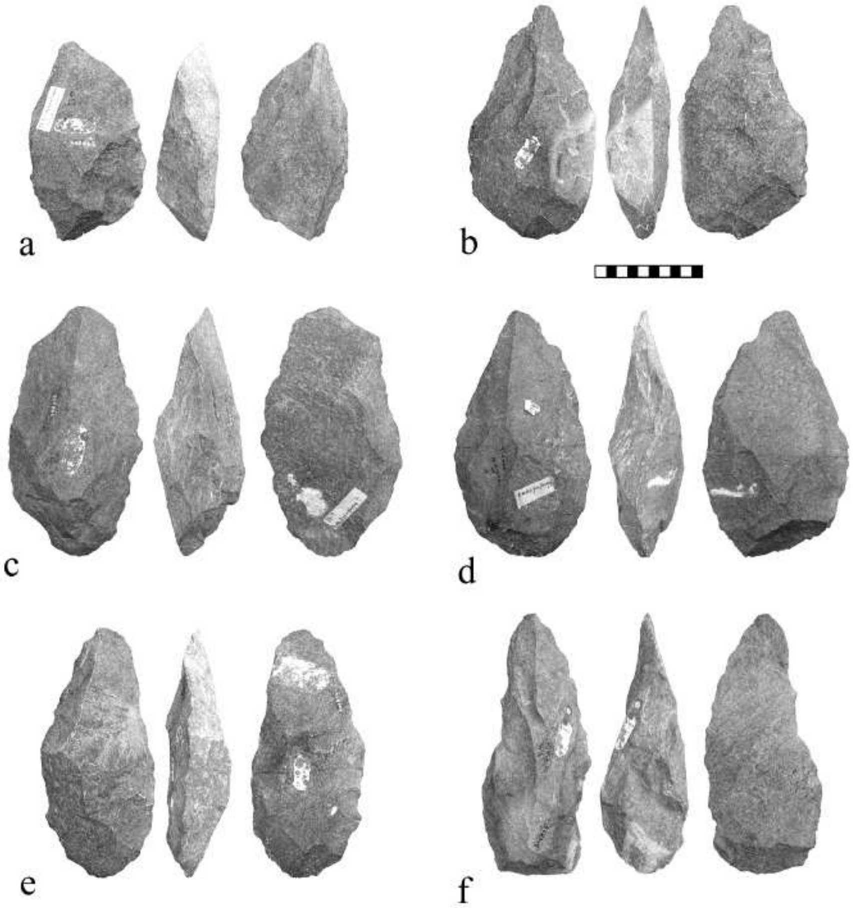


Figure 131. Isimila K19 preforms.

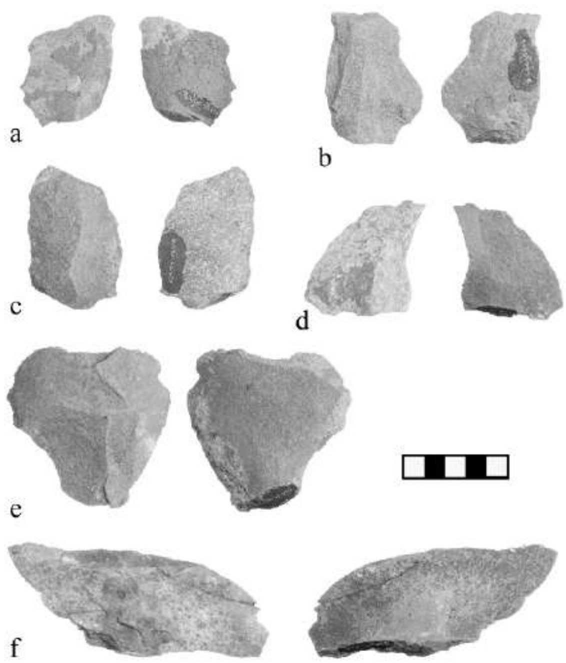


Figure 132. Biface manufacturing flakes from STIC.

When comparing the Isimila K19, STIC and Doornlaagte assemblages with other samples, the first interpretation that comes to mind is that the former sites are of greater age and represent a less evolved lithic entity. However, there are indications that this interpretation is erroneous. These three sites do not display a difference in their general tool type frequency and LCT technology (core technology, type of blank used, type of retouch, etc.). At the site of Doornlaagte, for example, Victoria West cores are present (both struck and preforms; Chapter 4). No difference in raw material exploitation strategy or frequency of use is apparent. If we compare these sites to a truly archaic Acheulian site like 'Ubeidiya (Bar-Yosef and Goren-Inbar 1993), we find that at 'Ubeidiya most of the tools are large, rough picks that bear very few scars, the main blanks for biface production were cobbles, no real cleavers are present and, above all, no evolved tool core technologies are present. None of the sites under study show any of these archaic Acheulian characteristics. Similar arguments may be made in support of a suggestion that these assemblages represent a post-Acheulian cultural stage (e.g. the Sangoan of South Central Africa; see Clark 2001 and Tryon 2003 for overviews), but these too may be dismissed on similar grounds.

Thus, an explanation along different lines was suggested: Doornlaagte, STIC and Isimila K19 are workshop sites in which LCTs were produced. The finished tools were usually removed from these sites, leaving behind unused large flake blanks, rejects, preforms and technological failures. The presence of large bifacial thinning flakes in these assemblages supports this interpretation. The nature of the site is evident from the study of the handaxe, rather than of the cleaver, because after its blank was selected, a cleaver required minimal labor investment, its thickness mirroring the thickness of its original flake blank. Moreover, since close attention was devoted to the blank selection stage, fewer cleavers were rejected during or after final shaping. Even so, the Isimila K19 cleavers show a much smaller scarred facial area than do the other two Isimila assemblages.

Recent studies have demonstrated that differences between Acheulian lithic assemblages can be explained in part by the mobility of lithic artifacts in and out of the site (Goren-Inbar and Sharon 2006). The technological data presented here have facilitated the identification of specific characteristics that define a workshop site, where LCTs were shaped and later removed. This is a primary identification, based solely on observation of the LCTs. Additional aspects of the assemblage (large and small flakes, cores, other tools, etc.) should also be studied, in order to arrive at a more comprehensive interpretation of the said sites. The nature, size and shape of the available raw materials, as well as their distance from these sites, are unknown. It seems that tools were brought into the sites as preforms, with the thinning and finishing stages taking place on-site. The finished tools were then exported to other localities.

The Indian sites of Hunsgi and Chirki share some workshop site characteristics (i.e. low number of handaxe scars, rough and unfinished nature of handaxes, many pick-like shapes and tool-tip focus), but lack others, such as size attributes. The cleavers from these sites are of high quality and do not show any workshop characteristics. It is therefore uncertain whether these should be identified as workshop sites. Other sites in the Hunsgi-Baichbal region, like Tegihally (Paddayya 2001), seem to show even finer finished tools. In addition, large quarry sites like Isampur, located at a raw material source, are present in the vicinity (Paddayya et al. 2006; Petraglia et al. 1999). We may be looking at a cultural phenomenon, in which the handaxes of the Indian Acheulian were less carefully made. Cleavers, on the other hand, seem to be very well evolved and their technology is developed.

Although many Acheulian sites have been identified as quarry sites (Kuman 2001; McNabb 2001; Petraglia et al. 1999; Stiles 1991), it can be predicted that LCT assemblages from such sites as Canteen Koppie (Beaumont 1990a; McNabb 2001) and Isampur (Paddayya et al. 2000; Petraglia et al. 1999) will all show characteristics similar to the ones presented above.

Chapter 6: The Shape of Large Cutting Tools

Typology in the Study of Acheulian LCTs

Typology is one of the main analytical tools at archaeologists' disposal to present and describe their finds and compare between them. Here I will give a brief review of some of the typological methods that have been applied to the study of Acheulian LCTs thus far. In their comprehensive discussion on the use of typology in archaeology, Adams and Adams defined "type" as "… a group of entities, our ideas about these entities and the words and/or pictures in which we represent our ideas". They pointed out that "type has the two essential properties of identity and meaning. That is, to be useful they have to be consistently identifiable, and they have in addition to tell us something that we want to know." In their view, practical archaeological typologies "…are developed with reference to a specific purpose or purposes, and it is those purposes that give meaning to the individual types in the system. Archaeological typologies can legitimately serve many different purposes, and these will affect the way in which types are formulated and used" (Adams and Adams 1991, 239–240). Hence, archaeological typology aims to group finds into clusters called "types" and then compare between them. This system is rooted in the Linnaean taxonomic system (Isaac 1972a; Krieger 1944) and is deemed to reflect stylistic origins and cultural differences and commonality.

In establishing their typological system for Lower Paleolithic African stone tools, Clark and Kleindienst (2001, 34) summarized the workings of typological cultural interpretation in prehistory:

> "In the belief that a group of artefacts with the same attributes will reflect the prevailing technical preferences and abilities, as well as the particular requirements of the individuals who made them, aggregates have been analyzed on a typological basis recognizing a number of categories and classes (or types). Artefacts that tend to share a cluster of specific attributes, regarded by the investigators as significant, constitute a class (or type) and certain major classes or categories are recognized according to the degree of secondary modification and retouch which their component artefacts undergone. This procedure follows largely from the assumption that the more a piece

> is modified the more clearly it will show the design principles formerly incorporated in the culture of the stone age artisans."

Isaac (1972b, 15) presented the assumptions underlying typological cultural interpretation in the study of Early Paleolithic lithic assemblages as follows:

> "1. Each phase, or culture, is demarcated by a distinctive stone tool kit, and conversely each distinctive stone tool assemblage must derive from a significantly different phase, or culture.
>
> 2. Specific resemblance between assemblages from successive stratigraphic zones must result from a continuous chain in the transmission of craft tradition. That is to say that alleged patterns of similarity linking assemblages of different ages must be due to the former existence of 'playa' of culture".

It may therefore be surmised that in Acheulian LCT research, typology strives toward the following goals (Debénath and Dibble 1994):

a) To establish a "common language" for describing finds and communicating observations to other archaeologists.

b) Like many other stone-tool types, LCTs are, in many sites, to be found by the thousands. As it is impossible to describe each of them individually, their classification into types offers a manageable way of presenting and describing an assemblage.

c) Typology arranges artifacts into a chronological framework that classifies them according to their relative age, thus providing a basis for most relative chronological schemes in archaeology.

Due to the great antiquity of prehistoric stone tools and the low resolution of the archaeological data, it is quite difficult to achieve the above aims. Ideally, typological classification is based upon as many aspects of the artifacts as is possible to cover. The shape of the tools, their technology of manufacture, their decorative technique and style, and even ethnographic and textual sources can all contribute to the classification process (Adams and Adams 1991; Krieger 1944). Since most of these aspects are lacking in the study of Acheulian LCTs, our typological system essentially relies on the shape of a tool and occasional fragmentary data on its technology of manufacture. Central developments that have occurred in the typology of Acheulian LCTs and the current state of research will be discussed below.

Bordes's (1961) typological system is the most comprehensive, influential and widely used typology that has been applied to the study of the Lower and Middle Paleolithic of Europe and most regions of the Old World (see Gisis and Ronen 2006; Marder et al. 2006;

Zaidner et al. 2006 for the most recent examples). It is still considered the “textbook” typology for the Acheulian of Europe and the Levant (Debénath and Dibble 1994), the Levantine Acheulian cultural sequence – particular the chronological scheme suggested by Gilead (1970a) for the Levant Late Acheulian – being based on typological considerations derived from Bordes’s scheme.

The Bordesian typology of Acheulian handaxes is based on ratios of metrical measurements that were found to be significant for handaxe shape description and classification into types. The definition of handaxe types also entailed some technological considerations. As for cleavers, Bordes (1961) described only two types, the bifacial cleaver and the cleaver on a flake, although he did make reference to Tixier’s (1957) typological system, which was based on the technology of cleaver blank production.

Since its introduction in the late 1950’s, the Bordesian typology has been subjected to much criticism (see overview in Debénath and Dibble 1994, 4–7). Recently, McPherron (2006, 270) demonstrated how the same shapes could be classified as different types when measured in accordance with the Bordesian system:

> “One can easily imagine a handaxe with a pointed tip in which, because the maximum width lies at the mid-point of the length, the ratio of the mid-width to the maximum width will equal one and the handaxe will measure as an ovate according to Bordes.”

The most pointed criticism has been that the Bordesian system fails to describe a good number of Acheulian assemblages that were found outside the borders of Europe. Based on her study of African Late Acheulian assemblages, Kleindienst (1962) has therefore suggested an alternative typology for African Acheulian stone tools. This typological system is less formal than Bordes’s method, as it does not involve applied measurements and metrical ratios. Instead, it comprises illustrated type-shape diagrams in outline (see below).

For the description of Acheulian handaxes in Britain, Roe (1964, 1968) developed yet a third approach to the study of LCT shapes, an approach that was later expanded to include African Acheulian types (Roe 1994, 2001). As he himself acknowledges, Roe’s system is not a typological system in the strict sense (Roe 2006). Rather than grouping LCTs into types, it uses measurements and metrical ratios for the graphic demonstration of different LCT shape frequencies in order to compare between assemblages. This method will be discussed further below.

In recent years, other means have been used in an attempt to explain LCT shape variability (mostly in European handaxes). In discussing the shape of the nodule that served as a blank in the production of many UK handaxes, White (1995, 1998) suggested that raw material shape was the main factor in dictating the shape of the finished tool. McPherron (1999, 2000, 2006) sees handaxe shape variability as reflecting different stages in the continuum of the tool manufacturing process (see below).

Handaxe Shape

"For almost as long as handaxes have been recognized as an important Lower Paleolithic stone tool type, we have been aware that this single class of objects encompasses a **great** (my emphasis, GS) variety of forms" (McPherron 2006, 268).

"Acheulean large cutting tools across Africa, Asia and Europe differ **enormously** (my emphasis, GS) in the size and shape, symmetry, plan form standardization and type or class frequencies between assemblages" (Noll 2000, 23).

The above citations reflect common knowledge pertaining to Acheulian handaxes, namely that they demonstrate great variability in form. However, evidence suggests that this axiom should be questioned. If one views handaxes in a less limited perspective than a single assemblage, the variability of Acheulian handaxe shape suddenly seems astonishingly limited, rather similarly to the size variability of LCTs (Chapter 5).

In this study, a handaxe is a tool that possesses a long and sharp cutting edge. Such cutting edges could have been produced on a large variety of geometric shapes, some of which are hypothesized in Fig. 133. Fig. 134, on the other hand, presents the actual scheme of the European handaxe shape inventory, as presented by Bordes (1961).

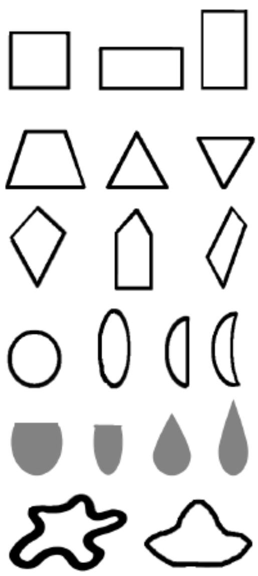


Figure 133. Hypothetical geometric shapes on which a long and useful cutting edge could be made.

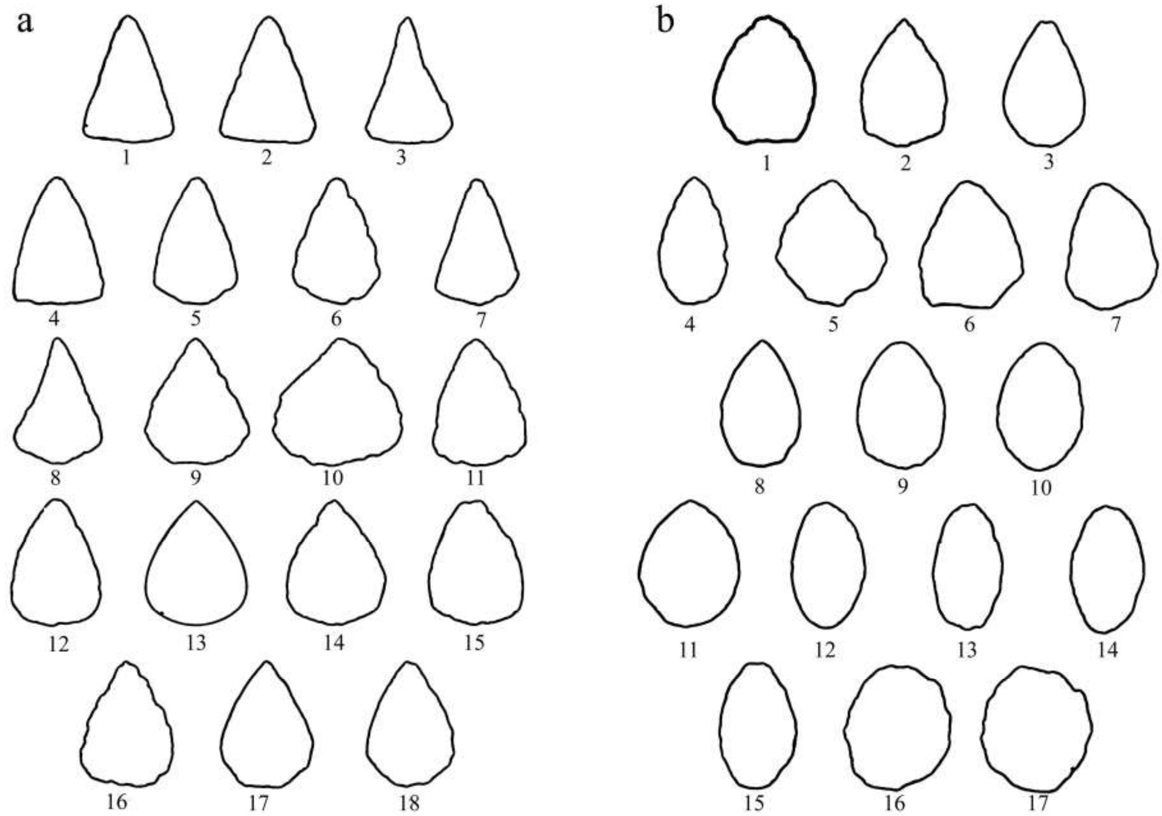


Figure 124. European handaxe contours (after Bordes 1961, Figs. 8, 9).

In light of the above examples, let us now examine the actual shape variability of the Acheulian handaxes under study. Figs. 135–141 present the shapes of **all** complete handaxes from this study's selected samples (see also the Isimila K6 handaxes in Fig. 146 below). The tools are arranged arbitrarily and are not to scale. Although this method of presentation is not quantitative, it does facilitate a comprehensive look at all tool shapes in a given sample.

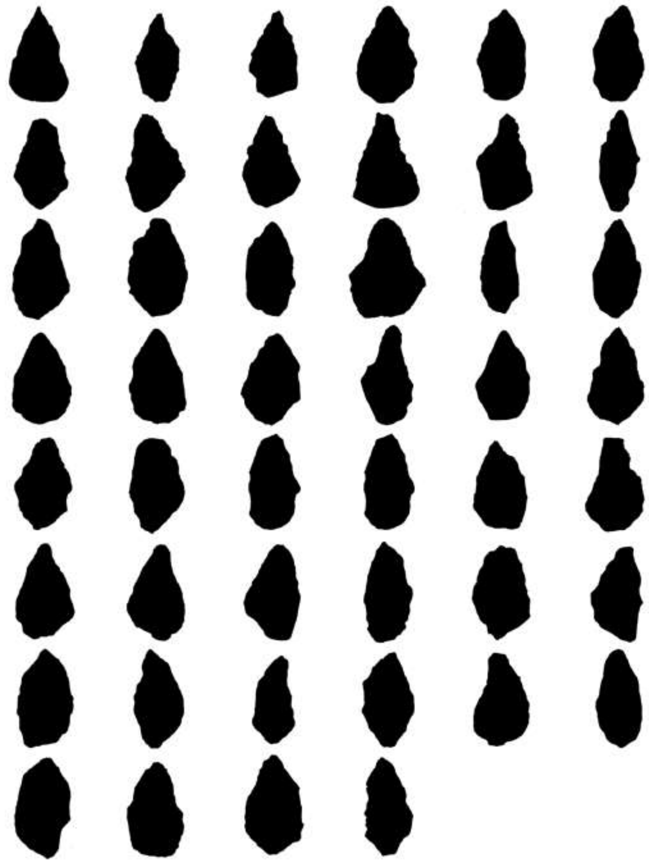


Figure 135. Chirki complete handaxe plan-shape diagram (not to scale).

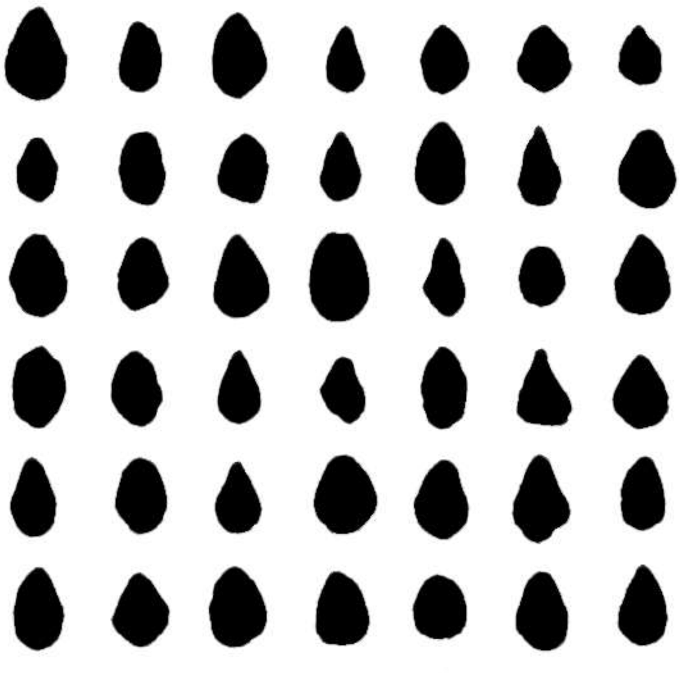


Figure 136. Ma‘ayan Barukh complete handaxe plan-shape diagram (not to scale).

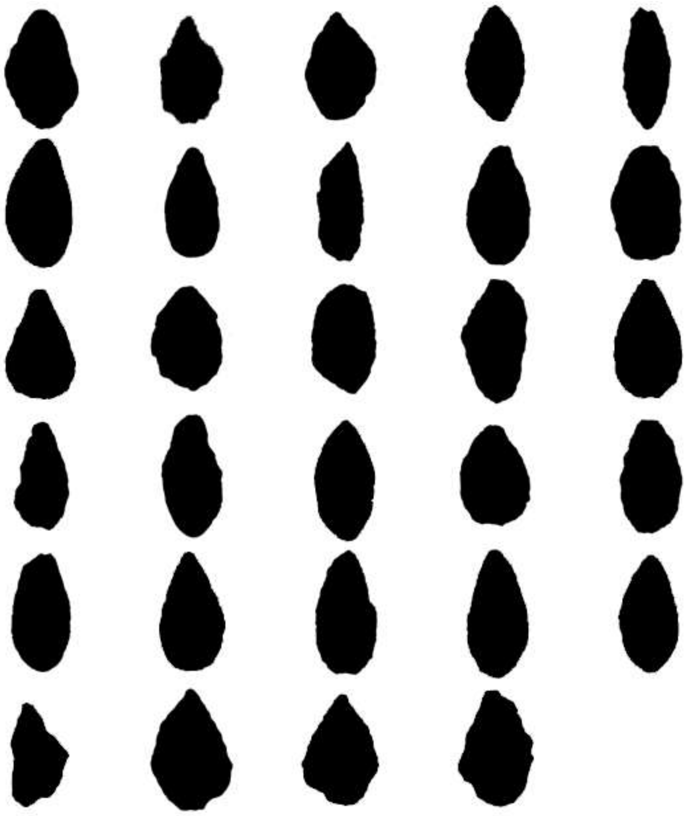


Figure 137. Isimila K14 complete handaxe plan-shape diagram (not to scale).

Figure 138. Ternifine complete handaxes plan-shape diagram (not to scale).

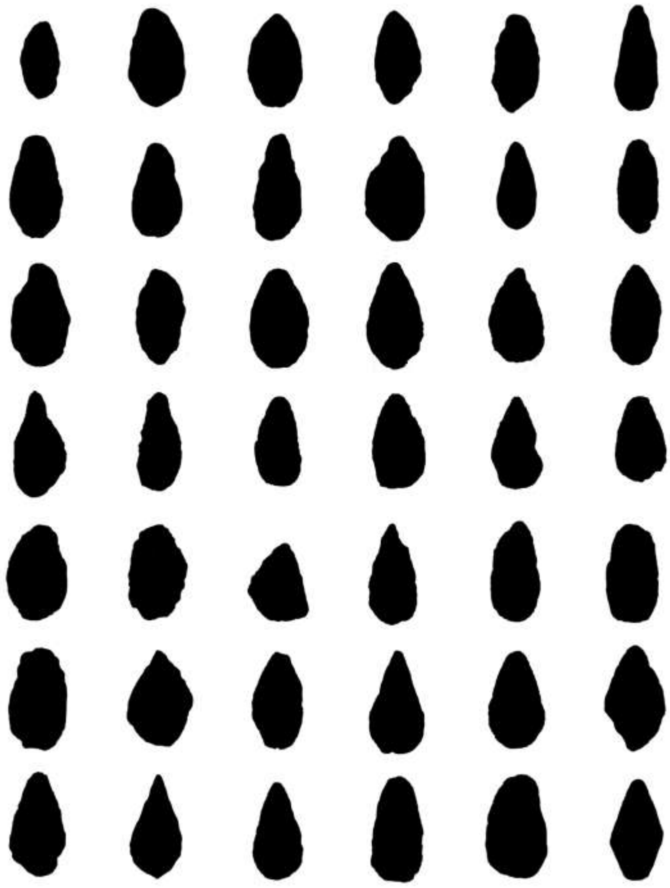


Figure 139. Pniel 7b complete handaxe plan-shape diagram (not to scale).

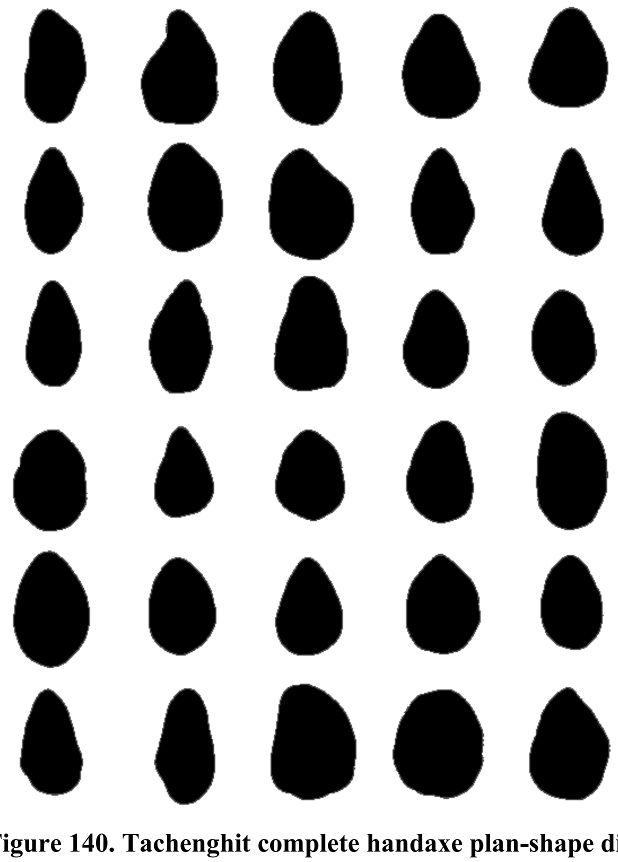


Figure 140. Tachenghit complete handaxe plan-shape diagram (not to scale).

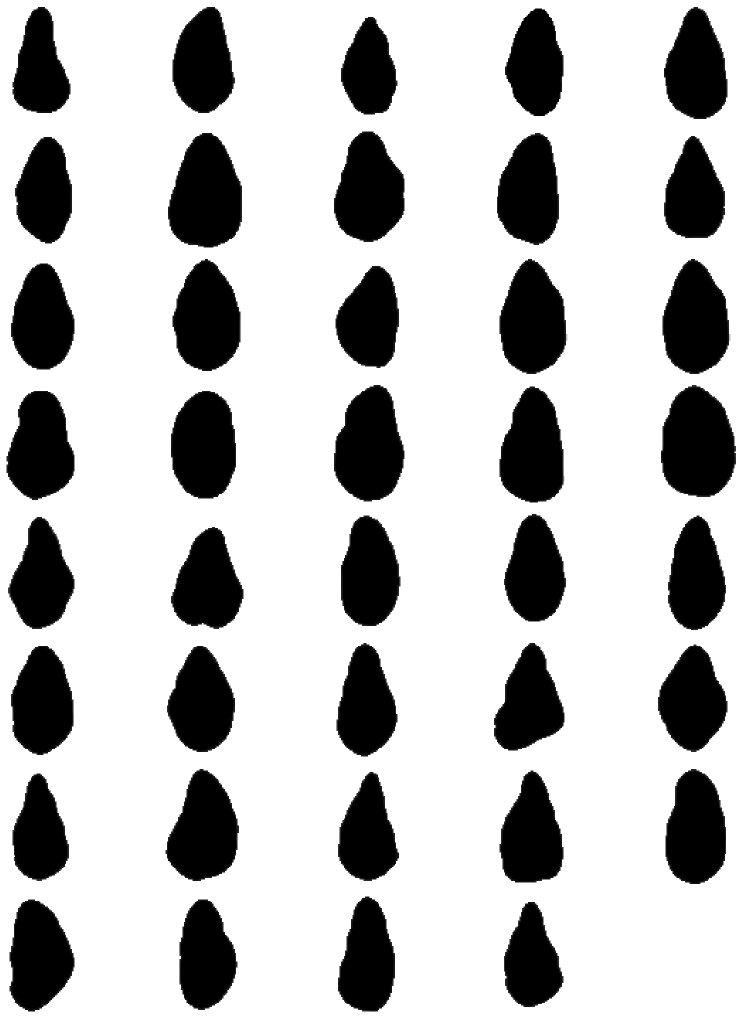


Figure 141. Grotte des Ours complete handaxe plan-shape diagram (not to scale).

It is a striking fact that almost all handaxes are more or less "teardrop" shaped, ranging from a long, pointed teardrop (Fig. 142:a) to a long oval (Fig. 142:c) one. Oval, broad-tipped handaxes (Fig. 142:d) are very rare, with the exception of the Ma'ayan Barukh handaxes. It should be noted that because handaxes from sites like Chirki and Ternifine were made on large flakes and are rough (and in many cases cortical and minimally retouched), Bordesian typology would have classified most of them as either "partial" or "Abbevillian" types and would have excluded them from a detailed description, even though in general their shapes show similarity to handaxe shapes worldwide.

The observed similarity in handaxe shape becomes even more pronounced when the shape of the **butt** is considered, since variability at this end is much lower than it is at the tip. There are almost no pointed, square or straight butts. The majority of handaxe butts are rounded and are so similar to cleaver butts (see below) as to render the tools indistinguishable in this respect. Gowlett and others (2001, 619) have proposed that the shape and size of the butt were kept consistent with the hand that held them. They also suggested that the much thicker Kalambo Falls Sangoan bifaces were so shaped because they were held in both hands. In addressing Paleo-Indian bifacial tools, Kelly (1988) postulated that the entire shape of a biface was dictated by the need to fit it onto a pre-existing haft. Such functional explanations, however, remain hypothetical.

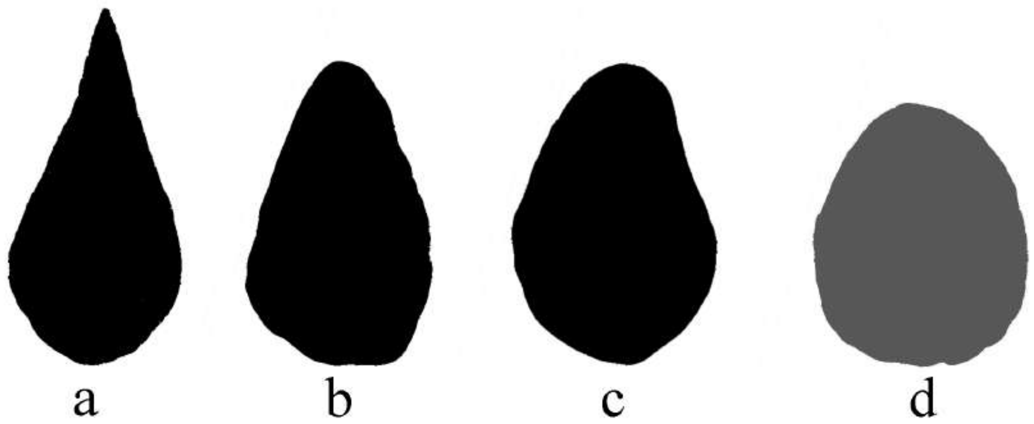


Figure 142. Handaxe shape range.

As discussed in Chapter 2, the presence of a few deviant shapes (types) in any given assemblage is to be expected, their presence serving to emphasize their actual scarcity in these assemblages. Thus, the presence of two or three triangular shapes in the sample from Chirki actually highlights the fact, that although the Chirki handaxe makers were familiar with this shape, it was very rarely selected. Although deviant shapes are present in all samples, actual variability seems to have been very limited. Rather than exemplifying a distinctly different geometric form, a deviant shape was usually a less regular, less uniform and less symmetrical form of the familiar handaxe shape.

Why a Teardrop Shape?

The most convincing explanation for the dominance of the teardrop shape in the handaxe was put forward by Jones (1994), whose argument can be summarized as follows:

Handaxes were functional tools whose shape was dictated by the need to achieve the longest cutting edge in relation to a minimum of stone mass. Jones (1994, 270) demonstrated that for some basic shapes:

"…the internal area for all shapes has to be quadrupled in order for the perimeter length to be doubled. Thus, if we consider the five shapes [Fig. 143] as possible biface plan shapes with flaked perimeters, we can see that the longer thinner shapes will produce more edge length per unit area. This will become even more important if we consider the corresponding increase in volume with size of solid shape."

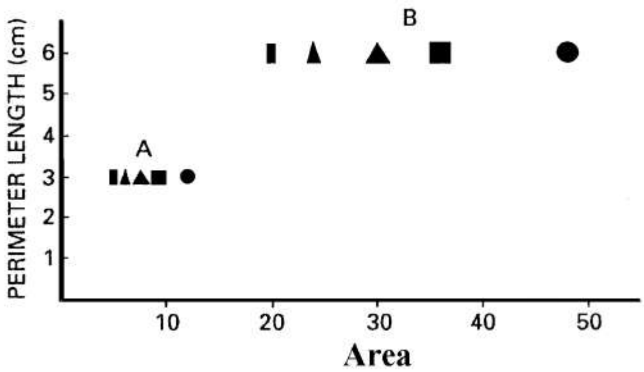


Figure 143. Fourfold increase of shape and area (a) as perimeter length is doubled (b) (after Jones 1994, Fig. 10.8).

According to this calculation, the best edge-length-to-mass ratio is achieved by long, narrow shapes. In addition, Jones demonstrated that the continuous edge of a circular shape is less efficient than that of a triangular one, as only a small portion of it can actually be used at any one time on the material being cut (see below). Jones concluded that "pointed triangular shapes are easy to flake, have very low mass per perimeter length and have the advantage of long continuous stretches of edge" (Jones 1994, 270). He also envisaged that as a handaxe grew larger, it would also get narrower, in order to decrease its weight for the same length of cutting edge. The large handaxes from Isimila seem to support this view (see below).

According to Jones, two technological problems hampered the use of these forms in biface shaping: 1) The "structure of the stone only allows a certain minimum of length/breadth/thickness ratios to be flakable and strong". 2) The phenomenon of end-shock, which tended to snap long and narrow tools in two during knapping (Jones 1994, 270). In this connection, Gowlett et al. (2001, 619) have shown that "… In the Acheulian, the allometry was probably also a device for maintaining relatively thin sharp edges in larger specimens, as well as a mean of keeping the butt relatively constant in size in relation to the hand."

My reservations about Jones's argument are that he seems to have considered only cutting edges that run all around the peripheral margins of the handaxe, while disregarding other possibilities (see Chapter 5), including such tools as cleavers and cleaver-edged handaxes.

Handaxes with an Ultra-Pointed Tip

A very prominent morphological trend in all assemblages is the presence of ultra-pointed shapes. In shaping a handaxe, the knapper focused on the properties of the cutting edge, particular the tip (Jones 1994; Matskevich et al. 2002; Zaidner et al. 2006). This sometimes resulted in handaxes with a ultra-pointed tip (Fig. 144). These pointed shapes resemble Bordes's "*biface massiforme*" (Bordes 1961, Planche 94, 2) and may have been used for tasks involving accurate piercing (Roe 2006). It is interesting to note that ultra-pointed tips were formed on both roughly shaped tools (Fig. 144:a, d, e, f, h) and tools worked with the highest degree of dexterity (Fig. 144:b, c, g). It would seem that in some cases the achievement of a suitably pointed tip was sufficient in the eyes of the Acheulian handaxe makers, even if the overall shape of the tool was far from being perfectly symmetrical and regular. Corvinus (1983, 56–57) identified a group (n=22) of similarly pointed bifacial tools from the site of Chirki, which she named borers or beaked bifacial tools.

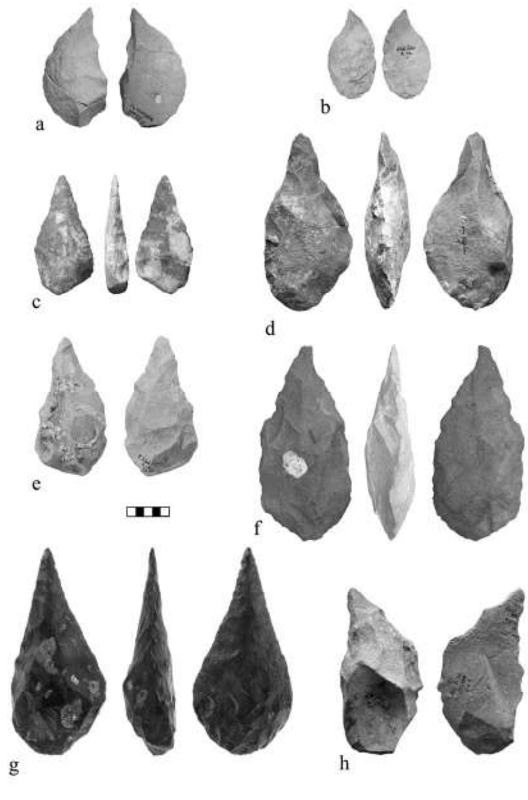


Figure 144. Ultra-pointed handaxes. a. Ternifine. b–c. Sidi Zin. d. Pniel 7b. e. Grotte des Ours. f. Isimila K6. g. GBY NBA. h. Hunsgi.

Handaxe Typology - Isimila K6 *Ficrons* as a Test Case

Many of the Isimila K6 handaxes have a shape that attributes them to the *ficron* group in the Bordesian typological system (see Bordes 1961, Pls. 50–52). According to Bordes (1961, 78), a *ficron* is close in shape to lanceolate or Micoquian handaxes, although it is less finely made. Fig. 145 presents a few examples of these Isimila K6 *ficrons*. Many of them are elongated and their tip has shallow shoulders. Some variability in tip shape is observable, as some tips are pointed (Fig. 145:a, j), while others are broad and have an almost cleaver-like edge (Fig. 145:g, h, i). *Ficron* shapes are also found in the other two Isimila localities under study (K14 and K19), but their frequency is lower (see the Isimila K14 shape diagram, Fig. 137).

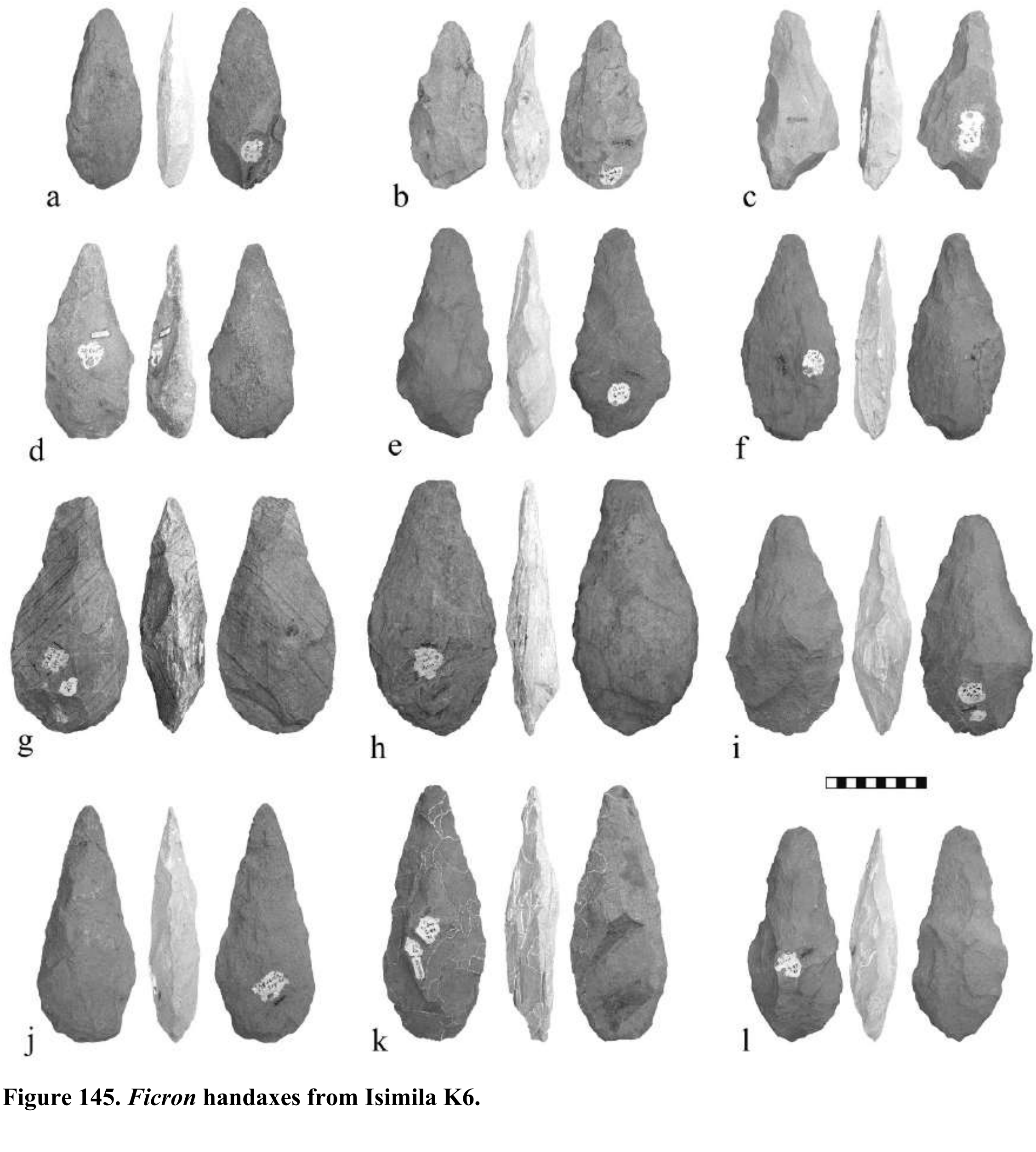


Figure 145. *Ficron* handaxes from Isimila K6.

Although technological constraints may explain the shape of these tools to some extent (i.e. maintaining a valid cutting-edge-to-mass ratio), the handaxe makers of the Isimila K6 assemblage apparently had a propensity toward the *ficron* shape. Unlike the Ternifine *entame* flakes or the Victoria West cleavers of the Vaal River sites, the high frequency of *ficrons* in Isimila K6 cannot be explained by the core method applied to the production of their blanks. The Isimila K6 *ficrons* were shaped into their desired final form by intensive bifacial secondary retouch.

The three parts of Fig. 146 encompass the large sample of handaxes from Isimila K6. The high frequency of *ficron* shapes is clear. Many of the other handaxes, while not elongated enough to be classified as *ficrons*, exhibit shouldered tips that associate them with the *ficron* group.

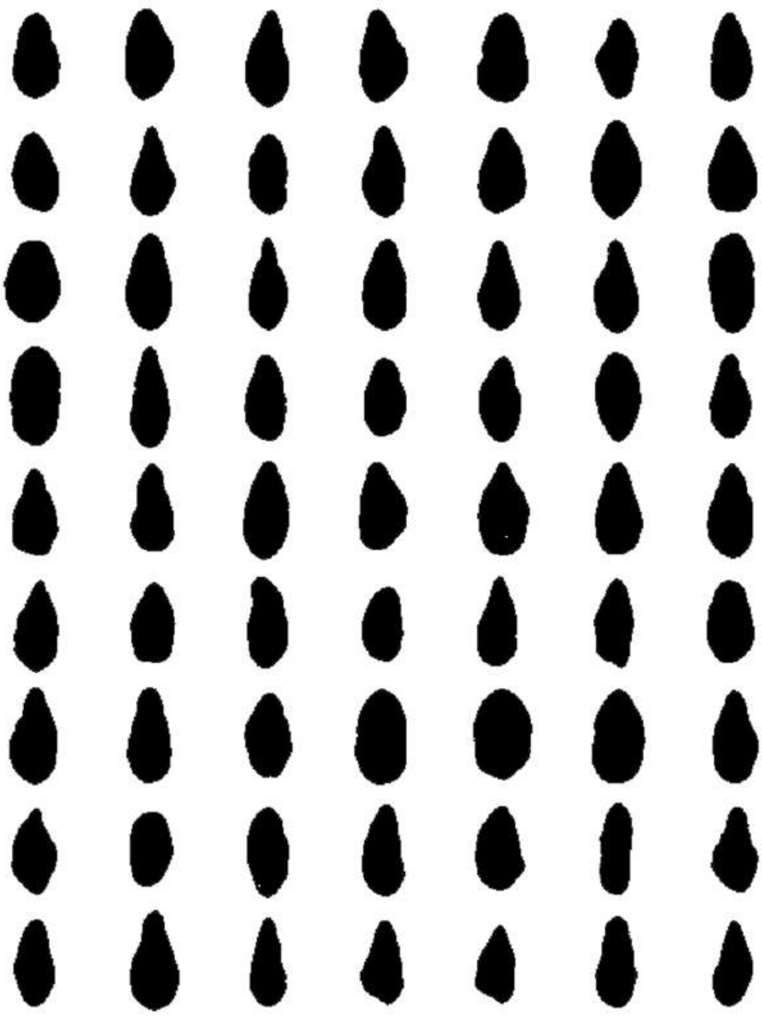


Figure 146a. Shape diagram (part 1) of handaxes from Isimila K6.

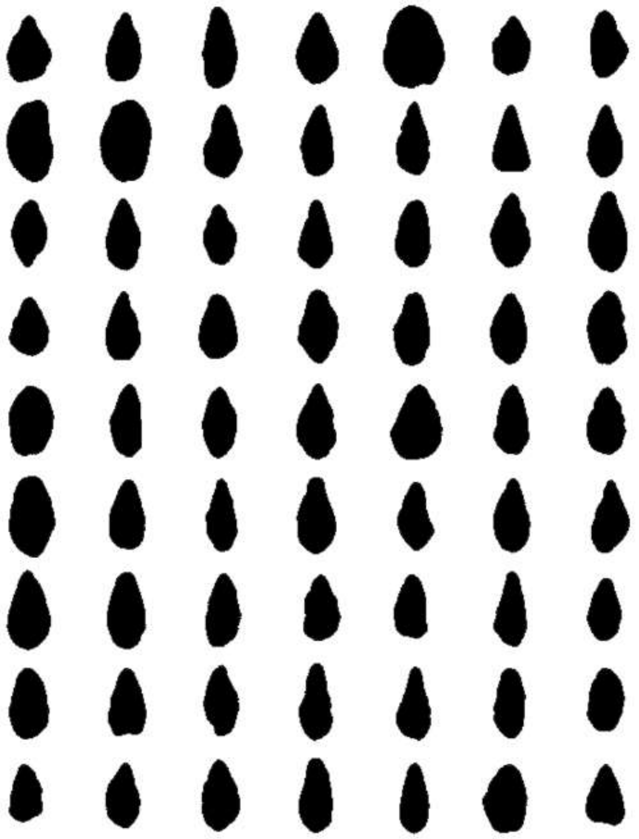


Figure 146b. Shape diagram (part 2) of handaxes from Isimila K6.

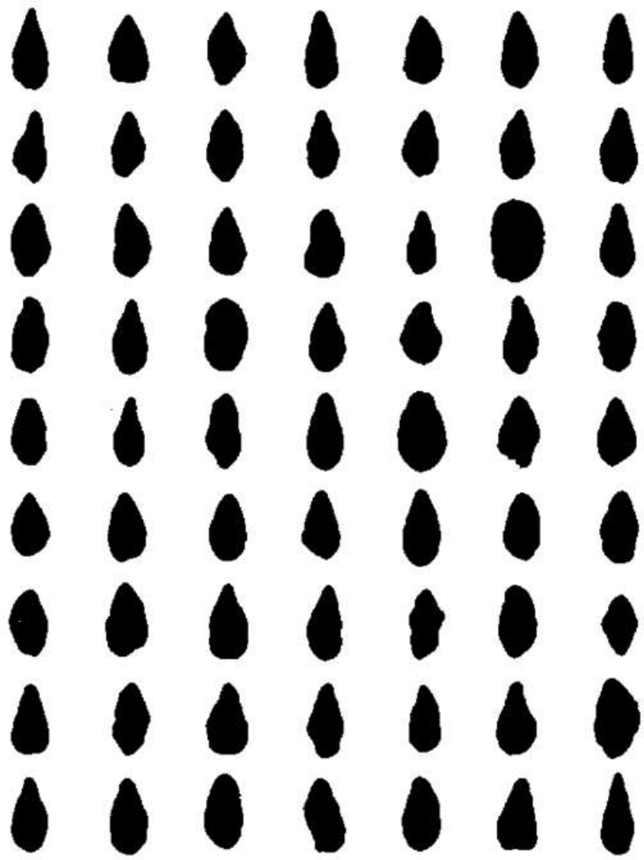


Figure 125c. Shape diagram (part 3) of handaxes from Isimila K6.

As far as I can judge, the Isimila K6 *ficrons* comprise the only example of a handaxe "type" (i.e. a distinguishable and distinctive shape), since all other assemblages are dominated by teardrop shapes, which are minimally diverse.

Handaxe Shape – Summary and Discussion

Aspects of handaxe shape can be summarized as follows:

1. The variability of handaxe shapes is very limited. Almost all handaxes can be associated with the teardrop shape and can be placed on the shape scale presented in Fig. 142.
2. Triangles, ovals and cleaver-edged shapes are nearly absent from the samples.
3. Deviations from the teardrop shape tend toward a less regular form of the same shape and do not metamorphose into a distinctly different geometric shape.
4. A shape trend can be identified in many of the samples, where narrow, ultra-pointed-tipped handaxes were produced.

The propensity toward a teardrop shape can be explained by the fact that this form provided the best cutting-edge-length-to-mass ratio (Jones 1994). Much of the observable variability in handaxe shape can be explained in terms of technological constraints and failures. On occasion, the knapper failed to achieve the desired shape during either blank production or the shaping stages of the *chaîne opératoire* (see below). On the other hand, it seems that raw material shape, size and quality had minimal effect on handaxe shape.

The Isimila K-6 *ficrons* clearly meet Adams and Adams's (1991) "type" criterion of being consistently identifiable. However, since they formulate a singular example of a "type", they fail to teach us about the relations and connections of this assemblage with other assemblages, rendering us unable to suggest a cultural framework for the Acheulian. Many years ago, Isaac (1968, VII-12) phrased the situation thus:

> "More elaborated multivariate analysis will be necessary to test this view of the pattern of differentiation – which represents to some degree a return to the more vaguely expressed perception of Evans…, de Mortillet… and many other workers prior to the vogue for comprehensive categorization established by Bordes."

Final and Post-Acheulian Handaxe Shape Variability

The minimal variability observable in Acheulian handaxe shape becomes even more marked when contrasted with the bifacial tools of the succeeding lithic traditions. A few examples are offered below:

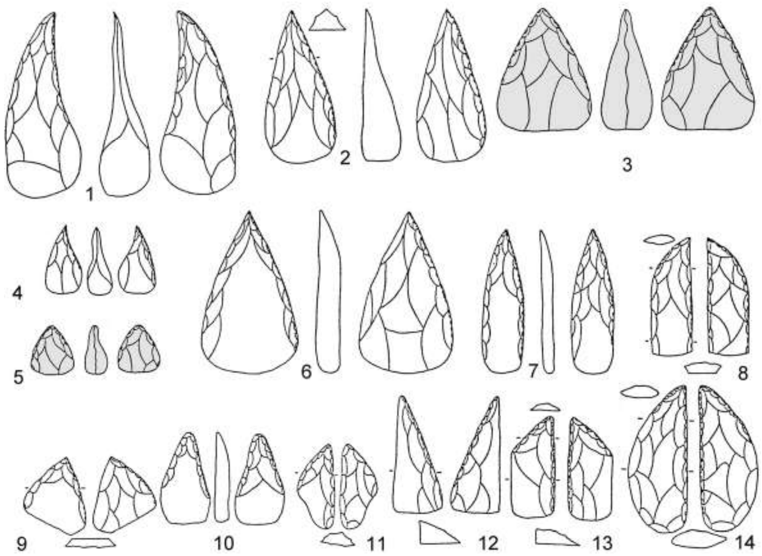


Figure 147. Type spectrum of the Micoquian (after Bosinski 1967) in relation to different handaxe forms. 1–5. *Micoquekeil.* 6–11. *Faustkeilblätter*. 12–14. *Keilmesser* (not to scale, after Jöris 2006, Fig. 4).

Middle Paleolithic bifacial tools of the European Micoquian industry (Fig. 147) are much more varied in type and shape than are the handaxes of Figs. 135–141. Triangular shapes and many types of knives and points are largely absent from the LFB Acheulian assemblages under study. In the Acheulo-Yabrudian assemblages from the Levant, on the other hand, different types of knives, ovate handaxes and triangular forms, which are clearly not a part of the Levantine Acheulian handaxe type inventory (see discussion in Matskevich et al. 2002), have been identified and described (Garrod 1937; Matskevich et al. 2002; Zaidner et al. 2006). A diversity in the shapes of core-axes and picks is observable in the Sangoan of Kalambo Falls (Clark and Kleindienst 2001; Roe 2001a).

Acheulian handaxes are unmistakably different from the bifacial tools of all later periods. It is almost impossible to mistake a Neolithic axe for an Acheulian handaxe. The same holds true for Upper Paleolithic leaf-points, Paleo-Indian bifacial points, or Egyptian Predynastic knife preforms. It may be suggested that variability in bifacial tool shape and type is a chronological marker that distinguishes between the LFB Acheulian, the Final Acheulian (Marder et al. 2006) and most definitely the Post-Acheulian bifacial industries.

Acheulian Cleaver Shape

Figs. 148–151 illustrate the outline shape of all complete cleavers from the selected samples. Outwardly, the cleaver shape diagrams seem to demonstrate a greater shape variability than that of handaxes, a variability that is evident in the shape of the cleaver butt (e.g. rounded, pointed, square and others) and in its cutting edge (e.g. straight, diagonal, double/pointed, splayed and more). The shape of most cleavers was dictated by two related factors: a) The core method by which the cleaver's blank was produced. b) The morphology of the blank that was selected prior to any secondary reshaping.

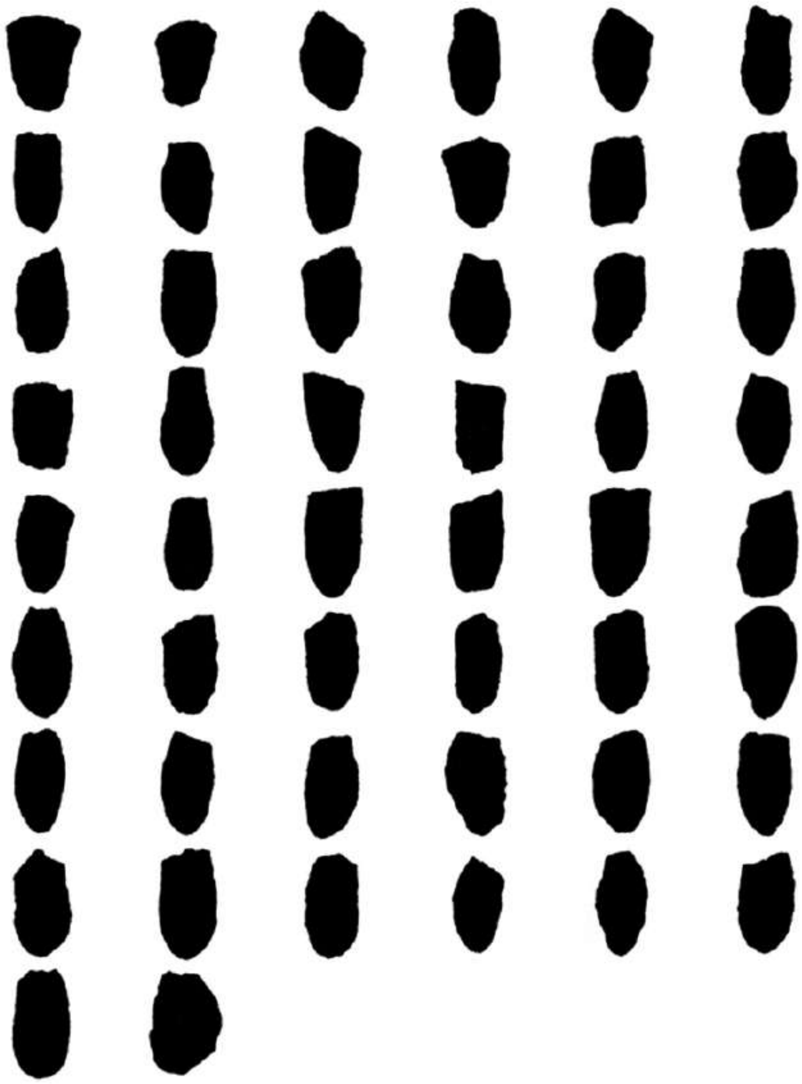


Figure 148. Isimila K14 complete cleaver plan-shape diagram (not to scale).

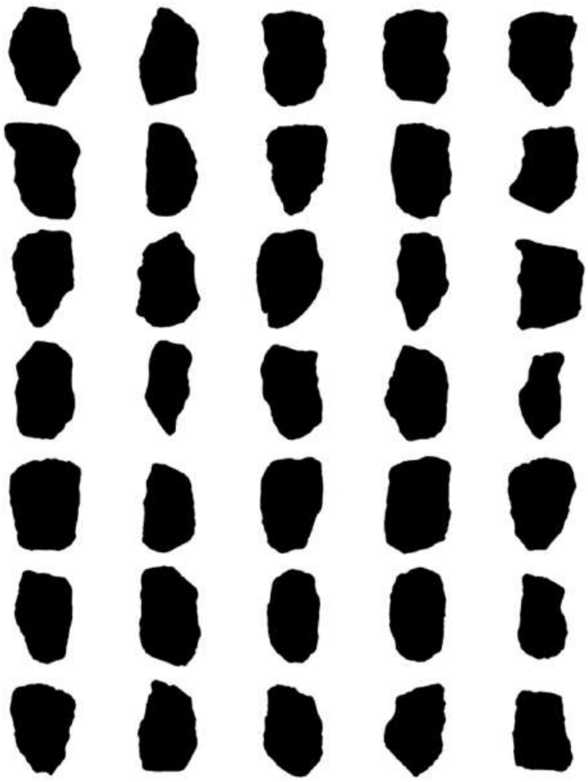


Figure 126. Hunsgi complete cleaver plan-shape diagram (not to scale).

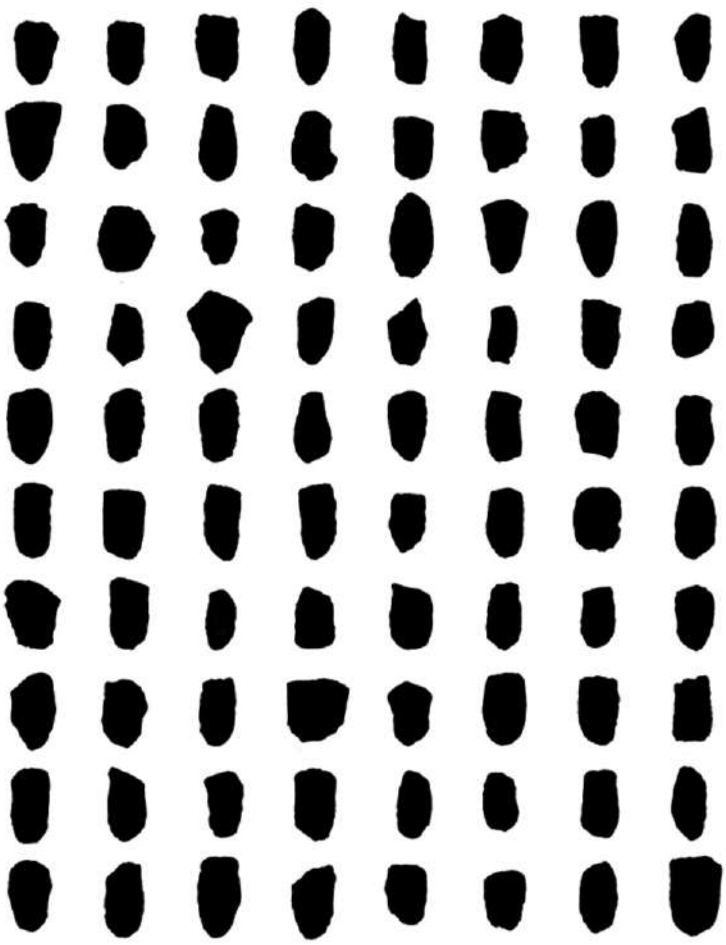


Figure 150. Pniel 7b complete cleaver plan-shape diagram (not to scale).

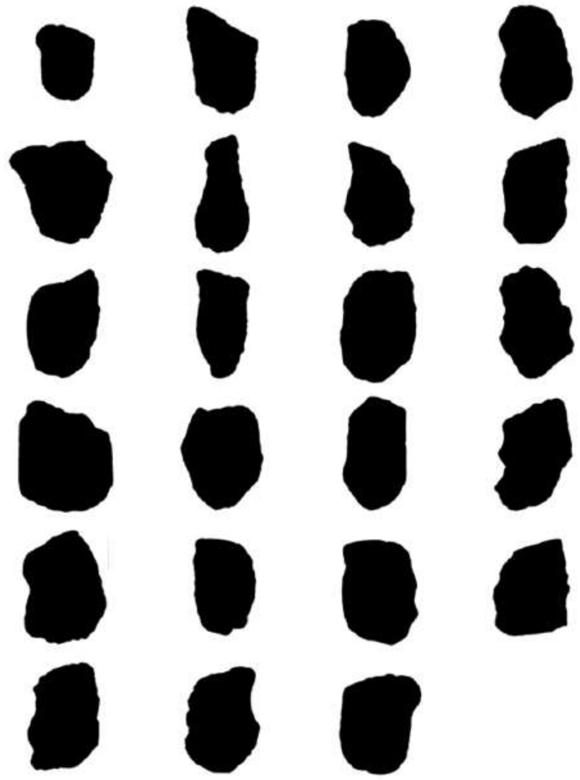


Figure 151. Ternifine complete cleaver plan-shape diagram (not to scale).

The Impact of Core Method on Cleaver Shape

The Victoria West cleavers of the Vaal River Acheulian best demonstrate a core method's impact on the shape of cleavers. In this case, the Victoria West method is evident in the cleavers' elongated, narrow, steep and pointed butts (Figs. 62, 70), which were formed by removing the tips of the bifacial cores along with the detached blanks (Fig. 68). The scar pattern on many of the Victoria West cores indicates that the cleavers produced from them had convex cutting edges. The latter do indeed appear on many of the Vaal River site cleavers, although many other cutting edge types are also present (see also discussion below). A similar morphology (pointed butts and convex edges) is observable on the Tabelbala-Tachenghit cleavers of the Northwestern Sahara sites (Fig. 71).

The slice cleavers of Hunsgi exemplify a similar phenomenon (Chapter 5; Figs. 42, 47). The cortical rounded butts and margins and the steep edges of the cleavers were produced by the slicing technology of their manufacture. The *entame* flakes of Ternifine (Chapter 5; Fig. 48, 51) represent another example. These examples notwithstanding, the core method used in the production of the blanks of a given assemblage cannot explain **all** variability in cleaver shape.

The Impact of Blank Shape on a Cleaver's Final Shape

Each of the morphological features (straight, angled, splayed, pointed, or irregular cutting edges; square butts) appearing in Fig. 152 can be attributed either to the relevant giant core method or to the shape of the selected blank. Unlike handaxes, the shaping of cleavers involved minimal secondary retouch of the blank. This unique technological attribute makes cleavers an ideal source of technological information, since it is possible to identify the type of blank that was used and examine its original morphology. Fig. 152 presents a few cleaver examples from Vaal River assemblages. Cutting edge types are guillotine (b and c), splayed (e to h), pointed and splayed (e, f) and oval (d and g); the butts are square (a and h). The cutting edges display a large variety of angles and shapes, many of which are classified as Late Acheulian cleaver types in Kleindienst's (1962) typological system (Fig. 153).

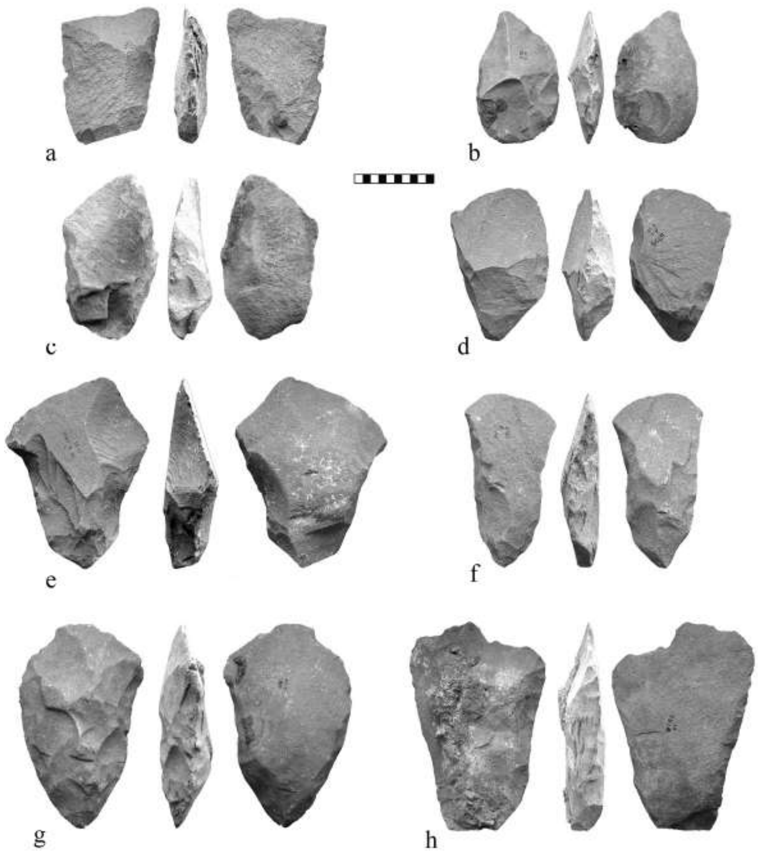


Figure 152. Cleavers from the Vaal River sites. a, b, c, g, h. Power's Site. d, f. Pniel 6a. e. Pniel 7b.

As has been demonstrated with the aid of experimental giant core knapping (Madsen and Goren-Inbar 2004; Sharon 2000), one of the main measures of a knapper's expertise was his ability to select a blank for a desired tool from a range of flakes that he had previously produced (Fig. 154; see also Fig. 81). The flakes were chosen according to their size (manageable and proportional to requirements) and shape (available cutting edge and resemblance of the flake's shape to the desired final shape of the tool).

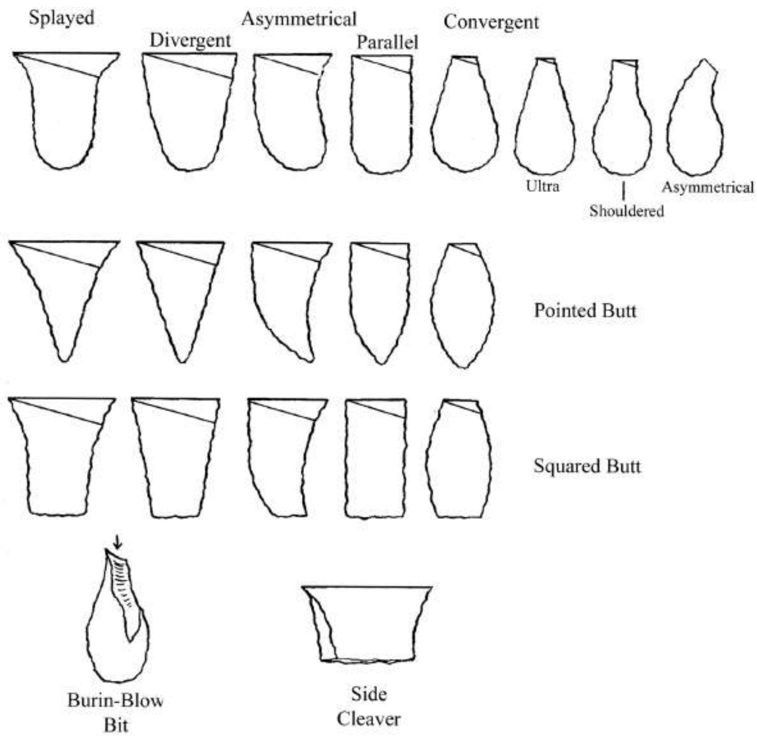


Figure 153. Typological schemes for cleaver shapes (after Kleindienst 1962).

The examples in Fig. 152 show that when a blank shape did not exactly accord with this "ideal" cleaver scheme, the Acheulian knapper did not automatically reject it. For instance, the shape of cleaver 6.20:e is not the typical one of most Vaal River cleavers, since it was detached with a significantly splayed pointed edge and a pointed butt. Yet not only was this blank selected to be used as a cleaver, but the Pniel 7 toolmakers perceived it as suitable in shape and applied only minimal secondary retouch to its final shaping. Deviant blanks that were shaped into tools form different "types" of Acheulian cleaver, albeit not intentional "types" that would constitute cultural markers.

a

b

Figure 154. Experimental giant core with its resulting flakes. a. Some larger flake shapes. b. All flakes, hammers and the core (to the left).

In this context, mention should be made of Ashton and McNabb's (1994) "non-classical" handaxes, which were identified by their deviation from the acceptable shape range of UK handaxes. It was postulated that raw material constraints were the main cause of their form, but to my mind, the explanation again lies in blank shape. Not all large flakes were successfully detached (Fig. 63), and many of them either proved too small or had an unsuitable morphology, even though they did possess a usable cutting edge along some portion of their margin (Fig. 155). A small minority of bifaces were manufactured from such flakes; these were crudely made, had a low number of scars and were very diverse in shape and size. Their presence in many of the assemblages suggests that the Acheulian knappers, who normally expended great effort in the production of the "right" classically shaped and sized blank, tended not to reject “non-classical” blanks of poor morphology as long as their cutting edge was usable.

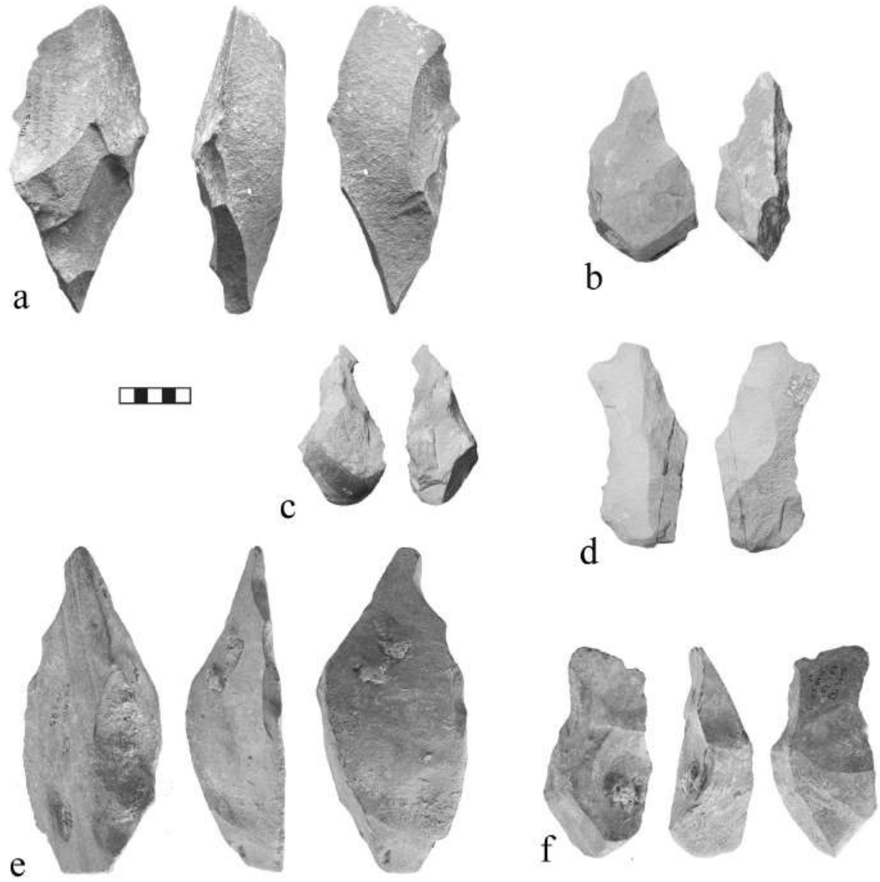


Figure 155 . LCTs of non-classical morphology. a. Riverview. b. STIC. c–d. Ternifine. e–f. Hunsgi.

“Ideal” Cleaver Shape

The Isimila K14 cleavers (Fig. 156) are good examples of cleavers that were shaped by intensive secondary retouch, as opposed to other LFB assemblages, where final blank shape was predetermined by the core reduction method. Although some of the Isimila K14 cleavers show a minimal investment of labor (Fig. 156b), a frequent Acheulian approach toward cleaver production, most of the Isimila K14 cleavers required much work and dexterity all along their lateral edges and butts. Unretouched cleaver flakes are rare among the Isimila cleavers in general (Table 39). Secondary retouch allowed the knapper full control of the final shape of the tools, with the exception of the cleaver’s cutting edge, which was formed by the original shape of the flake blank. Isimila K14 shapes are similar to those of cleavers from all other assemblages under study, including sites at which much less energy was invested in shaping the cleavers. Because the shape of the tools’ butt and margins was so highly controlled, it may be suggested that the Isimila K14 cleavers reflect the "ideal" cleaver shape (or the cleaver "mental template") of the Acheulian knappers.

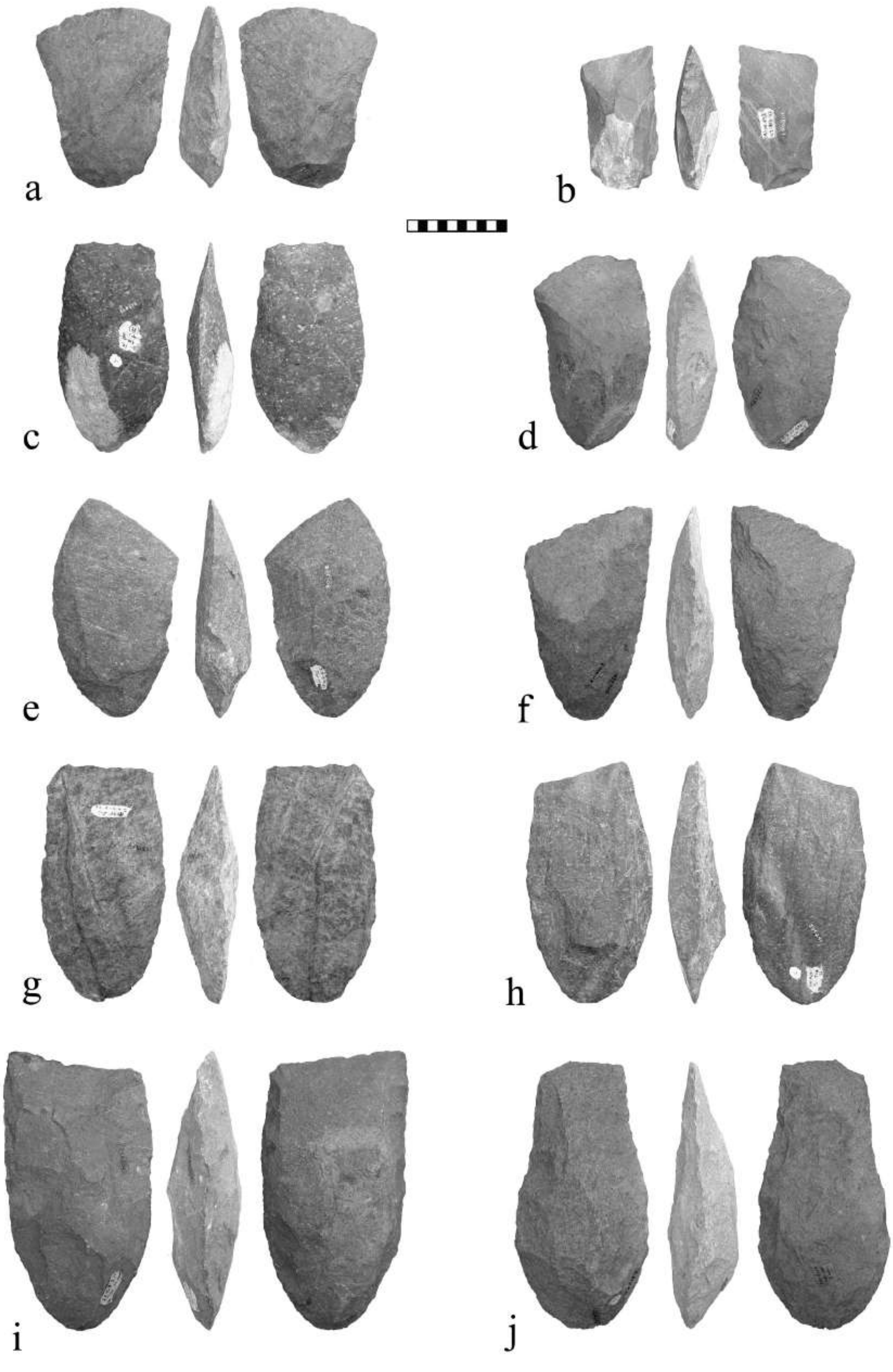


Figure 156. Cleavers from Isimila K14.

Cleaver Flakes

Cleaver flakes were defined by Kleindienst (1962, 100) as:

> "Flakes in the large size range which have a cleaver-bit edge, but which have not been secondarily trimmed. Of the type on which cleavers or other large implements could have been made. Presumably, the shape is due to the type of core used."

Cleaver flakes are present in most of the LFB assemblages under study. This serves to buttress the argument that blank selection had fundamental impact on the shape of the final tool. If a flake had the desired shape and no further modification was needed, it was left in its form as a cleaver flake (Fig. 157; see also further discussion in Roche and Texier 1995).

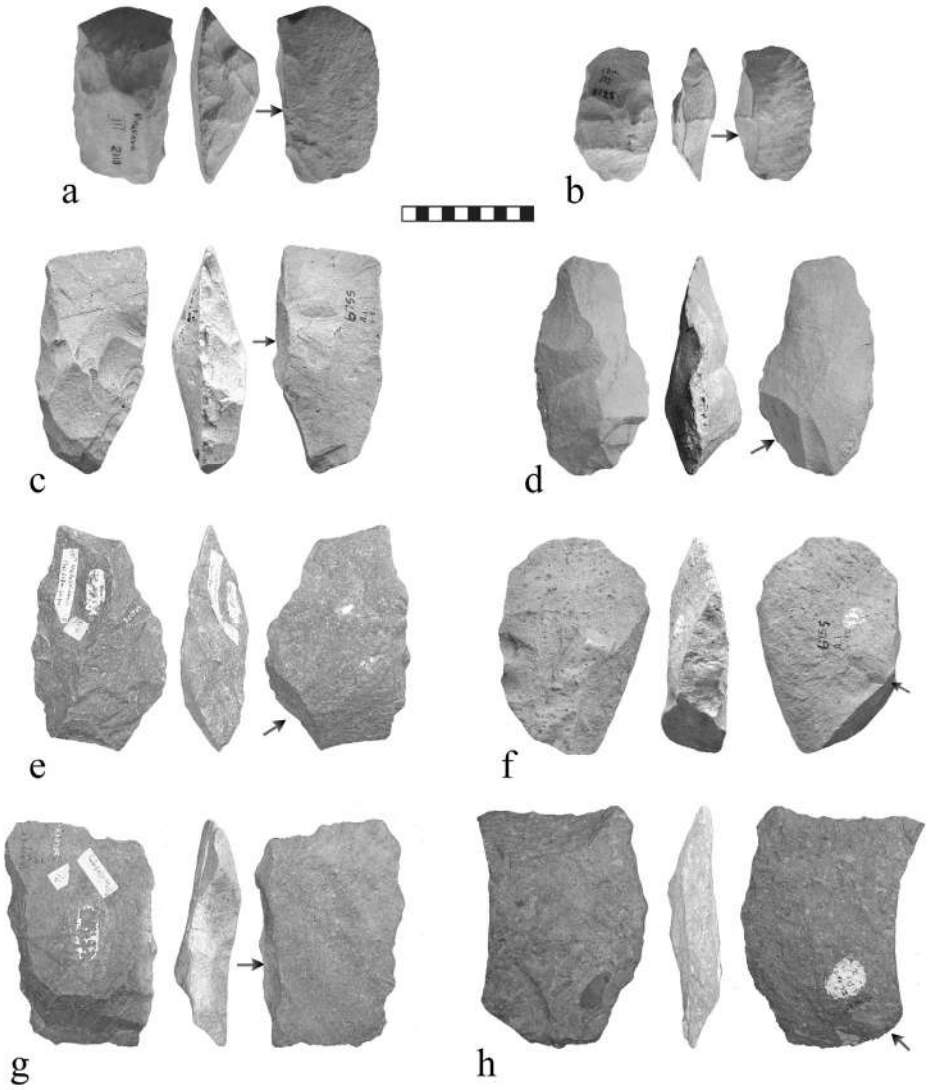


Figure 157. Cleaver flakes. a–b. Chirki. c. Grotte des Ours. d–e. Pniel 6a. f–g. Isimila K19. h. Isimila K6. Arrows indicate direction of blow.

Table 39 presents the frequencies of cleaver flakes among retouched bifacial cleavers.

Table 39. Frequency of cleaver flakes.

Site	Cleaver		Cleaver flake	
	N	%	N	%
Power's Site	109	92.4	9	7.6
Pniel 6a	94	92.2	8	7.8
Riverview	71	93.4	5	6.6
Pniel 7b	92	92.0	8	8.0
Doornlaagte	13	92.9	1	7.1
Isimila K6	28	100	0	0
Isimila K14	52	92.9	4	7.1
Isimila K19	38	95.0	2	5.0
STIC	2	40.0	3	60.0
Ternifine	28	59.6	19	40.4
Grotte des Ours	10	100	0	0
Tachenghit	12	75.0	4	25.0
GBY NBA	81	82.7	17	17.3
Hunsgi	33	67.3	16	32.7
Yediyapur	10	83.3	2	16.7
Chirki	37	77.1	11	22.9

Note the high frequencies of cleaver flakes in the Indian and North African sites. On the other end of the scale, the lowest numbers of cleaver flakes appear in the Isimila sites.

Fig. 158 indicates that in none of the sites under study could cleaver flakes be distinguished from bifacially knapped cleavers by their size. In order to present adequately sized samples, all cleavers from Isimila are grouped together (a), as well as those from the South African Acheulian Vaal River sites (b).

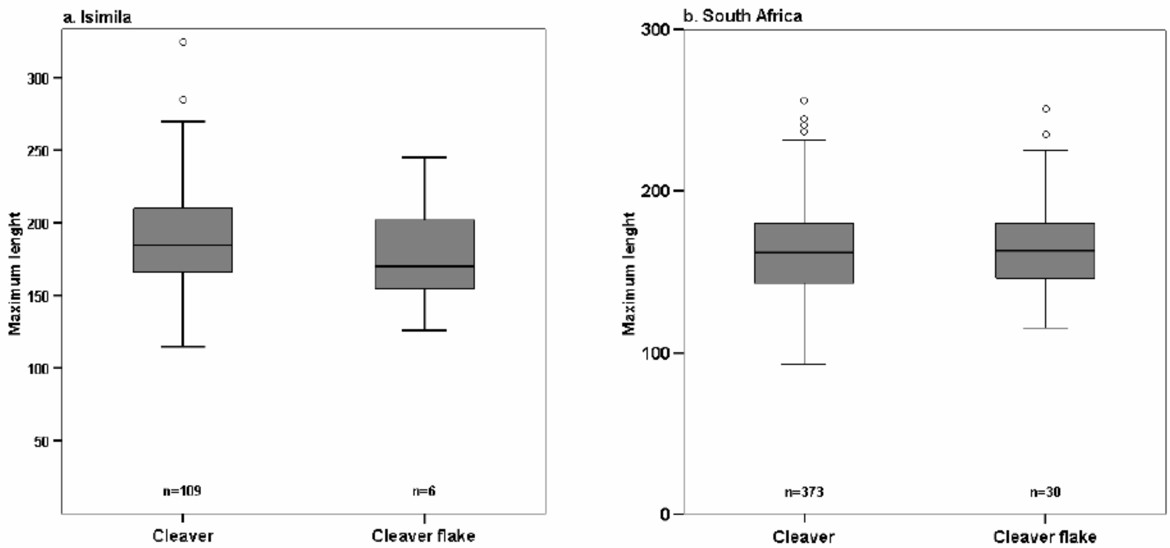


Figure 158. Size of cleavers and cleaver flakes.

The Dichotomy of Cutting Edges:

Pointed and Oval Handaxes *vs.* Cleavers

Handaxe shapes are surprisingly homogenous and oval shapes are very rare in LFB cleaver-rich assemblages. An explanation for this worldwide pattern can now be suggested.

Acheulian LCT makers designed two basic types of cutting edge: a convergent, pointed edge (i.e. handaxes; Fig. 159:a) and a broad edge (i.e. cleavers; Fig. 159:b). The preferred Acheulian LCT butt shape was rounded (for such functional reasons as hafting or grasp; Fig. 159:c). In other words, almost all Acheulian assemblages include two groups of bifaces: a pointed-tipped group and a broad-tipped group. It is possible that in assemblages in which cleavers were a significant component, broad-tipped handaxes were unnecessary and therefore rare. Where cleavers were absent, the need for a broad cutting edge was filled by the presence of broad-tipped handaxes (oval types). These were in some cases fashioned by the *tranchet* blow typical of some of the European cleaver-like handaxes (Roberts and Parfitt 1999; Roe 1968; White 2006; for a recent overview, see White 2006, Table 1). A similar approach to broad-tipped handaxes, in connection with Tabun Cave (Matskevich 2006) and assemblages from Eastern Jordan (Rollefson et al. 2005), was recently presented and discussed.

The dichotomy hypothesis is further supplemented by the following points:

1) **The shape diagrams:** Examination of the handaxe shape diagrams (Figs 135–141) indicates an almost complete absence of ovate shapes from all sites except that of Ma‘ayan Barukh (Fig. 136) and the small surface collection of Tachenghit (Fig. 140). The non-LFB site of Ma‘ayan Barukh accords with the dichotomy model. Note that Stekelis and Gilead (1966, Appendix 3) identified 45.6% of the 300 handaxes in the assemblage as cordiform in shape, 41.6% as oval and round and only 4% as pointed. The sample from Tachenghit is too small and probably biased, but one must admit that the site contains many cleavers alongside broad-tipped handaxes. Only careful study of the site’s excavated assemblage can clarify this issue.

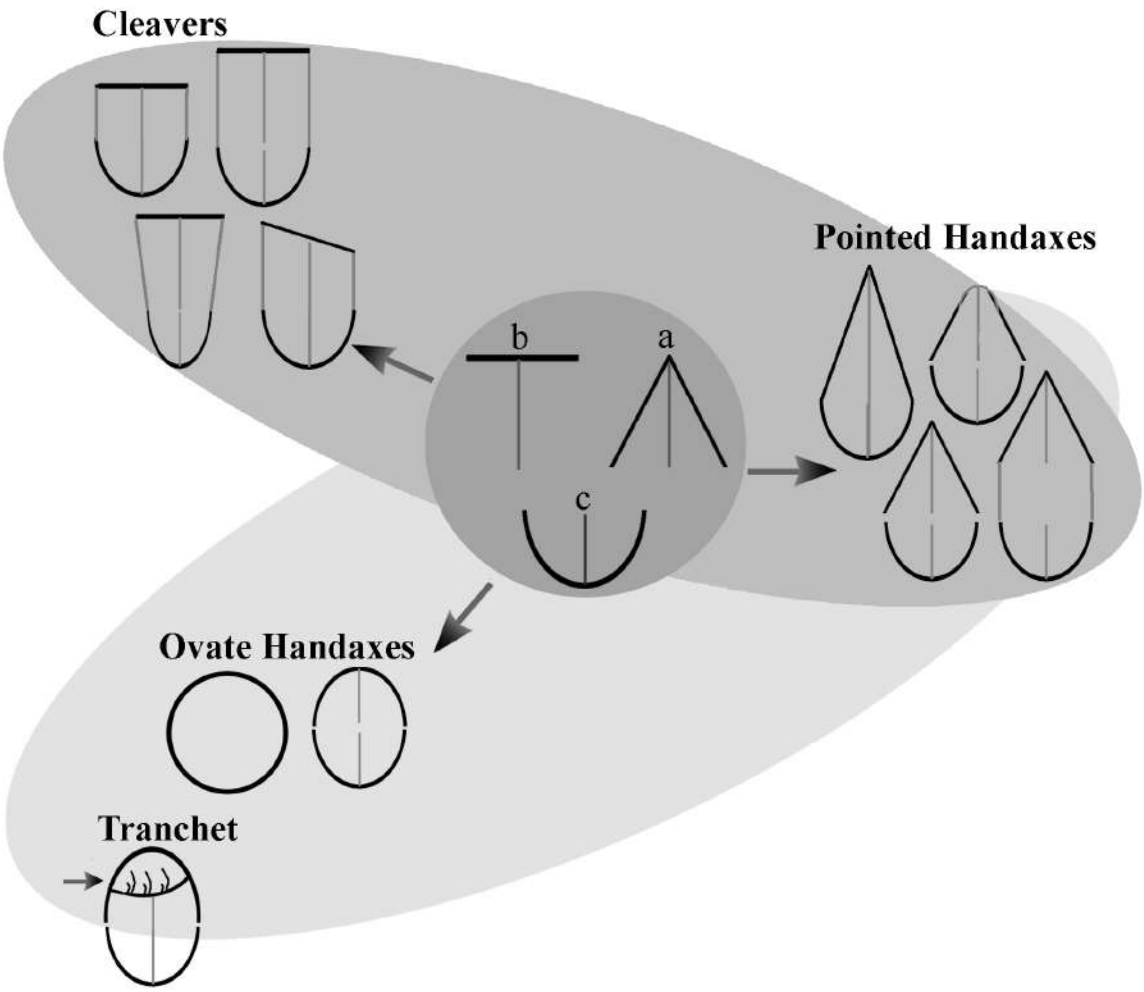


Figure 159. Cleaver and ovate handaxe dichotomy, tool edge and butt groups.

2) Roe's (1968, 1994, 2001) **shape diagrams**:

> "Essentially, the diagram is a scattergram in three parts, and the implements are each assigned to one of the tree according to their value for the ratio L1/L (= distance from the base to the maximum width/length): those with low position of maximum breadth are plotted on the right-hand section (L1/L values up to 0.350), those with maximum breadth centrally placed on the centre section (L1/L values in the range 0.351–0.550) and those with high position of maximum breadth on the left-hand section (L1/L values over 0.550). Then on each section, values for B/L (breadth/length) are plotted horizontally against values for B1/B2 (breadth at 1/5 of the length from the tip/breadth at 1/5 of the length from the base) vertically, so that each individual handaxe is represented by a dot whose position is further to the right according as the implement is broader (i.e. has higher values for B/L), and lower down according as the implement is more pointed (i.e. has a lower values for B1/B2)" (Roe 1994, 154).

[Fig. 160:B] "… shows how this operates in terms of actual plan-forms which are here given as silhouettes drawn symmetrically. The large crosses, one on each section, are merely visual coordinates, always marked in the same place to assist comparison of shape diagrams" (Roe 2001a, Fig. 9.7b).

All complete handaxes from adequately sized samples (>10 handaxes) were plotted on the Roe handaxe shape diagrams and are presented in Fig. 161. Ma'ayan Barukh and Tabun Layer E (highlighted in gray) represent non-LFB/cleaverless assemblages.

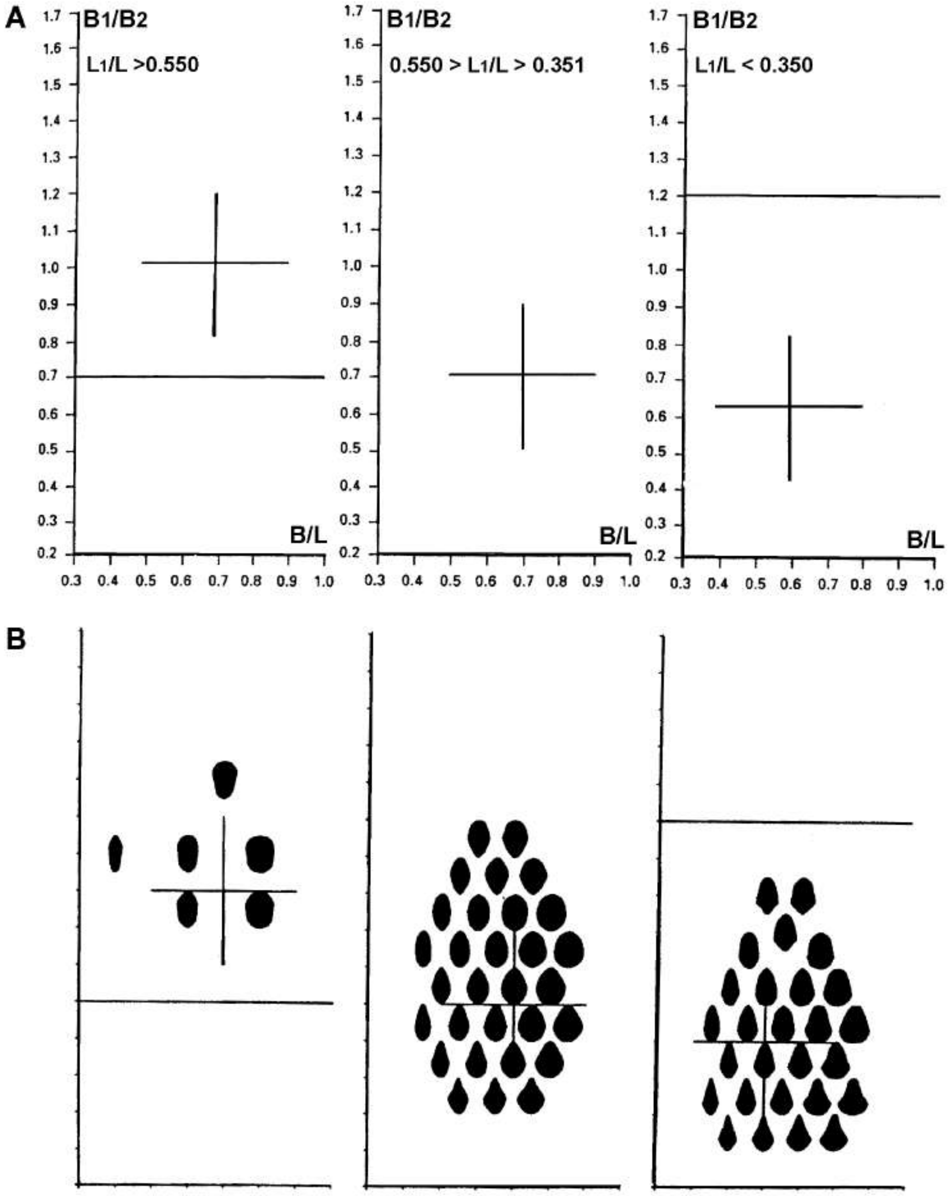


Figure 160. a. Framework of handaxe shape diagrams. b. Key array of handaxes' plan form (after Roe 1994, Fig. 8.2).

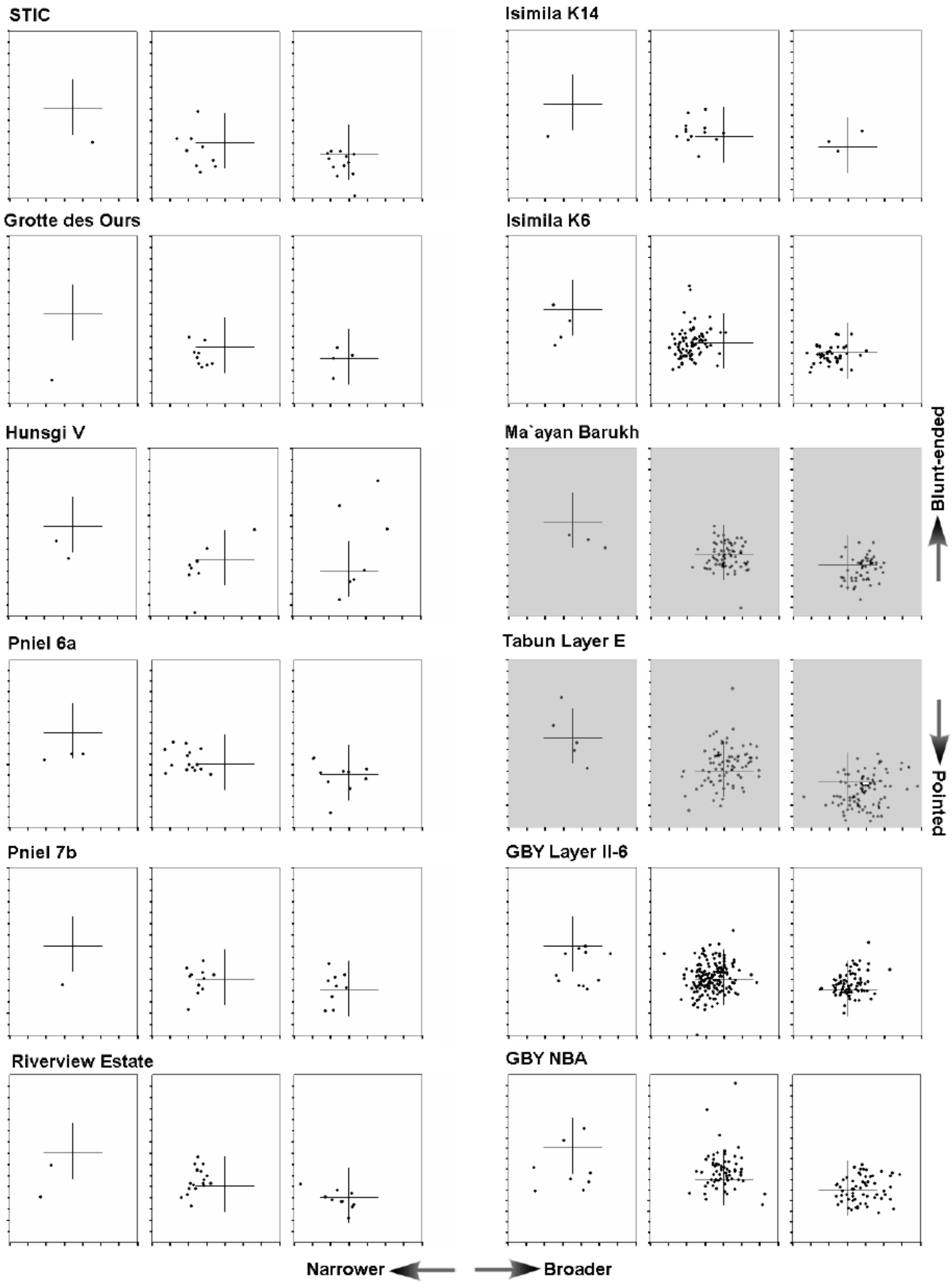


Figure 161. Handaxe shape diagrams. "… The lower an implement falls on the shape diagram, the more pointed it is, and the higher up, the more blunt-ended. The further to the left, the narrower it is, and the further to the right, the broader" (Roe 2001a, 501).

The diagram in Fig. 161 confirms that oval shapes (center box, top right of the cross) are infrequent in all assemblages, apart from those of Ma‘ayan Barukh, Tabun Layer E and to a smaller extent GBY NBA, their handaxes being much broader than those of cleaver-rich LFB assemblages. Note, for example, the pronounced difference between these samples and the samples from Isimila K6 and GBY Layer II-6, which almost completely lack broad handaxes. The handaxes in most LFB samples clearly fall within the left-hand side of the shape diagrams when compared to the non-LFB samples. Narrowness marks the large sample from Isimila K6, the smaller sample from Isimila K14, and the assemblages from the Vaal River sites (Pniel 6a, Pniel 7b and Riverview Estate) and the North African sites of STIC and Grotte des Ours, where the tools are also pointed. Note the narrow shape range for Isimila K6, Ma‘ayan Barukh and GBY II-6 handaxes. The Tabun sample is relatively scattered, suggesting wide variability in shape. It also shows a tendency, shared by the Ma‘ayan Barukh sample, to a broad base and very pointed shapes (Fig. 161:b, right box, bottom right). This is probably due to the close attention paid to the tip of the tools in these sites, as discussed above.

Two additional observations should be made on UK handaxes:

1) In concluding his study on the British Lower Paleolithic, Roe (1968) suggested a scheme in which two phyla can be identified: the “pointed tradition” and the “ovate tradition”. The debate over this UK dichotomy and its sources is ongoing, principally between the proponents of the “raw-material” model and those advocating the “reduction” model (see Ashton and White 2003 for overview and references). It should be noted that pointed handaxes almost never comprise less than 30% of an assemblage, even in ovate-dominated sites. In assemblages devoid of cleavers, the dominance of either pointed or ovate shapes suggests that the picture is probably much more complex than a clear-cut “pointed” vs. “broad” handaxe shape dichotomy.
2) In Britain, ovate handaxes were claimed to have had an advantage over pointed forms in their length, the symmetry of their cutting edge, and their prehensile qualities (Ashton and McNabb 1994; Ashton and White 2003; White 1995). Moreover, it was claimed that pointed handaxes were the less desired shape and were only manufactured when raw material constraints did not allow for the production of ovate shapes. According to Jones (1994), pointed triangular shapes had an advantage over ovate shapes, due to their long and continuous stretches of edge. While it is true that circular forms also had unbroken edges, only a small portion of them was in actual contact with the worked

material at any given point in time. Triangular shapes had much longer straight edges, which were constantly in contact with the worked material (Fig. 162).

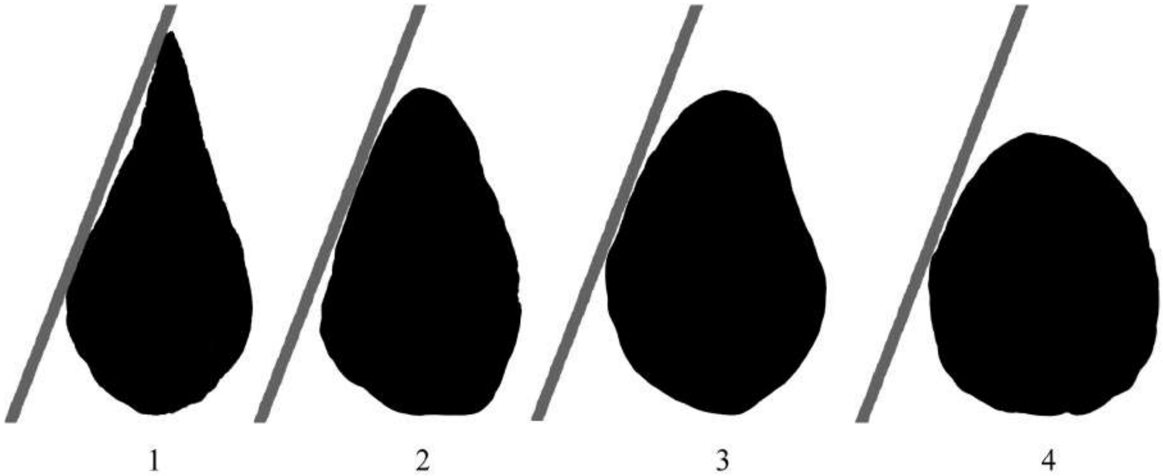
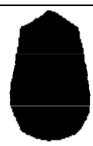


Figure 162. Different handaxe shapes: contact between cutting edge and worked material. Ovate shapes had a shorter cutting edge length, of which use was made at various points.

Cleaver Cutting Edge Shape

So far, we have tested the cutting edge dichotomy hypothesis by examining handaxe tips. We can now turn to evidence drawn from cleaver cutting edge shape, as presented in Table 40.

Table 40. Frequency of cleaver cutting edge shapes.

	 **Straight**		 **Convex**		 **Concave**		 **Pointed**		 **Indet.**		 **Diagonal**		**Total**	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Ternifine	2	5.3	20	52.6	3	7.9	-	-	1	2.6	12	31.6	38	100
Tachenghit	1	6.7	9	60.0	-	-	1	6.7	2	13.3	2	13.3	15	100
Hunsgi	6	13.3	15	33.3	2	4.4	1	2.2	8	17.8	13	28.9	45	100
Yediyapur VI	2	18.2	3	27.3	1	9.1	-	-	2	18.2	3	27.3	11	100
Chirki	6	15.0	12	30.0	-	-	1	2.5	5	12.5	16	40.0	40	100
Power's Site	12	10.8	40	36.0	4	3.6	5	4.5	14	12.6	36	32.4	111	100
Pniel 6a	10	10.2	47	48.0	2	2.0	2	2.0	8	8.2	29	29.6	98	100
Riverview	5	6.8	26	35.6	-	-	2	2.7	10	13.7	30	41.1	73	100
Pniel 7b	6	6.5	24	26.1	2	2.2	7	7.6	20	21.7	33	35.9	92	100
Doornlaagte	1	8.3	2	16.7	-	-	1	8.3	-	-	8	66.7	12	100
Isimila K6	2	7.4	15	55.6	1	3.7	1	3.7	5	18.5	3	11.1	27	100
Isimila K14	5	10.4	7	14.6	-	-	2	4.2	22	45.8	12	25.0	48	100
Isimila K19	2	5.4	5	13.5	-	-	2	5.4	10	27.0	18	48.6	37	100
GBY NBA	14	16.1	31	35.6	3	3.4	1	1.1	19	21.8	19	21.8	87	100
GBY Layer II-6	49	39.5	29	23.4	16	12.9	5	4.0	14	11.3	11	8.9	124	100
GBY Area C	1	7.1	2	14.3	1	7.1	3	21.4	-	-	7	50.0	14	100

As can be seen, the variety of edge shapes is quite wide and diversified between assemblages. Concave and pointed cutting edges are infrequent in all assemblages, while convex cleaver cutting edges form a significant component within them. Going by the cutting edge dichotomy, convex cleaver cutting edges are the equivalent, both in shape and probably in function, of the oval handaxe, which is to be found in cleaverless sites. In addition, it seems that straight cutting edges, even when combined with diagonal-shaped edges that share the same straight morphology, never exceed 50% of all instances. At GBY, there is a high frequency of straight versus diagonal shapes, probably due to a difference in the recording method. Jones's (1994) observation that straight-lined edges have an advantage over rounded edges seems to be over-simplistic.

Additional Typological Notes on Large-Flake Tools

Knives as an LCT Type

Based on her research of Late Acheulian East African assemblages and the site of Isimila in particular, Kleindienst (1962) presented a definition of a new class of LCTs, which she named "knife":

> "Characterized by having one side, or part of one side, blunted or 'backed' while the opposite side and one end, has a sharp cutting edge. The backing may be an original surface-cortex or a fracture plane in the raw material; it may be striking platform of the flake, plain or facetted; or it may be a deliberately trimmed surface. The cutting edge may be untrimmed, formed by intersecting flake surface, unifacially trimmed, or bifacially trimmed. If trimmed, it is thinned and sharpened. The backed edge is markedly thicker in minor section then the opposing cutting edge" (Kleindienst 1962, 89).

K6 is the only site in Isimila that has a high frequency of "knives" (Howell et al. 1962, Table 2), with no other African Acheulian site being dominated by these tools (Fig. 163; Isaac 1968, VII-26 and Fig. VII:5). At the site of Hunsgi, India, the core method used in the production of flake blanks from large slabs (Chapter 5) produced a large flake with at least one backed edge on the margin. According to Kleindienst's definition, such tools are to be regarded as "knives". However, since the technology of manufacture was responsible for this particular morphology, the shape of the finished tool could easily be assigned to a standard tool category (i.e. handaxe or cleaver). Roe (2001, 496) expressed similar doubts about defining knives as a distinct LCT type, although he eventually followed Kleindienst's example. Nevertheless, he did note that these tools were very rare at Kalambo Falls and were not defined as a group in any of the sites that he had studied. His analysis of the assemblage of Kalambo Falls demonstrated that its "knives" formed a part of the handaxe group, in terms of both shape and of size (Roe 2001a). In his study of Olorgesailie LCT morphology, Isaac (1977) did not find justification for isolating knives as a typological group. Roe (2006) noted that he did not encounter knives in the Lower Paleolithic of Britain.

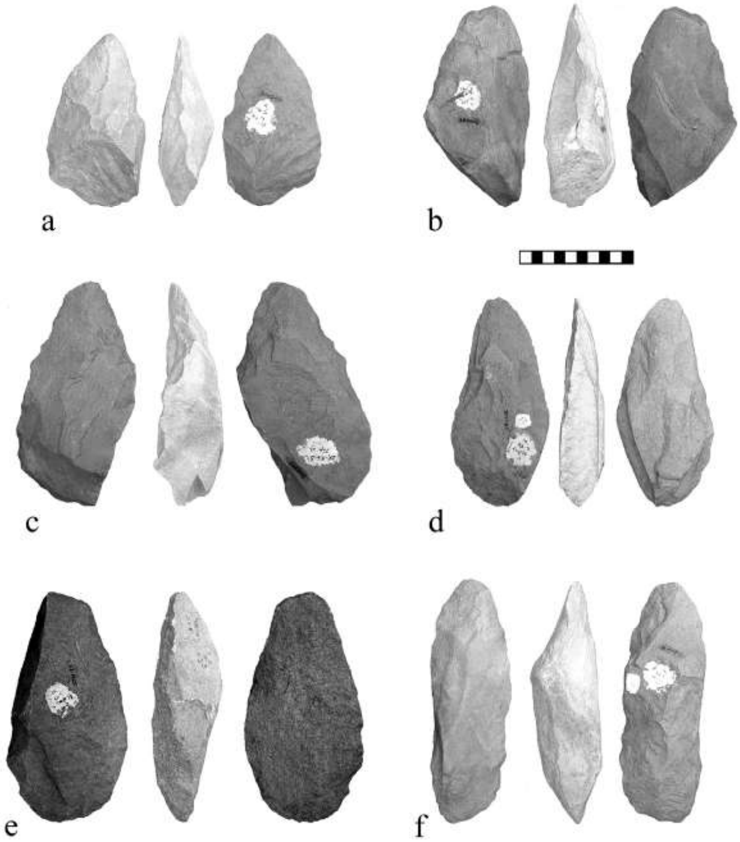


Figure 163. Possible knives from Isimila K6 (compare to the knife typology presented by Kleindienst 1962).

The presence of knives has been demonstrated among the Middle Paleolithic bifacial tools of Europe. Jöris (2006) has recently summarized the current state of research on the *Keilmesser* knives of the European Late Pleistocene industries. The bifacially knapped tool types of these industries include tools in which a blunt back was an integral and intentional part of their morphology, and very likely their functionality (Fig. 164). Matskevich and others (2002) describe a similar phenomenon in the Tabun Cave Acheulo-Yabrudian assemblage. It may be added here that the Sangoan assemblage of Site B, Horizon IV, Kalambo Falls contains a high frequency of “knives” in comparison to the Acheulian horizons (Roe 2001a).

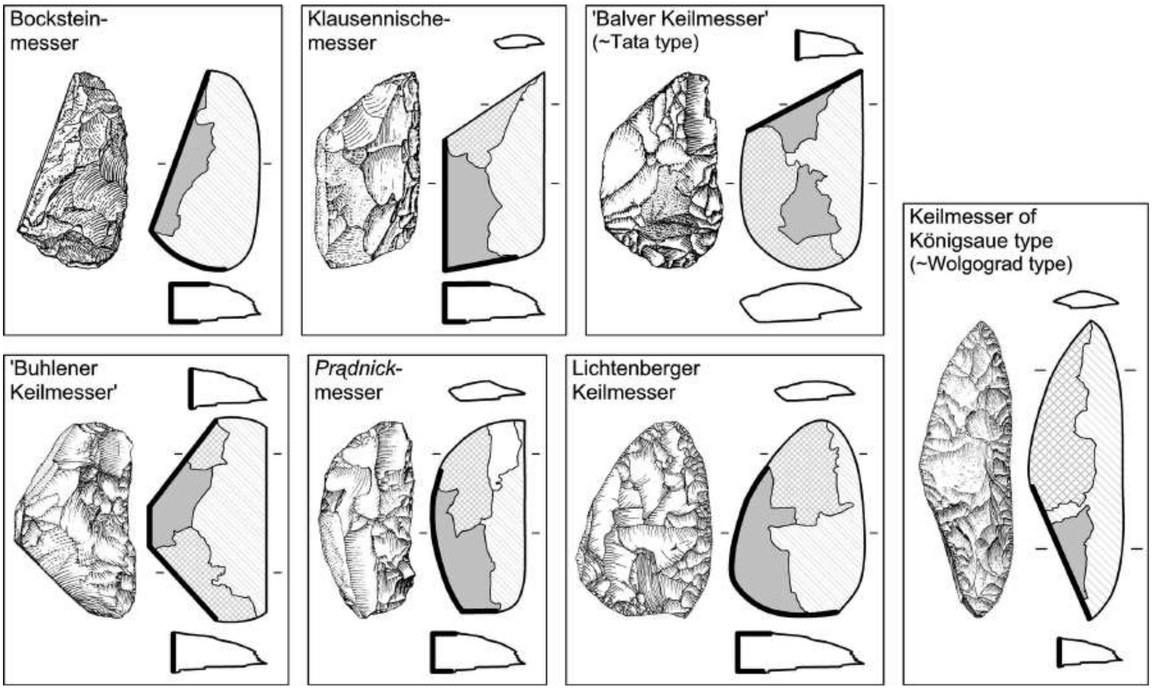


Figure 164. Partially schematic depiction of the spectrum of different *Keilmesser* shapes relative to the position of their back and base (thick line) and the configuration of the distal posterior part of the tool (not to scale, after Jöris 2006, Fig. 6).

It is my contention that knives are not found as a distinct typological group in LFB Acheulian assemblages. Backed edges, on which the identification of these tools was based, can in most cases be explained by means of blank shape, natural or accidental breakage, minimal thinning of the bulb, and other technological causes. The presence of “true” knives in any given assemblage, like the *Keilmesser* of the European Micoquian and the knives of the Levantine Acheulo-Yabrudian or the South African Sangoan, may serve as a chronological marker for Late/Post-Acheulian bifacial tool assemblages.

Non-bifacial Acheulian Tool Types on Large Flakes

There is a surprisingly small number of instances in which large flakes were used by the Acheulians as blanks for tool types other than LCTs. In many sites, there are large, unretouched flakes that do not have cleaver flake morphology (Fig. 165), but are morphologically relatable to the LCT “family”. They are flat and have long margins that could have been used as a cutting edge. They also fall within the size range of LCTs.

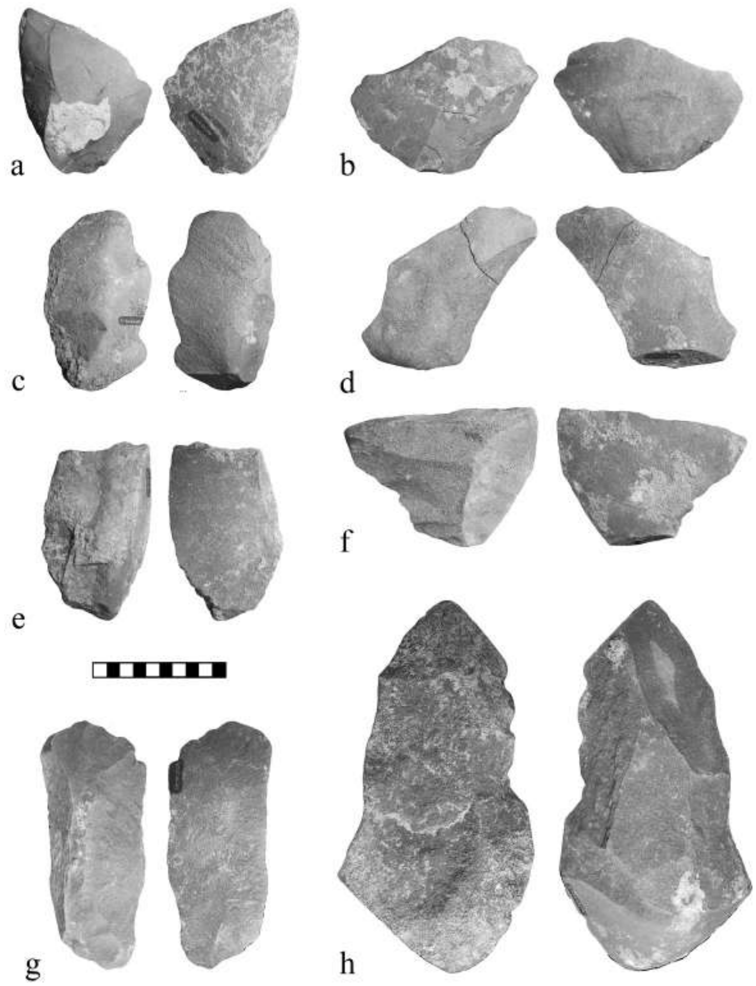


Figure 127. Large flakes from STIC (e. cleaver flake).

Large Flake Scrapers

In some cases, large flakes were retouched and transformed into large flake scrapers. One example is the large Kombewa flake scrapers from the site of Ternifine. Although Kombewa flake handaxes and cleavers do occur at the site (Fig. 57), most of the well-made Kombewa flakes found there were retouched into large scrapers (Fig. 166), although these are few in number. Another example is the large flakes from the site of Hunsgi, which show extensive abrupt scraper retouch on their lateral sides (Fig. 167). This retouch occurs on both large flakes and the margins of cleavers and handaxes. As a preliminary conclusion, it can be argued that large flakes were used by Acheulian knappers as blanks for the production of large scrapers. Yet it seems that only at Ternifine can systematic production of scraper blanks be identified. In most other assemblages, large and medium-sized flakes, which were probably byproducts of LCT blank production, were employed.

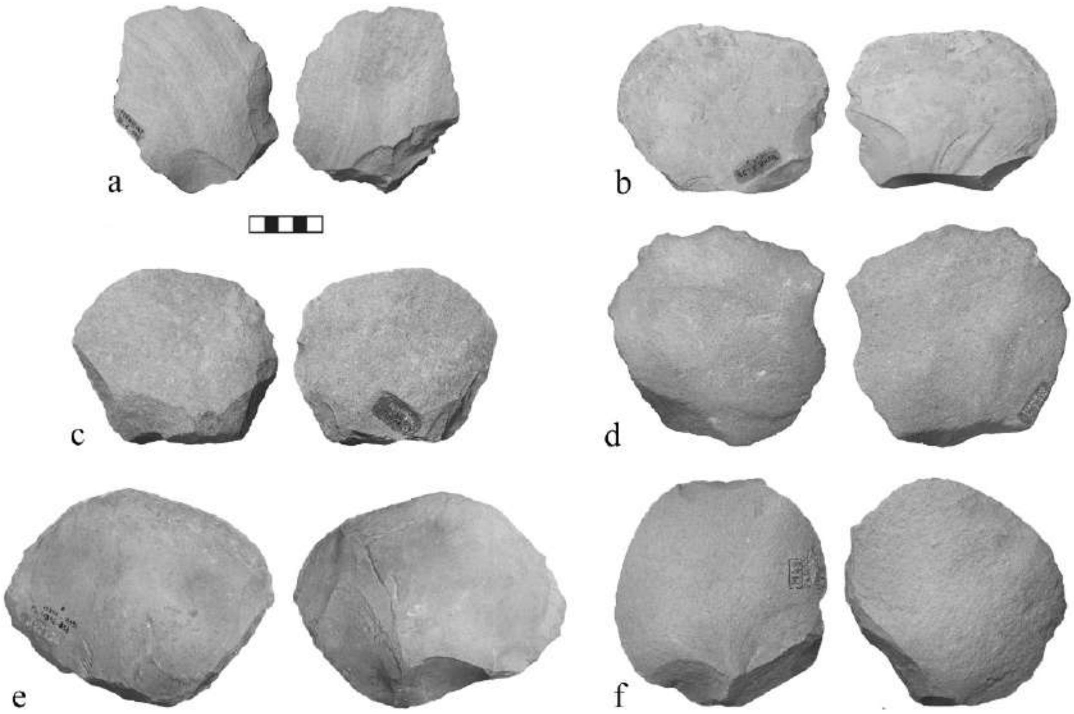


Figure 166. Scrapers on large Kombewa flakes from Ternifine. Note the minimal scraper retouch and the near absence of bifacial retouch.

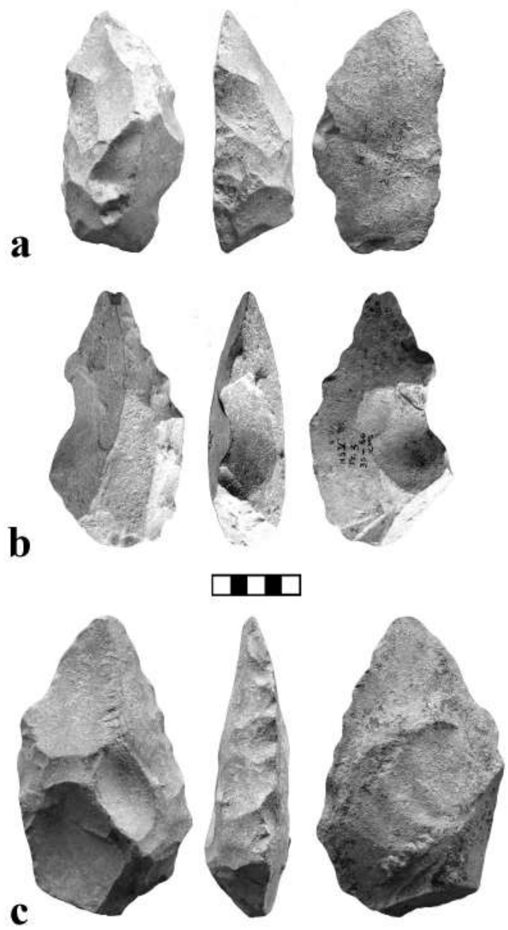


Figure 128. Hunsgi large flake scrapers.

Other Large Flake Tool Types

Some of the tools that were described above as ultra-pointed handaxes (Fig. 144) can be defined as awls or borers (Corvinus 1983b). Some rare handaxe tips present what was described as the "burin-bit" blow (Kleindienst 1962), but my own experimental knapping has shown that this could have resulted from knapping accidents, rather than deliberate design. Although additional large flake tool types can probably be identified, large flakes were rarely used for the production of non-bifacial tool types.

Chapter 7: Discussion and Conclusions

This chapter attempts to integrate the wide range of technological and morphological data presented above into a comprehensive picture of what is known about the LFB Acheulian, and then discusses the implications of this data for the study of human evolution, dispersal and behavior during the Lower and Middle Pleistocene. First, a definition is presented for the LFB stage of the Acheulian techno-complex. The implications of this definition for the global cultural sequence of the Lower Paleolithic, the geographical distribution of the different stages, and the chronology of the Acheulian are discussed next. A special section is dedicated to the previously undervalued importance of cleavers in the study of lithic traditions of the Pleistocene. Once the overall picture is presented, the sophistication of Acheulian toolmakers is assessed, as revealed by their technological behavior during three stages of the LCT *chaîne opératoire*. The discussion is concluded by an examination of Acheulian LCT variability in size and morphology from a wider perspective, and its implications for the debate over the Acheulian as a lithic culture.

Defining Acheulian LFB Industries

It is clear that LFB Acheulian assemblages comprise a distinct segment in the Acheulian techno-complex that is technologically and typologically distinguishable from others. Due to its large sample of LCTs and the meticulous excavation that it has undergone, the site of GBY has provided the most comprehensive picture of this type of assemblage to date. When they are grouped with other assemblages from a very wide geographical and (probably) chronological range, there is a striking degree of resemblance that warrants defining these assemblages as an Acheulian stage, characterized by the following criteria:

1. The primary lithic technology for manufacturing LCTs in these assemblages was the production of large flakes from giant cores. Other types of blanks were infrequent (Figs. 90, 91).
2. Acheulian hominins applied a large variety of systematic, well-planned and predetermined core methods in the production of large flakes, all well adapted to the type and shape of the raw material at hand. At none of the sites is there evidence of opportunistic, ad hoc production of large flakes.

3. A general propensity toward the production of large flakes from coarse-grained rock types rather than from fine-grained raw materials was observed in the LFB Acheulian industries. Acheulian knappers of large flakes possessed the ability to produce large flakes from flint, obsidian, hornfels and similar fine-grained rocks, which were available in the vicinity of many of the sites. However, they preferred to use such rocks as basalt, dolorite and quartzite in the production of LCTs. There are some assemblages in which fine-grained rocks were the primary raw material for the production of large flakes (Gowlett 1980), but these are exceptions.
4. The study of LCT size supports the definition of a large flake as one exceeding 10 cm in maximal length (Kleindienst 1962). LFB assemblages frequently include large, unretouched flakes, among which cleaver flakes are the most notable group.
5. In LFB assemblages, most handaxes and cleavers were shaped with minimal retouch of the ventral face. The main feature of this shaping procedure was thinning the flake blank's bulb of percussion, a technological trait that distinguished LFB tools from other Acheulian industries. In the latter, LCTs were also frequently produced on flake blanks (Figs. 90, 91), but final tool shaping involved a much higher intensity of retouch on both faces of the tool. The ability to predetermine blank shape prior to its detachment from the parent giant core, and the knowledge that guided the blank selection process, enabled the makers of large flakes to produce blanks of desirable shape that needed almost no additional shaping work. This efficient and sophisticated strategy is one of the main characteristics of the LFB Acheulian. In all of the assemblages under study, handaxes were frequently more heavily retouched than cleavers, mainly by means of more extensive retouch of the ventral face.
6. LFB assemblages contain significant frequencies of "true" cleavers (i.e. made on flakes, with an unmodified cutting edge), although it is impossible to establish a rigid frequency threshold at this time. Indeed, Acheulian sites that are not a part of the LFB industry rarely have more than one per cent of flake cleavers among their LCTs. Even if bifacial cleavers are included in the count, the total number of cleavers rarely exceeds 3% of these assemblages (Gilead 1970; Mourre 2003; Ranov 2001; White 2006). It should be borne in mind, however, that excavated assemblages, as well as surface collections, represent a sample from a population. In many sites, the excavated area is limited, and it has been proven that diverse localities, as well as different layers in a single Acheulian site, can yield a very varied lithic composition, even where the

duration of occupation was relatively short (Clark 2001; Goren-Inbar and Saragusti 1996; Howell et al. 1962; Isaac 1977).

7. Broad-tipped ovate handaxes are rare in LFB Acheulian assemblages. The great majority of handaxes in these sites have pointed tips. A cleaver vs. ovate handaxe dichotomy rule was suggested in Chapter 6, maintaining that these tool types comprised different solutions to a similar functional need for a wide, sharp and thin cutting edge. The choice between these tools seems to have been rooted in traditional lithic preferences, sites being dominated by either one or the other.

Although the LFB Acheulian could have been termed "Middle Acheulian", this term bears a chronological connotation that cannot be justified by the available data. In light of the current chronological data, it seems that in Sub-Saharan Africa, the LFB Acheulian was a significant Acheulian entity until the disappearance of this techno-complex. As Roe has put it: "There is not much appetite for terms like 'middle Acheulian' with their echoes of the bad old days of typology run riot" (Roe 2001b, 642).

Geographical Distribution and Chronology of the LFB Acheulian

Now that the LFB Acheulian phase has been defined, its chronological and geographical distribution can be explored. Our data are fragmentary in nature, due to the low geographical resolution of Acheulian sites, combined with the near-absence of reliable chronology. What can be gleaned is the following picture (Fig. 168):

A phase of Early Acheulian can be observed in Africa and the Levant, which predates the LFB Acheulian (Asfaw et al. 1992; Bar-Yosef and Goren-Inbar 1993; Isaac 1982; Leakey 1975). Early Acheulian assemblages comprise a relatively high frequency of picks and robust handaxes among their LCTs, with large flakes not constituting a primary technological praxis and cleavers being lacking. This stage is represented at such sites as 'Ubeidiya, Israel (Bar-Yosef and Goren-Inbar 1993), Konso Gardula, Ethiopia (Asfaw et al. 1992), Sterkfontein Cave, South Africa (Kuman and Clark 2000), Thomas 1 Quarry, Morocco (Raynal et al. 2001) and a few other East African sites (Isaac 1997; Roche 1995). These sites are all older than one million years.

The next stage of the Acheulian is that of the LFB industries, whose LCT blank production was primarily based on large flake technology. Isaac (1969) and Leakey (1975) perceived the ability to produce large flakes as a technological threshold, enabling the Acheulian LCT makers to evolve beyond the developed Oldowan. These assemblages made their first appearance in East Africa around 1 mya at sites like Olorgesailie (Isaac 1977), Olduvai Gorge (Leakey 1975; Leakey and Roe 1994) and Kilombe (Gowlett 1991). Throughout its duration, the LFB Acheulian, with its significant presence of cleavers, seems to have characterized many of the Acheulian assemblages in Sub-Saharan Africa. The Late Acheulian sites of Kalambo Falls (Clark 2001) and Isimila (Howell et al. 1962) are unmistakable members of this stage. Hence, it could be argued that the LFB Acheulian was a main component of the Sub-Saharan Acheulian up to the very last stages of its existence.

In the Sahara, North Africa and the Iberian Peninsula, the chronological and cultural sequence of the LFB Acheulian is unclear. Radiometric dates are rare, and the discussion of the cultural sequence is largely based on typological and cultural correlations. Large flakes were a major technological method in the production of blanks in all of the North African sites that were sampled here. Most of these sites included cleavers as a significant part of their assemblage. Early Acheulian was reported in the site of the Thomas 1 Quarry, and Late non-LFB Acheulian may yet be demonstrated to be present. The existence of LFB industries and many cleavers in the Iberian Peninsula (Santonja and Villa 2006) provides strong evidence for cultural connections over the Straits of Gibraltar. Some Acheulian assemblages in Spain clearly resemble North African LFB industries in technology and typology, the most obvious being the presence of many *entame* flakes and cleavers in both regions (see Mourre 2003; Santonja and Villa 2006 for references). These features are not found anywhere in Western Europe beyond the Pyrenees.

In the Levant, the site of GBY, dated to OIS 18–20 at the type locality and as late as 600 kya at GBY NBA, has the only assemblage in the entire region that can be ascribed to the LFB group (Bar-Yosef 1998; Copeland 1998; Gilead 1970; Goren-Inbar 1995; Hours et al. 1973). Other sites surely await discovery, and some clues are beginning to emerge from Egypt's Western Desert (Haynes et al. 1997, 2001). Nevertheless, no other large assemblage from a well-excavated site situated between Egypt and Turkey has been reported to date. Thus, GBY's geographical and chronological position makes it fundamental to all discussions of the LFB Acheulian beyond Africa. It is not known whether there were other Acheulian sites later than GBY or, alternatively, if more than one Acheulian type existed in Israel during the Middle Pleistocene. Of the Lower Paleolithic sites in the Levant, only 'Ubeidiya (Bar-Yosef and Goren-Inbar 1993) and Bizat Ruhama (Zaidner et al. 2003) have been demonstrated to be older than GBY. The former is Early Acheulian, while the latter has a non-Acheulian lithic assemblage.

As for the Caucasus, all that is known is that large flakes were produced from coarse-grained rocks there and that few flake cleavers were in evidence (Lioubine 1998; Lyubin and Belyaeva 2006 for references).

India, a region for which we lack any type of chronological framework, seems to be the easternmost limit of the LFB Acheulian. Some of the evidence suggests that LFB industries were present in South Central India earlier than 1 mya (Paddayya et al. 2002, 2006). An LFB Acheulian in which cleavers are more dominant than handaxes – both in number and their level of workmanship – is attested in many Indian sites. Large flakes were produced from the foothills of the Himalaya in Nepal (Corvinus 1991, 1998) to the South Indian site of Attirampakkam, Tamil Nadu (Pappu et al. 2003; Pappu and Akhilesh 2006). The variety of rock types used for raw materials by the Acheulian knappers of India was truly great, paralleled only in the African Acheulian. Most of the Indian Acheulian may therefore be attributed to the LFB Acheulian. The presence of either Early Acheulian or Late Acheulian (non-LFB and cleaverless) in the region has yet to be established.

Europe beyond the Pyrenees (with the exception of a small, narrow stretch along the Garonne and Tarn Rivers in Southern France) seems to be the only region with a substantial presence of the Acheulian culture into which the LFB Acheulian never penetrated. It has been over a hundred years since research began all over Western Europe, and not a single site has been revealed that can be attributed to this cultural stage of the Acheulian. To my knowledge, there is not a single site in which tool production was based on large flakes, or one that reflects significant exploitation of raw materials other than flint. Flake cleavers are negligible in all of the region's sites (Guichard and Guichard 1966; Roe 2006; Rolland 1995; Santonja and Villa 2006; White 2006). This study has demonstrated that raw material constraints cannot be regarded as an explanation for this absence. Rolland (1995, 338) has shown that, although raw material other than flint was available to Acheulian knappers in Europe, they chose not to use it (see also Moloney et al. 1996 for additional examples from the Iberian Peninsula). There is also no evidence that they struck large flakes from giant flint nodules when these were available, although it has been demonstrated that Acheulian knappers elsewhere could, and did, produce large flakes from flint at will. Large flint flakes were produced in small numbers in the British Acheulian (Figs. 90, 91), but flake cleavers were almost absent and raw materials other than flint were rarely exploited. It is possible that the absence of the LFB industries from Western Europe was the result of the distribution of lithic traditions. The chronological significance of this hypothesis can be explored through the following evidence:

1. The date of the GBY lithic assemblage can be suggested as a chronological marker for the LFB Acheulian beyond Sub-Saharan Africa. The date of ca. 780,000 BP was obtained for the lower part of the excavated section (estimated duration of at least 100 thousand years). The layers below the Matuyama-Brunhes chron boundary at GBY that contain Acheulian archaeological remains, probably date substaintially earlier.
2. All Acheulian sites in the Levant prior to GBY are non-LFB Acheulian (exclusive use of flint and no cleavers).
3. The appearance of the Acheulian in Europe north of the Pyrenees is dated to ca. 600–500 kya (Roebroeks and Kolfschoten 1995 for discussion and references). This Acheulian is non-LFB (large flakes are not the main blank technology; absence of flake cleavers; exclusive use of flint).

The combination of all of these points suggest a scenario in which by 0.5 mya, the LFB Acheulian had disappeared from the Levant, and probably from North Africa as well. It was replaced by an Acheulian tradition that lacked the large flake and cleaver component. Handaxes were still produced, but the propensity toward coarse-grained rocks was replaced by flint as the dominant raw material. The first Acheulian inhabitants of Europe beyond the Pyrenees (after 0.5 mya) carried with them a non-LFB Acheulian tradition. The cultural characteristics of the European Acheulian at 0.5 mya on the one hand, and the absence of any large flake sites in the Levant postdating GBY on the other, date the disappearance of the LFB Acheulian from these regions to 0.5 mya. It was replaced by a lithic tradition that had lost many of the main characteristics of the large flake industry (the most obvious being the replacement of cleavers by ovate broad handaxes), but still preserved others (shape and size of handaxes) and was certainly a part of the Acheulian techno-complex. This view places in question the late dates that were assigned to the LFB Acheulian of the Iberian Peninsula (Santonja and Villa 2006). In Sub-Saharan Africa, the LFB Acheulian existed until the very end of the Acheulian entity.

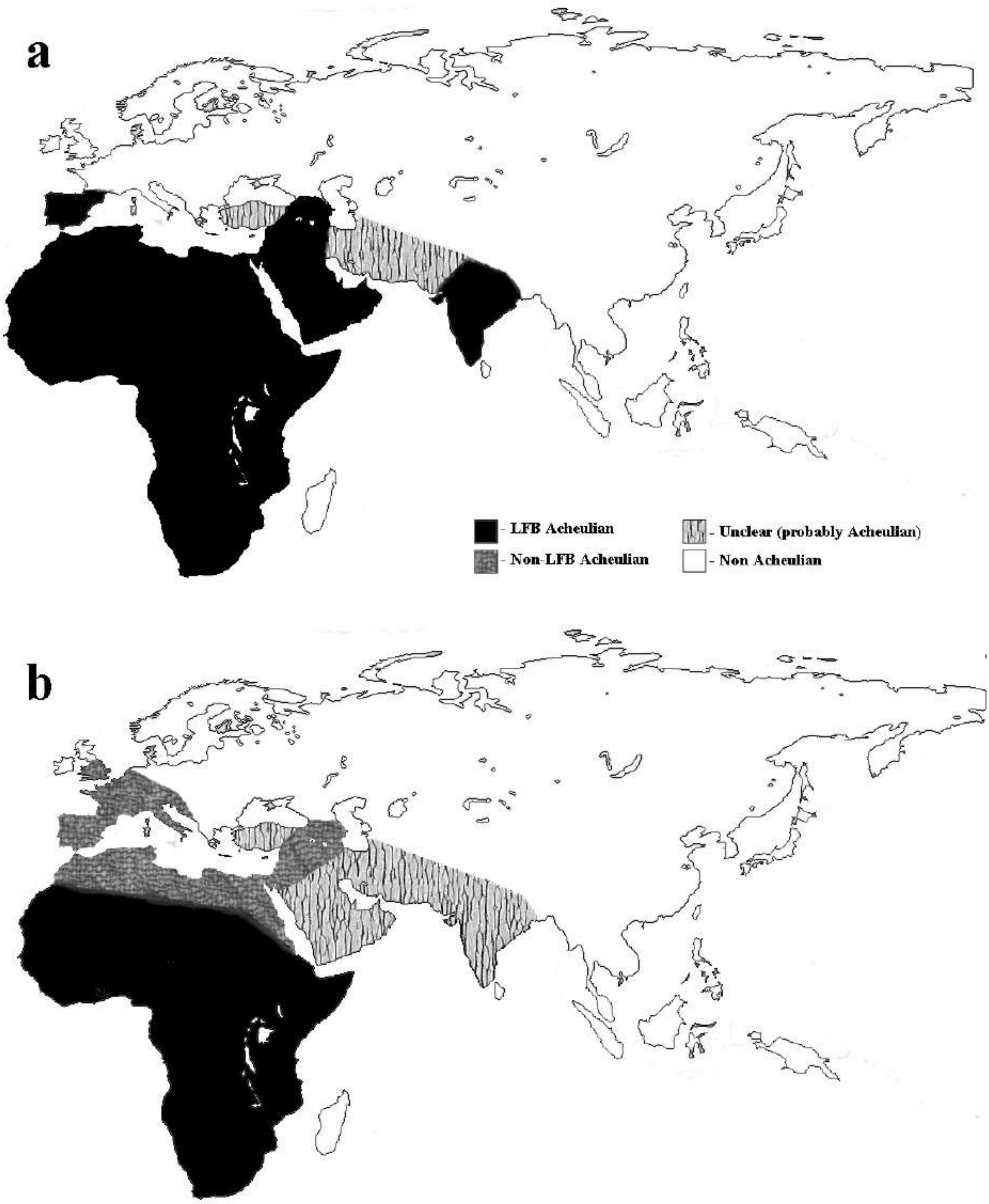


Figure 168. Schematic map of the Acheulian world before (a) and after (b) 0.5 mya.

The Position of the Cleaver in the Study of Acheulian LCTs

In its early stages, Acheulian research placed importance on the fact that cleavers were a dominant LCT in most sites. However, they have not received the amount of attention that has been bestowed on handaxes (but see Cahen and Martin 1972; Roe 1994, 2001a for oposit examples). Although there have been some recent important contributions to the study of cleavers (Mourre 2003; Ranov 2001; White 2006), the most recent debate over LCT variability, typology and technology and their implications for Pleistocene hominin cognition and mental evolution has entirely overlooked cleavers (Ashton and McNabb 1994; Ashton and White 2003; Gamble and Marshall 2002; Davidson 2002; Kohn and Mithen 1999; McPherron 2000; O'Brien 1984; White 1995; Wynn 1979, 1995). Furthermore, new methodologies that have developed in recent years have been applied only to handaxes (McPherron 1999; McPherron 2006; Nowell et al. 2003; Saragusti 2003; Saragusti et al. 2005; Vaughan 2000; Wynn and Tierson 1990). Some of these studies have indeed focused on assemblages from cleaverless sites, but others, which were seeking a global perspective, have been weakened by their neglect of cleavers.

As we have seen, in most regions of the Acheulian distribution, cleavers were as predominant as handaxes and frequently outnumbered them. A global study of Acheulian bifaces (a term incorrectly used as synonymous with handaxes) that disregards cleavers can yield only partial results. In most cases, cleavers are much more rewarding than handaxes as a source of technological information. The cleaver reduction sequence is much easier to trace, and the impact of raw materials, blanks and shaping technology on the morphology of the finished cleaver can be efficiently assessed. For example, a major issue in the discussion of Acheulian handaxe shape variability is the confrontation between the "raw material" model and the "reduction sequence" model (Ashton and White 2003 for discussion and references). The raw material model perceives the shape of the original block of raw material (i.e. the shape of the flint nodule that was used as a blank; White 1995) as the main conduit of final tool shape. The reduction sequence model, on the other hand, views ovate and pointed handaxes as reflecting different stages in the reduction sequence, in which large pointed handaxes were eventually resharpened into smaller ovate forms (McPherron 1999). The study of LFB LCTs has proved that both of these models are irrelevant to the tools' morphological variability. It has been demonstrated that raw material constraints had minimal impact on LCT shape and size, and that the morphology of LFB handaxes and cleavers cannot be explained by the reduction sequence model, since their minimal retouch shaping strategy ruled out intensive resharpening.

There has also been blatant disregard for cleavers in studies dealing with hominin cognition and language abilities, as they relate to handaxe shape and meaning (Davidson and Noble 1993). The distinctive geometric microliths of the Middle Stone Age (MSA) in Southern Africa have been considered the earliest “imposed forms” (i.e. tools whose shape did not result from an incidental sequence of removals intended to detach flakes). The reasons for identifying these tools as “imposed forms” were summarized as follows (Davidson 2002, 188): “Here the form was seen to be imposed because the shape of the artefacts did not depend on any aspect of the mechanics of production or use, the modified edge was not that used, and the forms were standardized within a very narrow range of shapes.” These features are as applicable to Acheulian cleavers as they are to MSA microliths. Cleavers can therefore be identified as the earliest “imposed forms”, illustrating the sophisticated cognitional abilities of their makers.

On Comparing between Apples and Oranges in the Study of Acheulian LCTs

A short methodological conclusion should be pointed out at this stage. The current study has placed emphasis on one of the main fallacies of Acheulian LCT study and its interpretation, namely the comparison of European and Levantine Final and Post-Acheulian sites to Acheulian assemblages of much earlier date. For example, due to its accessibility and size (Garrod and Bate 1937), the handaxe assemblage of Tabun Cave, Layers F and E has been used as a key to the debate over handaxe shape variability (Gamble and Marshall 2002; McPherron 2003; McPherron 2006; Rollefson 1978; Rollefson et al. 2005). Recent studies have demonstrated that the Tabun handaxe assemblage differs from those of all other Acheulian sites in the Levant. These handaxes are much smaller in size (Gilead 1970; Gisis and Ronen 2006; see also Chapter 6), they display a different morphology and degree of refinement and symmetry (Saragusti 2003), and the Tabun assemblage contains handaxe types that are rarely found in other Acheulian LCT samples (Matskevich et al. 2002). The Tabun Cave handaxe assemblage is equivalent only to a few Final Acheulian (Acheulo-Yabrudian) assemblages, like the newly excavated Misliya Cave (Zaidner et al. 2006), and perhaps Qesem Cave (Gopher et al. 2005). The data presented in Chapter 5 clearly demonstrate that the Tabun handaxes are not comparable to any other Acheulian assemblage.

Assessing Acheulian Technological Capability

> "That's all the motorcycle is, a system of concepts worked out in steel. There's no part in it, no shape in it that is not out of someone's mind… I've noticed that people who have never worked with steel have trouble seeing this... that the motorcycle is primarily a mental phenomenon. They associate metal with given shapes... pipes, rods, girders, tools, parts...all of them fixed and inviolable, and think of it as primarily physical. But a person who does machining or foundry work or forge work or welding sees 'steel' as having no shape at all. Steel can be any shape you want if you are skilled enough, and any shape but the one you want if you are not. Shapes, like this tappet, are what you arrive at, what you give to the steel. Steel has no more shape than this old pile of dirt on the engine here. These shapes are all out of someone's mind. That's important to see" (Pirsig 1974).

The following sections will review the stages of a tool's reduction sequence, which in effect formed a series of decisions that a knapper had to make in order to realize the idea of an envisioned tool into an actuality. Some scholars have regarded LCT production as the most basic level of stone tool standardization, which has been termed "coincidental" (Nowell et al. 2003 for discussion and references). It is my contention, however, that the production of large flakes from giant cores and the shaping of LCTs from these blanks was a very difficult task to accomplish, entailing extreme dexterity, knowledge, force and a long learning process.

In order to be able to detach his first series of well-controlled flakes, a knapper required many hours of trial and error (Jones 1994; Madsen and Goren-Inbar 2004; Toth 2001). The reconstruction of the decision-making process accompanying the *chaîne opératoire* is the only method that we have at our disposal of glimpsing the Acheulian mind at work. The following sections aim to assess Acheulian workmanship and sophistication through examination of a few technological aspects of their tool-production process.

Raw Material Exploitation Strategies

This study's examination of raw material usage by Acheulian knappers has led to the following conclusions:

1. The LCT knappers of the LFB Acheulian industries used a large variety of raw material types for the production of their tools.

2. A propensity toward coarse-grained rock types is observable in the production of large flakes.
3. In many sites more than one raw material was used, with one of these being dominant.
4. In most of the sites under study, LCT size did not relate to the raw material from which it was made.
5. The availability of a raw material in the vicinity of a site was not the sole explanation for its frequency of use.
6. The knapping quality of a raw material did not dictate the frequency, size or shape of the resulting LCTs (at least in the eyes of a modern knapper).

All of these observations reflect a scenario in which such raw material constraints as availability, knapping qualities, technological knowledge and block size placed no limitation on hominin knapping behavior. The ability to produce large flakes from many types of raw materials equipped the Acheulian knappers with a highly efficient method of producing desired LCTs from almost any type of hard rock, and freed them from dependence on suitably large flat river cobbles or natural slabs that provided the only alternative to large flake blanks. This technological ability was probably one of the main contributions to the success of the Acheulian culture in inhabiting a great variety of environments throughout its vast geographical distribution.

The adaptation of the Acheulian knapper of large flakes to local raw materials reflects astonishing sophistication and innovativeness. In the words of Ashton and White (2003, 116), they "…tailored a generalized knapping strategy to meet local raw material contingencies". In their desire to produce large flakes, the Acheulian knappers developed specific core methods to suit the available shape and size of each raw material. The large quartzite cobbles of North Africa were utilized by the Ternifine knappers first to detach an *entame* flake, and then to produce a Kombewa flake (see Chapter 4 for references). The slabs of Isampur were sliced as if from a large cheese, and large boulders of many types were bifacially knapped in many regions. In some cases, the core technology advanced to a level that enabled the knappers to design the cores fully, regardless of their original size and shape, as exhibited in the Victoria West, Tabelbala-Tachenghit and Levallois core methods. In addition, when suitable flat cobbles and slabs presented themselves, they were not rejected for use.

Large Flake Core Technology

As many as seven Acheulian large core methods were identified and described as part of this study. These include the bifacial method, the sliced slab method, the opening flake (*éclat entame*), and the Kombewa, Victoria West, Tabelbala-Tachenghit and Levallois core methods. Two additional methods were described on the basis of the literature: the Chirki cleaver core (Corvinus 1983b) and the Kerzaz core method (Alimen 1978). These blank production methods should be added to the use of cobbles and natural slabs as a source of LCT blanks. All of these core methods are fundamentally different from one another and reflect different technological solutions aimed at achieving a similar result – the production of flakes suitable in shape and size to be used as LCT blanks. In the LFB Acheulian, the majority of handaxes and cleavers were shaped on similar blanks that were produced by the core methods that were common at a given site. Cleavers were more conservative than handaxes, since in some assemblages the latter were produced on a larger variety of raw materials and in a larger range of sizes (particularly small sizes).

Acheulian giant core methods have been shown to be extremely efficient, even in comparison to the large flake production of the modern knapper (Pétrequin and Pétrequin 1993). The ability to produce many large flake blanks in a short time-span with a minimal investment of labor explains, to some extent, the enormous quantity of LCTs that were found in some of the Acheulian sites described above.

In the production of large flake blanks at a given site, more than one core method was used at any one time (Table 20). At GBY, blanks were obtained by as many as five simultaneous methods (bifacial, Levallois, Kombewa, sliced slab, cobble blanks), thus illustrating the Acheulian knapper's high technical capabilities. These core methods were as technologically advanced as those of the succeeding Middle Paleolithic Mousterian culture. Levallois cores, both small and large, are present in many Acheulian assemblages, with buds of the Levallois method being evident in the Victoria West and Tabelbala-Tachenghit core methods, as well as in the bifacial shaping process (Debono and Goren-Inbar 2001; Marder et al. 2006; White and Ashton 2003).

The advanced Acheulian core method also finds expression in its level of blank shape predetermination. Texier and Roche (1992, 2) have defined blank morphology predetermination as follows:

> "…a particular programming of débitage and transformation of the blanks obtained, which materialize through a series of technical actions carried out previously and at

the very moment of acquisition of the blank. The preparation of the core (affecting the débitage surface as well as the striking platform) aims essentially at controlling one or several parameters permitting the acquisitions of one, several or all morpho-technical characteristic elements of the planned object. These elements are thus acquired from the débitage and not by shaping or by retouching."

All giant core methods aimed to determine the shape of a planned blank by forming a specific scar pattern on the core and/or determining blow direction and location. The flakes produced by these methods enabled the knapper to create a large selection of LCT blanks that were suitable in both morphology and size. The highest level of blank morphology was achieved through the Victoria West core method. These blanks were designated for cleaver production, with special emphasis being paid to the scar pattern of the core debitage surface in order to ensure an efficient cleaver edge. The blank predetermination of the Tabelbala-Tachenghit method was of the same high technological caliber, while the *entame* flakes were much simpler in their technology, but no less efficient. In the latter instance, flake predetermination was not achieved through core method morphology. It relied upon suitable cobble core selection and correct blow application at an exact spot on the cobble, at a perfectly controlled angle and with the right force to ensure the production of cortical flakes, usually suitable for use as handaxe blanks. The systematic production of *entame* flakes by the Ternifine LCT makers demonstrates their close familiarity with the raw material resources in the site's vicinity. They possessed the ability to envision the finished tool as a potential shape within their selected cobble, thus displaying their mastery of stone workmanship and the sophistication of their *chaîne opératoire*.

Some core methods are found in all regions of the LFB Acheulian distribution (i.e. the Kombewa method; see Table 20), while others were restricted to a limited geographical area and represented a local invention. Victoria West cores, for example, are found only in Central South Africa, and the Tabelbala-Tachenghit core method is confined to the Western Sahara desert of North Africa. Although the methods differ in their morphological and technological character, they resemble one another to a great extent. It is notable that an astonishingly limited range of end-products was obtained through these core methods, and that all LCTs dating from the LFB Acheulian worldwide share the same size, morphology and typology. They represent similar, but not identical, solutions to the same necessities felt by different groups of Acheulian large flake makers.

In evolutionary biology, the term "convergent evolution" describes the disconnected evolution of a similar feature in different biological species, embodying an analogous adaptation that has been attained by separate ecosystems. Examples are the wings of insects, birds and bats, or the elongated faces and long sticky tongues of various anteaters inhabiting different continents. Darwin (1859) recognized this mechanism, which in recent years has been applied to the study of human cultural evolution (see Mesoudi et al. 2004 for discussion and references) and is exemplified by the invention of writing in the Egyptian, Mesopotamian and Chinese cultures. The fact that core methods closely resembling one another in technology and design were instigated by different Acheulian populations in remote and disconnected geographical regions provides us with a very early example of convergent cultural evolution.

While the giant core technology provides us with examples of convergent cultural evolution, the end-products of the LFB Acheulian – handaxes and cleavers - demonstrate the opposite scenario. The striking similarity in both size and morphology of LCTs from all over the geographical and chronological distribution of the LFB Acheulian provides clear evidence against the hypothesis suggesting that they are the result of similar, unrelated innovations in the different regions. In light of the data presented here, it is unlikely that tools knapped from such a variety of raw materials by such different core methods would all be shaped into such similar end-products. Even if we claim that the makers of the Acheulian LCTs designed their tools to face similar functional needs, such similarity in end-products is inconceivable. The enormous adaptive variability in raw material strategies and core methods on the one hand, and the astonishing similarity in the end-products on the other, can be explained only in terms of lithic tradition. The makers of the LFB Acheulian LCTs had a clear idea of the shape and size of desired tools that resulted from their lithic culture. Their sophistication, innovation and adaptive capabilities are evidenced by the many technological paths that they took to achieve this idea.

Blank Selection Strategies

A crucial stage in the Acheulian LCT *chaîne opératoire* was the selection of a specific blank from an inventory of potential ones that could be manufactured into tools. To the archaeologist, large flake blanks, particularly those used for cleaver production, provide a means of reviewing core method and shaping technology in great detail.

Blow direction: At some sites (such as the Vaal River sites), blanks detached by a single direction of blow are much more frequent (Figs. 82, 83), while at other sites (e.g. GBY) blank flakes were chosen simply for their morphology, regardless of the blow direction. The LCTs assemblages of the Vaal River sites show high frequencies of direction 3, necessitated by the Victoria West core design (see Chapter 4). To the modern eye, however, two possible blow directions could have been applied to these cores (i.e. directions 3 and 6). The fact that the makers of the Victoria West cores chose to strike them only from direction 3 is still inexplicable. At any rate, blow direction ensured blank shape predetermination on the parent core. The great majority of blanks at most sites were detached from the side or special-side directions (directions 3 to 7), while the cleaver samples from Ternifine are the sole examples of end-flakes (direction 5).

It can be suggested that the GBY knappers invested less energy and time in core preparation than the Victoria West knappers. They were less rigid in their blank selection requirements, at least in terms of blow direction. Consequently, they may have been required to invest more energy in reshaping blanks that varied in morphology from the desired LCT, as blank morphology was the main guideline in their blank selection.

Minimal work investment during shaping: The analysis of the intensity and location of retouch on LCT faces (Chapter 5) has revealed that most LFB LCTs were shaped by thinning the bulb of percussion (Goren-Inbar and Saragusti 1996; Isaac 1977). This provides strong support for the view that sees LCT morphology as the product of functional needs. Bulb thinning did not change the overall shape of the cleaver or handaxe; rather, its aim was to achieve tool balance and efficacy of use. The fact that this shaping method was practised similarly in all LFB Acheulian assemblages is possibly an indication of the functional nature shared by all the samples under study.

Acheulian LCT Size and Shape in a Wider Perspective

The first stage of the LCT *chaîne opératoire*, namely the production of large flakes, differed dramatically from site to site and from region to region. In the next stage of the sequence, an LCT was shaped from a selected blank in a manner that is uniform worldwide, in order to achieve tools of similar shape and size. Technologically, all LCTs produced on large flakes (and, admittedly, most other LCTs subsequent to the Early Acheulian) were shaped by a bifacial knapping technique (e.g. Bordes 1961; Callahan 1979; Crabtree 1967; Madsen and Goren-Inbar 2004; Newcomer 1971) that adhered to the same principles everywhere. The thickness of the bulb was reduced. The knapping was marginal (Bradley and Sampson 1978 coined this term, which refers to what has been defined as "soft hammer technique" by many scholars, but in some instances could have resulted from the knapping method that was used rather than the type of hammer; see discussion in Sharon and Goren-Inbar 1999; Sharon and Goring-Morris 2004). Long, thin flakes were detached in order to reduce the thickness (and mass) of the preform with minimal loss of cutting edge length (Jones 1994).

The largest dimensions of over 90% of the sampled LFB LCTs (and most other handaxes prior to the very Late Acheulian) fall within the 10 to 20 cm range (Table 32). Moreover, 50% of the handaxes fall within the 5.3 cm interquartile range and 50% of the cleavers fall within the 4.1 cm interquartile range. Other measurements also indicate a similar uniformity in various size attributes (Chapter 5). Nevertheless, some assemblages contained LCTs that were larger than others, and even indicate regional patterns in this respect (e.g. the large size of Southeast African LCTs).

Size variability between samples, or between different levels in the same site, has helped to illustrate many aspects of intersite Acheulian assemblages in numerous studies. Yet, when we zoom out from the site level and adopt a wider perspective, it might have been expected that such a variety of raw materials and core methods would yield a much larger range of LCT sizes, especially since the evidence shows that the Acheulian knapper was able to produce much smaller tools (Tabun Cave) and very large flakes from rocks that were very hard to knap (all sampled sites). Nevertheless, the Acheulian toolmakers worked according to a very narrow set of size specifications, which the *chaîne opératoire* was designed to execute.

When plotted next to one another, all sampled Acheulian handaxes and cleavers present a shape variability that is surprisingly low. The shape diagrams presented in Chapter 6 clearly show that handaxes were of a very limited number of shapes and constituted variants of the same basic teardrop form (Fig. 142). Deviations from this shape were very rare and in most cases were less formal forms of the same shape. Some shape trends are discernible among the sampled handaxes, like the presence of ultra-pointed shapes. Since handaxes differ in the quality of their workmanship and the amount of work invested in them, some sites contain very refined tools, while in others the tools are coarser.

One of the main attributes of LFB assemblages is the near-absence of ovate handaxe forms. A dichotomy of cutting edge models was suggested as an explanation for this, viewing this near-absence as stemming from a functional need for two basic types of tool-tip shape: a narrow, pointed edge and a broad, straight and thin edge (Fig. 159). Teardrop handaxes (and their shape variations) fulfilled the pointed edge requirement, and cleavers provided the best solution for a straight, thin and sharp cutting edge (the sharpness was achieved by the fact that the edge was never shaped by secondary retouch). In assemblages in which cleavers were no longer a part of the tool arsenal (non-LFB assemblages), ovate handaxes were produced as an alternate solution to the need for a broad cutting edge. Some of these broad handaxes were designed as bifacial cleavers (White 2006), while other sites developed an alternative solution: the removal of a tranchet flake from the ovate handaxe's tip.

Cleavers show less uniformity of shape than do handaxes, although they too manifest a restricted range of forms (Figs. 148–151). To a large extent, the variety of cleaver forms stemmed from the relatively small amount of work invested in shaping them. It is possible to surmise the "ideal" cleaver shape from the Isimila K14 cleavers (Fig. 156). These beautiful and fully worked cleavers offer a glimpse into the mind of the knapper who designed them and represent the cleaver mental template (see below). Here, knappers fully mastered every aspect of cleaver form, excluding the cutting edge. These cleavers present elongated and symmetrical lateral edges and rounded butts, which were probably the ultimate attributes of any cleaver, had more shaping been invested in its manufacture.

It is important to note that the butt of all LCTs was highly uniform in shape and was often designed with the same gusto as the tip. While it may be suggested that hafting technology stands behind this design and uniformity of shape, this is no more than an educated guess.

To sum up, it has been shown that LFB Acheulian handaxe and cleaver shape variability does not justify the definition and isolation of distinct "types". According to Isaac (1977, 120), only (pointed) handaxes and cleavers can be identified as a stand-alone group of shapes, while other forms are part of the "… arbitrary zones within a structured continuum". This view is strongly supported by the data presented here. The typological variability found in Late and Final Acheulian assemblages is not part of the very limited shape range of the LFB Acheulian.

It has been maintained that since Acheulian hominins differed from us in many features of the neuro-physiological system (chiefly the size and structure of the brain) and are removed from us by such a long span of time, we cannot explain their behavior in terms of "culture". The holders of this view argue that the similarity in handaxe shape over such a vast geographical range (again, cleavers were largely overlooked) was caused by "coincidental" factors, like raw material constraints, blank selection strategies, or the final stage of a core reduction sequence that was aimed to produce small flakes (e.g. Davidson 2002; Davidson and Noble 1993; Nowell et al. 2003 and references therein). I believe that the data presented above in connection with the sophistication of Acheulian technological behavior are sufficient to reject this approach.

This study is based on an approach that places functionality at the foundation of any interpretation. The *raison d'être* of bifacially knapped LCTs was their cutting edge. The properties of the cutting edge (in terms of its efficiency in cutting, piercing, slicing, etc.) and its length and ratios to tool mass were the main factors dictating the shape of these tools. A functional approach has proved the most fruitful in understanding the morphology of LCTs (e.g. Jones 1979, 1994; Madsen and Goren-Inbar 2004; Newcomer 1971; White and Ashton 2003). An obstacle to this approach is the fact that we do not know the exact function of LCTs. Many options have been suggested (see Chapter 1), but most researchers seem to agree that slicing meat, probably during the processing of large game, was their main use (Isaac 1986; Jones 1980, 1994; Potts et al. 1999).

Much of the debate over Acheulian LCTs derives from our own difficulty in accepting the fact that people who were spread over a wide geographical expanse adhered to the same tool morphology over a very long stretch of time, without any observable change (Isaac 1972a, 1977). LCTs were all of a size that is easily handled by a human hand. Had their morphology been dictated by symbolic or sexual expression, as has been suggested by some (Kohn and Mithen 1999), much larger (sexually impressive?) and smaller (usable as votive objects?) specimens should have been found among them.

It is necessary to emphasize that similarity in shape and size is not restricted to the teardrop handaxe shape, but is also evident in the cleaver U-shape throughout the geographical distribution of the LFB Acheulian. Additionally, other distinct shapes, e.g. spheroids, were imposed upon Acheulian lithic artifacts throughout their distribution in time and space (Willoughby 1987).

The makers of Acheulian LCTs were simultaneously very flexible about their stone technology and extremely conservative about the morphology of their tools. They followed a cultural tradition in which large cutting tools had to be made within a restricted range of shapes.

> "In setting about their highly efficient production of large cutting tools, which were only a part of their total lithic output, these makers purposefully followed a local technological and stylistic tradition, which varied little in general, but within which individual expertise preferences for particular rock types, or interpretation of desired proportions or angles, might leave a stamp of human variation upon the successive expressions of an essentially unaltered theme. This – with slight appropriate changes

> for the performance of particular tasks - would give rise to all the variation seen in eight of the nine Kalambo Falls horizons” (Roe 2001a, 521–522).

The image of the finished tool in the mind of its maker was used as a “plot” that dictated all stages of the reduction sequence. This has acquired many names in the debate over LCT shape similarity, the most renowned being Deetz’s (1967) “mental template”:

> “The idea of the proper form of an object exists in the mind of the maker, and when this idea is expressed in tangible form, an artifact results. The idea is the mental template from which the craftsman makes the object. The form of an artifact is a close approximation of this template, and variation in a group of similar objects reflect variation in the ideas which produced them” (Deetz 1967, 43–44, as quoted in Cross 1983).

Wynn (1995, 12) expressed the same idea with regard to Acheulian handaxes:

> “The handaxe was an idea that was imposed on the natural world and also shared by many individuals. It is a true cultural category. Stone knappers set out to produce handaxes as final products. They may also have been cores, but the shape itself was clearly intentional, and therefore provides us with a glimpse into the mind of the knappers.”

Many scholars (Davidson 2002; Davidson and Noble 1993; Nowell et al. 2003 and references therein) have challenged the concept of a mental template. This criticism led Wynn to adopt a much more cautious attitude: “The knappers must have imposed shape, at least occasionally. This does not, however, require that an image existed ahead of time; it only requires that the knappers attended to shape as they produced the artefact” (Wynn 2004, 672). Others have used different terms to describe the same concept, “mental construct”, for example (Ashton and White 2003; McNabb et al. 2004). Whatever name we choose, it is clear that the shape of a handaxe or a cleaver was the objective of a very complex sequence of technological and mental activities that led from a large block of raw material to the final tool.

The similarity of tool types and size, raw material strategies and lithic technology clearly shows that the LFB Acheulian, which was developed in Africa, was transported “Out of Africa” into Asia and as far as India. This dispersal, or migrational wave, can easily be distinguished from the earlier “‘Ubeidiya-like” Acheulian (Goren-Inbar 1992; Goren-Inbar et al. 2000). Once this had occurred, the Acheulian knappers adapted to the changing conditions of the landscape and developed a variety of core methods that were suited to available raw material types and shapes. In some regions (Africa), the lithic tradition remained unchanged, while in others (the Levant), significant parts of the tradition (the dominance of large flakes and cleavers) disappeared and only a remnant (handaxes) survived. The LFB Acheulian never reached Europe beyond the Pyrenees, where the LFB Acheulian was substituted by the next stage of the Acheulian techno-complex, probably the "Late Acheulian". Our archaeological resolution, both in chronology and in excavated site density, does not even permit a guess as to whether these changes were the result of different waves of "Out of Africa" migrations or local regional developments.

This global perspective maintains that the Acheulian techno-complex was the product of human groups sharing the same lithic tradition over a span of thousands of kilometers, possibly as early as one million years ago. However, it is unlikely that any kind of connection existed between the Acheulian people of South Africa and India. A high degree of cultural conservatism, combined with similar functional needs, probably lay behind the astonishing worldwide similarity in Acheulian LCT shape and size. Nevertheless, it should be noted that in a geological blink of an eye, the Acheulian was totally replaced by the Levallois Mousterian lithic tradition over the entire enormous range of its geographical distribution.

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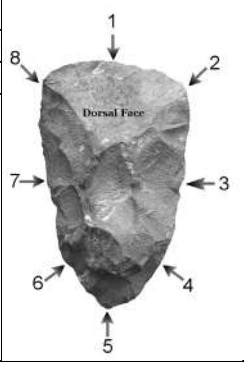
Appendix: Lithic Analysis Attribute Lists

General records for all artifacts: Site, elevation, layer, excavation trench/square, number of artifact.

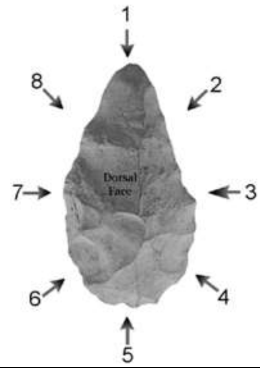
List of Attributes: Cleavers

Raw Material	**Preservation State**
1. Flint	1. Fresh
2. Lime/flint	2. Slightly abraded
3. Limestone	3. Rolled
4. Basalt	4. Too rolled for analysis
5. Quartz	5. Crumbling
6. Quartzite	
7. Sandstone	**Patina**
8. Calcareous	1. No patina
9. Mudstone	2. Patina
10. Indeterminate	3. Double patina
11. Granite	
12. Dolerite	**Cortex**
13. Andesite	1. No cortex
14. Hornfels	2. 0–25%
15. Mylonite	3. 25–50%
16. Chert	4. 50–75%
20. Metamorphic rock	5. 75–100%
	6. Indeterminate
Complete/Broken	
1. Complete	**Type of Blank**
2. Distal break	1. Flake
3. Lateral Break	2. Chunk
4. Proximal Break	3. Indeterminate
5. Lateral & Distal	4. Kombewa
6. Distal & Proximal	5. Possibly Kombewa
7. Fragment	6. Transverse flake
8. Proximal & Lateral	7. On Levallois flake
9. Indeterminate	8. Flat cobble
10. Exfoliate	9. Probably flake
11. Use damage of distal edge	10. Special side strike
12. Small break on distal edge	
	Type of Striking Platform
Amount of Retouch	1. Indeterminate
1. 0–25%	2. Cortical
2. 25–50%	3. Punctiform
3. 50–75%	4. Plain
4. 75–100%	5. Dihedral
	6. Facetted
Type of Retouch	7. Removed
1. Flat and limited	8. Missing
2. Scraper type	9. Crushed
3. Thinning	
6. Indeterminate	**Shape of working edge**
12. Bifacial	1. Straight
Type of Retouch (continuation)	**Shape of working edge (continuation)**
20. Rough bifacial	2. Convex

21. Bifacial & finishing	4. Pointed
22. Biface and scraper	5. Indeterminate
23. Thinning and scraper	6. Diagonal
	7. Weathered
Metrical Measurements	
No. of scars for each face	**Location of Retouch**
Striking platform angle	1. Distal
Cutting edge length	2. Proximal
Circumference	3. Left side
Length	4. Right side
Length cleaver-wise	5. Both sides
Maximum length	6. Convergent
Max. width	7. Distal & both sides
Max. thickness	8. Distal & left
Weight	9. Distal & right
	10. All around
Edge Retouch Type	11. Proximal & both sides
1. Use marks	12. Proximal & left
2. Notch	13. Proximal & right
3. Wavy	14. All tool's face
4. Light damage	15. Indeterminate
5. Finishing retouch	16. Distal & prox. & left
6. Scraper	17. Distal & prox. & right
	18. Convergent & prox.
Forming of Working edge	
1. Before the flake	**Scar Pattern**
2. On the flake	1. Indeterminate
3. Indeterminate	2. Cortical
	3. Ventral
Technological Features	4. Simple
1. *Outrepassé*	5. Parallel
2. Hinge	6. Convergent
3. *Debordant*	7. Opposed
4. Kombewa	8. Radial
5. Possibly Kombewa	9. Ridge
7. Steps	10. Side
8. Éclat siret	11. Simple & side
9. Lip & bulb scar	12. Both sides
9. Lip	13. Side & opposed
10. Lip & cone	
11. Removals on ventral face	**Direction of Blow**
12. Double cone	9. Indeterminate
13. Large cone	
14. Thinning of bulb	
15. Bulb scar	

Handaxes: List of Attributes

Raw Material	**Preservation State**
1. Flint	1. Fresh
2. Lime/flint	2. Slightly abraded
3. Limestone	3. Rolled
4. Basalt	4. Too rolled for analysis
5. Quartz	5. Crumbling
6. Quartzite	
7. Sandstone	**Patina**
8. Calcareous	1. No patina
9. Mudstone	2. Patina
10. Indeterminate	3. Double patina
11. Granite	4. New patina
12. Dolerite	
13. Andesite	**Complete/Broken**
14. Hornfels	1. Complete
15. Mylonite	2. Distal break
16. Chert	3. Lateral break
20. Metamorphic rock	4. Proximal break
	5. Lateral & distal
Cortex (for each face)	6. Distal & proximal
1. No cortex	7. Fragment
2. 0–25%	8. Proximal & lateral
3. 25–50%	9. Indeterminate
4. 50–75%	10. Exfoliated
5. 75–100%	11. Use damage at distal edge
6. Indeterminate	12. Distal damage (recent)
Blank	**Amount of Retouch**
1. Flake	1. 0–25%
2. Chunk	2. 25–50%
3. Indeterminate	3. 50–75%
4. Kombewa	4. 75–100%
5. Possibly Kombewa	
6. Transverse flake	**Type of Striking Platform**
7. On Levallois flake	1. Indeterminate
8. Flat cobble	2. Cortical
9. Probably flake	3. Punctiform
10. Special side strike	4. Plain
	5. Dihedral
Type of Retouch	6. Facetted
1. Flat and limited	7. Removed
2. Scraper type	8. Missing
3. Thinning	9. Crushed
6. Indeterminate	10. Victoria West
12. Bifacial	
20. Rough bifacial	**Metrical Measurements**
21. Bifacial & edge finishing	Number of scars
22. Bifacial & scraper	Striking platform angle
23. Thinning & scraper	Edge length
	Circumference
	Max. length
	Max. width
	Max. thickness

Location of Retouch	Width @ ½ length (whl)
1. Distal	Thickness @ ½ length (thl)
2. Proximal	Loc. of max. width (lmw)
3. Left side	Loc. of max. thickness (lmt)
4. Right side	Width @ upper 1/5 (wuf)
5. Both sides	Thickness @ upper 1/5 (tuf)
6. Convergent	Width @ lower 1/5 (wlf)
7. Distal & both sides	Thickness @ lower 1/5 (tlf)
8. Distal & left	
9. Distal & right	**Direction of Blow**
10. All around	9. Indeterminate
11. Proximal & both sides	
12. Proximal & left	
13. Proximal & right	
14. All tool's face	
15. Indeterminate	
16. Distal & prox. & left	
17. Dist. & prox. & right	
18. Convergent & prox.	

List of Attributes: Cores and Core Tools

Raw Material	**Preservation State**
1. Flint	1. Fresh
2. Lime/flint	2. Slightly abraded
3. Limestone	3. Abraded
4. Basalt	4. Rolled
5. Quartz	5. Exfoliated
6. Quartzite	
7. Sandstone	**Cortex on dorsal face**
8. Calcareous	1. No cortex
9. Mudstone	2. 0–25%
10. Indeterminate	3. 25–50%
11. Granite	4. 50–75%
12. Dolerite	5. 75–100%
13. Andesite	6. Indeterminate
14. Hornfels	
15. Mylonite	**Levallois**
16. Chert	1. Levallois
20. Metamorphic rock	2. Not Levallois
	3. Possibly Levallois
Complete/Broken	
1. Complete	**Nature of Dorsal Face**
2. Distal break	1. Indeterminate
3. Lateral	2. Cortical
4. Proximal	3. Plain
5. Lateral & distal	4. Simple
6. Proximal & distal	5. Parallel
7. Fragment	6. Convergent
8. Proximal & lateral	7. Opposed
9. Indeterminate	8. Radial
	9. Ridge
Type of Retouch	10. Side
1. Use marks	11. Simple & side
2. Regular	12. Simple & opposed
3. End scraper	13. Side & opposed
4. Scraper	14. Simple & radial
5. Notch – denticular	
6. Indeterminate	**Section Shape**
7. Irregular	1. Triangular
8. Half Quina	2. Flat
9. Quina	3. Indeterminate
10. Reclette (fine)	
11. Climbing	
12. Bifacial	**Patina**
13. Abrupt	1. No patina
14. Nahar Ibrahim	2. Patina
15. Thinning	3. Double patina
16. Half-abrupt	
17. Bipolar	
18. Mixed (on the same edge)	

Shape of Cutting Edge	**Metrical Measurements**
1. Straight	Weight
2. Convex	Length
3. Concave	Width
4. Convergent	Thickness
5. Wavy	Maximum length
6. Denticulate	Circumference
7. One tooth	Cutting edge length
8. Indeterminate	Number of cutting edges
9. All around	Number of platforms
	Number of scars
	Main scar length
	Main scar width

List of Attributes: Flakes & Flake Tools

Raw Material	**Patina**
1. Flint	1. No patina
2. Lime/flint	2. Patina
3. Limestone	3. Double patina
4. Basalt	
5. Quartz	**Complete/Broken**
6. Quartzite	1. Complete
7. Sandstone	2. Distal break
8. Calcareous	3. Lateral
9. Mudstone	4. Proximal
10. Indeterminate	5. Lateral & distal
11. Granite	6. Proximal & distal
12. Dolerite	7. Fragment
13. Andesite	8. Proximal & lateral
14. Hornfels	9. Indeterminate
15. Mylonite	
16. Chert	**Type of Striking Platform**
20. Metamorphic rock	1. Indeterminate
	2. Cortical
Metric Measurements	3. Punctiform
Weight	4. Plain
Length	5. Dihedral
Width	6. Faceted
Thickness	7. (Removed)
Maximum length	8. Missing
Striking platform length	9. Crushed
Striking platform thickness	
Number of scars	**Lipped Striking Platform**
Angle of striking platform	1. Lipped
	2. Unlipped
Technological Observations	3. Indeterminate
1. *Outrepassé*	
2. Hinge	**Preservation State**
3. *Debordant*	1. Fresh
4. Kombewa	2. Slightly abraded
5. Possibly Kombewa	3. Abraded
7. Steps	4. Rolled
8. *Éclat siret*	5. Exfoliated
Nature of Dorsal Face	
1. Indeterminate	**Cortex Cover of Dorsal Face**
2. Cortical	1. No cortex
3. Plain	2. 0–25%
4. Simple	3. 25–50%
5. Parallel	4. 50–75%
6. Convergent	5. 75–100%
7. Opposed	6. Indeterminate
8. Radial	
9. Ridge	**Direction of Blow**
10. Side	1. Indeterminate
11. Simple & side	2. Longitudinal
12. Simple & opposed	3. Latitudinal
13. Side & opposed	4. Side strike
14. Simple & radial	

Varia	Location of retouch
1. Removals on ventral face	1. Distal
2. Double cone	2. Proximal
3. Large cone	3. Truncation
4. (Reducing bulb thickness)	4. Left side
5. Scar on bulb of percussion	5. Right side
	6. Both sides
Shape of Cutting Edge	7. Convergent
1. Straight	8. Distal & both sides
2. Convex	9. All around
3. Concave	10. Distal & right
4. Convergent	11. Distal & left
5. Wavy	12. Proximal & both sides
6. Denticulate	13. Indeterminate
7. One tooth	
8. Indeterminate	**Location of Retouch 2**
9. Diagonal	1. Dorsal
	2. Ventral
Type of Retouch	3. Dorsal & Ventral
1. Use marks	4. Side
2. Regular	5. thinning the striking platform
3. End Scraper	
4. Scraper	
5. Notch – denticular	
6. Indeterminate	
7. Irregular	
8. Half Quina	
9. Quina	
10. Reclette (fine)	
11. Climbing	
12. Bifacial	
13. Abrupt	
14. Nahar Ibrahim	
15. Thinning	
16. Half abrupt	
17. Bi-polar	

תעשיות נתזים גדולים באשלית:
טכנולוגיה, כרונולוגיה, תפוצה ומשמעות

חיבור לשם קבלת תואר דוקטור לפילוסופיה

מאת

גונן שרון

הוגש לסינט האוניברסיטה העברית בירושלים

אוקטובר 2006

עבודה זו נעשתה בהדרכתה של

פרופסור נעמה גורן-ענבר

תוכן העניינים

תקציר

מבוא

אבני היד והקופיצים מן התקופה האשלית, שיוצרו על גבי נתזים גדולים, עומדים במרכזה של עבודת מחקר זו. כלים מאפיינים אלה התגלו והוגדרו באתר St. Acheul, צרפת (לתיאור ממצה של ההיסטוריה והטרמינולוגיה פרי חקר תקופה זו, ראה Isaac 1968). בראשית דרכם, התבססו מחקרי הטיפולוגיה והכרונולוגיה של התקופה ותרבותה על ממצאים מאתרים צפון אירופאיים (אנגליה וצרפת). במחצית השנייה של המאה העשרים, התרחבו המחקרים והחפירות וחרגו אל מעבר לגבולות אירופה, תוך שימת דגש על אפריקה ועל הלבנט. מחקרים אלה הוכיחו כי הסכימה המקובלת עד לאותה התקופה כמייצגת את הרצף התרבותי האשלי, לא הייתה מקיפה דיה. באפריקה ובלבנט נחשפו כלים אשליים דו-פניים, אשר כלל לא היו מוכרים מאירופה, ובהם דקרים, טריהדראלים, סכינים ובעיקר קופיצים. יתרה מזאת, נתברר כי האתרים האפריקאיים שגשגו משך זמן ארוך לעין שיעור מאתרי אירופה.

תופעה חשובה שנצפתה במהלך מחקרי התקופה האשלית באפריקה היא השימוש בנתזים גדולים ("נתז גדול" הוגדר על ידי Kleindienst {1962} כנתז העולה בגודלו המרבי על 10 סנטימטר) כבלנקס (blanks – בסיס לייצור כלים), לייצורם של קופיצים בעיקר. כיום, נהוג להשתמש במונח "כלי חיתוך גדול" (Large Cutting Tool - LCT) לתיאור כלי החיתוך האשליים המסותתים על שני פניהם. מושג זה יתורגם כאן ל"כלים דו-פניים", ויקיף טיפוסי כלים כגון אבני יד, קופיצים וסכינים). השימוש בנתזים גדולים לייצור כלים דו-פניים תואר כבר בראשית המאה העשרים בדרום אפריקה (Goodwin and van Riet Lowe 1929; Söhnge *et al.* 1937; van Riet Lowe 1945), ומאוחר יותר גם בחצי האי האיברי (Santonja and Villa 1990), בלבנט (Gilead 1970; Stekelis 1960) בהודו (Corvinus 1983b) ובאזורים אחרים, אשר בהם נפוצה התרבות האשלית. Isaac (1969), ובעקבותיו M. Leakey (1975), קבעו שהיכולת הטכנולוגית של הסתתים האשליים להפיק נתזים גדולים, ולהשתמש בהם כבסיס לייצור כלים דו-פניים, הייתה סף טכנולוגי, שחצץ בין סתתים אלה לבין קודמיהם, סתתי התקופה האולדובאית-המפותחת. למרות כל זאת, תופעה משמעותית זו טרם זכתה להתבוננות מקיפה, שבוודאי יש

ביכולתה לתרום להבנת התרבות האשלית כתופעה עולמית. עבודה זו, ניסתה למלא חלל זה, בהתייחסה לשאלות מרכזיות בחקר התרבות האנושית, אשר שלטה בעולם בפלייסטוקן הקדום והתיכון.

מכלול הכלים הדו-פניים מן האתר האשלי של גשר בנות יעקב הוא שעורר את שאלות המחקר העומדות בבסיסה של עבודה זו. המכלול מתייחד בשימוש אינטנסיבי בבזלת לייצור כלים דו-פניים, בנוכחות משמעותית של קופיצים ובהפקה של נתזים גדולים כחלק משמעותי בתהליך ייצור הכלים (Goren-Inbar *et al.* 2000; Goren-Inbar and Saragusti 1996; Goren-Inbar *et al.* 2002). למעט עובדייה (ר' בהמשך), רוב האתרים האשליים האחרים בארץ ישראל הכילו אבני יד שסותתו מצור כחומר הגלם הבלעדי, והציגו נוכחות אפסית של קופיצים במכלול (Bar-Yosef 1998; David Gilead 1970; Goren-Inbar 1995). כבר מראשיתו של המחקר באתר גשר בנות יעקב, אובחן כי מכלול כליו הוא בעל דמיון בולט למכלולים אפריקאיים, ואף צוין דמיונו לאתרים מחצי האי האיברי ומהודו (Goren-Inbar 1992; Goren-Inbar and Saragusti 1996; Sharon 2000; Stekelis 1960). עבודה זו מתמקדת בדמיון זה ובמשמעויותיו ולשם כך נבחנו השאלות המרכזיות הבאות:

1. האם ניתן להגדיר את האשלית המבוססת על שימוש בנתזים גדולים כשלב ייחודי במסגרת הטכנו-קומפלקס האשלי?
2. האם הדמיון, שאוזכר בין המכלולים, מקורו בזהות טכנולוגיות וטיפולוגיות בין הכלים המיוצגים בהם, או שמא מקורו בעיני המתבונן המודרני בלבד?
3. אם יתברר כי הדמיון בין המכלולים השונים הוא ממשי וניתן להגדרה, כיצד ניתן לאפיין אותו? מה הם הסממנים הטכנולוגיים, המורפולוגיים והטיפולוגיים המייחדים שלב זה בתרבות האשלית?
4. האם ניתן לתחום שלב תרבותי זה מן הבחינה הכרונולוגית מחד, ומהבחינה הגיאוגרפית מאידך?
5. מה הן ההשלכות שיש להגדרתו של שלב כזה בתוך האשלית, במהלך הפלייסטוקן הקדום והתיכון? מהי המשמעות שתרבות זו חלשה על פני שטח גיאוגרפי שהקיף את דרום אפריקה בדרום, אנגליה בצפון, ספרד במערב והודו במזרח?

חקר התעשיות האשליות המבוססות על נתזים גדולים נוגע גם ביכולותיו הטכנולוגיות וההתנהגותיות של האדם בתקופה זו. בחינת הכלים הדו-פניים, והגרעינים מהם הם יוצרו, יכולה לתרום לשחזור רמתם הטכנולוגית וכושר ההמצאה, אליהם הגיעו הסתתים האשליים, לבדיקת יכולתם להתאים את רצפי

ההפחתה של ייצור כלים אלה לאופיים הייחודי של חומרי הגלם ולצורה בה היו זמינים בסביבתם של האתרים, ועוד. מכלול הכלים הדו-פניים, שנחפר בגשר בנות יעקב, מספק הזדמנות ייחודית לחקור את השאלות הללו. מתודת החפירה בגשר בנות יעקב הייתה מודרנית ומדוקדקת, מאות אבני היד והקופיצים, שנחפרו משכבות האתר, מייצגים נאמנה אתר אשלי, אשר התבסס על טכנולוגיה מרכזית של הפקת נתזים גדולים. ובנוסף נערך באתר ניסוי בקנה מידה גדול, שהוקדש לסיתות מבוקר של כלים דו-פניים מנתזים גדולים של בזלת, אשר נאספה באזור (Madsen and Goren-Inbar 2004; Sharon 2000).

לשם השוואה עם אתר גשר בנות יעקב, נבחרו מכלולים מאתרים, אשר גם בהם התבססה טכנולוגית ייצור הכלים הדו-פניים על השימוש בנתזים גדולים. האתרים הנבחרים היו פרוסים על גבי שטח גיאוגרפי נרחב ככל שניתן, מתוך שאיפה לכסות את מלוא תפוצתה הגיאוגרפית של התרבות האשלית. אתרים אחדים, שבהם לא היה שימוש משמעותי בנתזים גדולים, נוספו למדגם זה כדי ליצור קבוצת ביקורת לבחינת התצפיות שהתקבלו. הרכב המכלולים, שנדגמו מכל אתר, מפורט בטבלה 1. האתרים, שנבחרו לדגימה, מפורטים בטבלה 2. שיטת עיבוד הממצאים התבססה על אנליזה רבת משתנים, שגובשה עבור עיבוד הממצא הליתי באתר גשר בנות יעקב (Goren-Inbar and Saragusti 1996). הנחות היסוד של הדיון כאן מבוססות על הגישה המחקרית הידועה בשם "רצף ההפחתה" (*Chaîne Opératoire*), על פיתוחיה בשנים האחרונות (Inizan *et al.* 1999; Roche and Texier 1995; Tixier and Roche 1992).

בעבודה זו, תופעת הנתזים הגדולים באשלית מוארת דרך שלושה פרקים מרכזיים, המתמקדים כל אחד בזווית אחרת של אנליזת המכלולים השונים. הראשון מבין פרקים אלה עוסק בטכנולוגיה של הפקת נתזים גדולים. השני סוקר את ההיבטים הטכנולוגיים של עיצוב כלים דו-פניים מנתזים גדולים, והשלישי סוקר את ההיבטים המורפולוגיים של כלים אלה ואת השלכותיהם על האמצעים לתיאור מכלולי כלים דו-פניים מן התקופה האשלית.

הפקת הנתזים הגדולים

שבע טכנולוגיות שונות להפקת נתזים גדולים מגרעיני ענק (Giant Cores) תוארו בפירוט בעבודה זו:

1. טכנולוגיה דו-פנית (Bifacial Core). הנתזים הגדולים הופקו לסירוגין משני פניו של הגרעין, תוך שימוש בצלקת, שנותרה מהסרת נתז הקודם, כשטח נקישה עבור הנתז הבא אחריו (Madsen and Goren-Inbar 2004).

2. הפקת נתזים מגרעין לוחי (Slab Core) על-ידי פריסתו ככיכר גבינה (איור 44). טכנולוגיה זו זוהתה במהלך עיבוד הכלים מן האתר Hunsgi, הודו (Paddayya 1979, 1982). היא ניצלה לוחות אבן גיר, שהיו זמינים באזור, ונחשפו בחפירות Isampur, אתר המחצבה האשלי (Paddayya *et al.* 2006; Petraglia *et al.* 1999). גרעינים שסותתו בטכנולוגיה דומה זוהו גם באתר גשר בנות יעקב. כאן, ניצלו הסתתים האשליים את לוחות הבזלת, שנוצרו בתהליך ההתגבשות האופייני של קילוחי הבזלת של רמת הגולן (Mor 1986; Sharon 2000).

3. נתז ראשוני מחלוק (Cobble Opening Flake/*éclat entame*). במסגרת שיטה זו, בחר הסתת בחלוק נחל גדול ושטוח והפיק ממנו נתז ראשוני, קורטיקאלי וגדול. אם הנתז הופק מהזווית המתאימה ומנקודת הנקישה הנכונה, צורתו דרשה אך מעט התאמה כדי לעצבו לאבן יד (ובמקרים נדירים יותר, לקופיץ). טכנולוגיה זו שימשה כמעט בכל אתר, בו היו זמינים חלוקי נחל בעלי גודל וצורה מתאימים. עם זאת, רק באתר אחד, Ternifine שבאלג'יריה, נצפה שימוש שיטתי במתודולוגית גרעין זו.

4. גרעיני קומבווה (Kombewa Core). טכנולוגיה זו הוגדרה לראשונה על-ידי Owen (1938) בקניה. בשיטה זו, הפיק הסתת נתז גדול מגרעין ענק. בשלב הבא שימש הנתז הגדול כגרעין להפקת נתז נוסף, קטן יותר, אך עדיין במימדים שהתאימו לעיצוב כלי דו-פני. נתזי קומבווה "קלאסיים" התאפיינו לכן בנוכחותם של שני פנים וונטראליים ושני שטחי נקישה. טכנולוגיה זו דווחה באתרים אשליים רבים (Alimen 1978; Dag and Goren-Inbar 2001; Dauvois 1981; Newcomer and Hivernel-Guerre 1974). במסגרת המחקר הנוכחי, נתברר כי שימוש תכוף ושיטתי בטכנולוגיית קומבווה בלט בשניים מן האתרים שנדגמו: גשר בנות יעקב ו Ternifine. בשאר האתרים, השימוש בנתזי קומבווה לייצור כלים דו-פניים היה אקראי. מן הראוי לציין כי ניתן לצפות שכמות מסוימת של נתזי קומבווה תהיה נוכחת כמעט בכל אתר בו הופקו נתזים גדולים (Dag and Goren-Inbar 2001).

5. ויקטוריה ווסט (Victoria West) – טכנולוגיית גרעין זו זוהתה על-ידי Jansen (1926) באתר ליד העיר ויקטוריה ווסט בדרום אפריקה. ההיסטוריה של המחקר ועיקרי הטכנולוגיה סוכמו לאחרונה על-ידי Sharon and Beaumont (2006). בטכנולוגיה זו, שהיא מן המתוחכמות שנצפו בתרבות האשלית, עיצב הסתת את הגרעין ככלי דו-פני גס, שאחד מפניו ייצג את שטח ההסרה (debitage face), והשני את שטח הנקישה (striking platform preparation face) – על פי המונחים שהגדיר Boëda (1995). בשלב הבא, הוסר נתז יחיד, שצורתו עוצבה מראש על הגרעין לפני הסרתו. עם התזתו, הוסר חלק מן הגרעין המקורי (tip), וכך (מגרעין קטן באופן יחסי) נוצר נתז גדול דיו להפקת כלי דו-פני (איור 68). כך הגיעו הסתתים האשליים לפסגת יכולתם לקבוע מראש את צורתו של הנתז. רובם המכריע של נתזי ויקטוריה ווסט שימש לעיצובם של קופיצים. תפוצתה הגיאוגרפית של טכנולוגיה זו הייתה מוגבלת מאוד, ולא חרגה מעבר למרכז-דרום אפריקה.

6. Tabelbala Tachenghit – טכנולוגיה זו מוכרת ממדבר סהרה המערבי במרוקו, ונראה כי הייתה מוגבלת מאוד בתפוצתה הגיאוגרפית (Alimen 1978; Champault 1951; Tixier 1956). במסגרת העבודה הנוכחית, נדגם מספר קטן של פריטי אבן, שיוצרו בטכנולוגיה זו (כלים דו-פניים וגרעינים כאחד), ולכן יש בידינו תצפיות כלליות בלבד. טכנולוגיה זו דומה בעיקרה לטכנולוגיה של ויקטוריה ווסט - עם מספר הבדלים. ההבדל המשמעותי ביותר הוא שיטת עיצוב שטח הנקישה, אשר בשיטת Tabelbala Tachenghit בודד על-ידי הסתת כדי להבטיח שיוסר מנקודה מדויקת אחידה, וייצור את שטח הנקישה האופייני (איור 89).

7. טכנולוגיית לבלואה (Levallois) – מינוח זה משמש לעיתים בספרות כדי לכלול את כל הגרעינים האשליים עם שטחי הנקישה שהוכנו מראש (prepared cores). לעיתים, ניתן להיתקל במונח "פרוטו-לבלואה" לתיאור גרעינים אשליים. עצם הגדרתה הטכנולוגית של מתודת גרעין זו אינה מוסכמת על כל החוקרים, ודעות רבות הובאו בספרות (לדיון בחלק מן הדעות, ראה: Dibble and Bar-Yosef 1995; Inizan *et al.* 1999). בעבודה זו, עדויות לשימוש במתודת לבלואה באשלית נבחנו לאור קריטריונים שהציב Boëda (1995). רבים מבין הגרעינים שנחקרו עמדו בקריטריונים הללו. עם זאת, הפקת הנתזים הגדולים הייתה כרוכה במאפיינים טכנולוגיים ייחודיים, שאינם ישימים

ביצורם של נתזים קטנים מגרעיני לבלואה נוסח הפליאולית התיכון. הבולט בהבדלים אלה הוא השימוש התכוף בשטחי נקישה גדולים ופשוטים (חלקים) להסרת הנתזים הגדולים.

בנוסף לשבע שיטות הגרעין הנמנות לעיל, מתוארות בספרות מתודות נוספות, שנסקרו כאן בקצרה. ביניהן: Chirki Cleaver Core, כפי שהוגדרו על ידי Corvinus (1983), ומתודת Kerzaz Core, שתוארה על ידי Alimen (1978). שיטה נוספת להפקת בלנקס לייצור כלים דו-פניים (ובעיקר אבני יד) הייתה השימוש בחלוקים שטוחים או בלוחות (slabs) של חומרי גלם זמינים. מתודה זו שימשה אמנם ברובם של האתרים שנחקרו כאן, אך רק במיעוט זניח של המקרים, ובדרך כלל כניצול מציאה מזדמנת של חלוק ההולם בצורתו את הצרכים.

כל טכנולוגיות הפקת הנתזים הגדולים שתוארו לעיל נמצאו יעילות מאוד מבחינת תפוקתן. ניסויים בסיתות מבוקר הוכיחו כי בפחות מעשרים דקות, הייתה ביכולתו של סתת מנוסה להפיק מבולדר של חומר גלם, במשקל של כשלושים קילוגרם, קרוב לעשרים בלנקס המתאימים לייצור כלים דו-פניים (Jones 1994; Madsen and Goren-Inbar 2004; Toth 2001).

מתודות הגרעין השונות, המתוארות בעבודה זו, מסוכמות בטבלה 20. ברוב האתרים שימשו כמה טכנולוגיות זו לצד זו, אך גם בלטה ההעדפה למתודת גרעין אחת. בחלק מן האתרים ניתן לייחס העדפה זו לצורתו ולגודלו של חומר הגלם הזמין (למשל, החלוקים של נתזי הפתיחה ב Ternifine, או הלוחות באתר של Hunsgi). במקרים אחרים, טכנולוגיית הגרעין עיצבה את חומר הגלם במידה כזו, שנטלה את משמעות צורתו המקורית (למשל במתודת ויקטוריה ווסט).

השימוש בנתזים גדולים בתרבות האשלית

טבלאות 28 – 29 ואיורים 90 – 91 מדגימים את שכיחות השימוש בנתזים גדולים כבלנקס לייצורם של הכלים הדו-פניים באתרים שנדגמו. מן המידע עולות הנקודות הבאות:

קופיצים ואבני יד נבדלים משמעותית זה מזה בסוגי הבלנקס ששימשו לייצורם. קופיצים יוצרו על נתזים, (עובדה התומכת בהכללת "נתזיותם" בעצם הגדרתם). מתוך 1044 הקופיצים, שנכללו במחקר, רק 6 (0.6%) יוצרו בוודאות על חלוק. התמונה המתקבלת מאבני היד מורכבת בהרבה. אחוז גבוה של אבני היד מכוסה לחלוטין בשברור, כך שלא ניתן לקבוע את סוג הבלנק ששימש לייצורן (indeterminate). עם זאת, המידע שבידינו מורה כי נתזים שימשו כבלנקס לייצורן של אבני יד **בכל** המכלולים שנחקרו.

אחוז השימוש הגבוהה ביותר בנתזים נצפה במכלול גשר בנות יעקב (72%). שכיחות הנתזים הגדולים במרבית האתרים נעה סביב 60%, אך, גם באתרים, שבהם טכנולוגיית הפקת הבלנקס לא הייתה מבוססת על נתזים גדולים, השימוש בנתזים היה משמעותי (טבלה 29). ראוי לציין כי בלנק מתאים לייצור כלי דו-פני היה צריך לעמוד בטווח מוגבל של דרישות מבחינת צורתו, גודלו ואיכות חומר הגלם שלו. ייצורם של כלים דו-פניים מחלוקי נחל או מלוחות טבעיים דרש זמינות של מקורות עשירים של חומרי גלם מסוגים אלה, הנדירים בחלקים רבים של העולם. הפקת נתזים גדולים ממגוון גדול של צורות וסוגי סלעים שיחרר את הסתתים האשליים מתלות גיאוגרפית במקורות של חומרי גלם, ותרם רבות ליכולתם להרחיב את תפוצתם לסביבות חדשות ומגוונות.

הטכנולוגיה של סיתות כלים דו-פניים מנתזים גדולים

דיון זה התמקד בשלושה היבטים: א. שכיחות חומרי הגלם, שישמשו בייצור הכלים הדו-פניים, והשפעת תכונותיהם על גודלם וצורתם של הכלים. ב. ממדיהם של הכלים הדו-פניים במכלולים שנדגמו, ומשמעותם של ההבדלים ביניהם. ג. טכנולוגיות הסיתות ששימשו את הסתתים האשליים.

חומרי הגלם

טבלאות 30, 31 ואיורים 93, 94 מסכמים את שכיחות השימוש בחומרי גלם לייצור הכלים הדו-פניים באתרים שנדגמו. התוצאות מראות כי סוגי סלעים רבים ושונים שימשו בייצורם של כלים אלה. אם מתייחסים למרחב הגיאוגרפי העצום שמכלולים אלה מייצגים, ניתן היה לצפות מגוון זה. מחד, ברור כי הסתתים האשליים השכילו לנצל את חומרי הגלם שהיו זמינים בקרבת אתריהם. מאידך, מן הנתונים עולה כי ברובם של האתרים, השתמשו הסתתים ביותר מסוג אחד של חומר גלם (בדרך כלל שניים מרכזיים), למרות שבכולם נצפה שימוש חומר אחד שזכה לשימוש מוגבר. ההעדפה של חומר גלם מסוים על משנהו לא הייתה תלויה רק בזמינותו הגיאוגרפית של חומר זה. נמצא כי מכלולים מאתרים, אשר שכנו בסביבה זהה, מציגים העדפה לחומרי גלם שונים. כך, למשל, הועדפה הבזלת בגשר בנות יעקב, בעוד שבמעיין ברוך, צור היה בשימוש כמעט בלעדי. דוגמה אחרת היא המגוון העצום של חומרי הגלם, ששימש את הסתתים בעמקי Baichbal ו- Hunsgi בהודו לייצורם של כלים דו-פניים.

נבחנה האפשרות כי "איכות הסיתות" של חומר גלם נתון יכולה לספק הסבר לשכיחותו במכלול מסוים. נמצא כי לסתתים האשליים הייתה העדפה לחומרים גסי-גרגר (=בעלי גבישים גדולים כגון: בזלת, גרניט

ושאר חומרים וולקניים ומטאמורפיים) על פני חומרים דקי-גרגר (=בעלי גבישים קטנים: צור, אובסידיאן, ציפחה וכיו"ב) בהפקת הנתזים הגדולים. כך, למשל, הועדפו בזלת על פני צור בגשר בנות יעקב, אנדזיט על פני צפחה (Hornfels) באתרי נהר ה Vaal בדרום אפריקה וסוגי לבה שונים על פני אובסידיאן באתרים אשליים בקווקז. זאת ועוד, הוכח כי הנתזים הגדולים ביותר, שמקורם מן האתר של Isimila, עוצבו בחלקם הגדול מגרניט. הדבר מפתיע מעט, שכן לעינינו המודרניות, סלעים הומוגניים, מחומר בעל גבישים קטנים, נתפשים כקלים יותר לשליטה בשעת הסיתות. כאשר נבחן המתאם בין סוגי חומרי הגלם לבין גודלם של הכלים, לא ניתן היה להצביע על קשר בין השניים. כל הכלים נמצאו שייכים לטווח גדלים דומה.

גודלם של הכלים הדו-פניים

אורך והיקף (איורים 102-105) מייצגים את ממדיהם המרביים של הכלים הדו-פניים מכל רחבי התפוצה הגיאוגרפית של התרבות האשלית. נראה כי רובם המכריע של הכלים הדו-פניים שנדגמו נמצא בטווח גדלים מצומצם ביותר, הנע בין 10 ל-20 ס"מ במימד האורך שלהם. הנתונים מראים כי ניתן אף למקד ערכים אלה שכן למעלה מ-50% מן הכלים נצפים בטווח שבין 13 ל-17 ס"מ (טבלה 32). בין המכלולים ניכרים הבדלים, אך הדמיון ביניהם, לא השוני, הוא הראוי לתשומת לב. מכלול אבני היד מאתר מערת טאבון מדגים היטב את הנקודה הזו: אבני יד אלה קטנות באופן משמעותי מכלים אשליים אחרים, ושונותן בולטת גם בטכנולוגיית הייצור שלהן ובמגוון טיפוסיהן (David Gilead 1970; Gisis and Ronen 2006; Matskevich 2006). מקורן בשכבות של האשלית הסופית, ובאשלו-יברודית, ולכן חריגותן משאר המכלולים שהודגמו מדגישה את הדמיון בין אלה האחרונים .

הטכנולוגיה של עיצוב כלים דו-פניים מנתזים גדולים

מספר הצלקות, שתועד על הכלים הדו-פניים במכלולים שנדגמו, משתנה מאוד בין אתר לאתר (איור 115). גודלם של הכלים לא היה גורם משמעותי בקביעת כמות הצלקות. ההבדלים במספריהן נבחנו בעבודה זו מכמה היבטים: ראשית, נבחן ההבדל בין הקופיצים ובין אבני היד מבחינת מספר הצלקות הכולל שלהם. נמצא כי לאבני היד מספר צלקות רב יותר, המעיד על עיבוד אינטנסיבי במהלך שלב העיצוב (Shaping). בדיקה של מספר הצלקות על פניהם (דורסאלי וונטראלי – איור 117) של הכלים השונים העלתה כי על גבי הפן הונטראלי של הקופיצים, השברור היה מזערי, בעוד שעל אבני היד,

השברור היה מוגבר יותר. רוב שטחו של הפן הונטראלי של אבני היד היה מסותת בדרך כלל, ואילו על גבי הקופיצים, חלקו הקטן של פן זה סותת באמצעות מספר נמוך של צלקות (איורים 119, 120). דיקוק גבשושית הנקישה (המהווה בדרך כלל את חלקו העבה ביותר של הנתז המשמש כבלנק), באמצעות מספר הסרות מועט, הוא העיקרון שהנחה את הסתתים האשליים בבואם לעצב קופיץ מנתז גדול (Goren-Inbar and Saragusti 1996).

בחלק מן המכלולים, נצפו כלים בעלי מספר צלקות, שהיה נמוך מן המצופה גם ביחס לממדי הכלי עצמו, וגם ובהשוואה למכלולים מאתרים סמוכים. דוגמה בולטת מקורה באתר Isimila K-19, המתאפיין במספר צלקות קטן במיוחד, ביחס לאתרי Isimila האחרים. דוגמאות נוספות מקורן באתרים כגון Doornlaagte בדרום אפריקה, והאתר של מחצבת STIC במרוקו. קיים מתאם בין ספירת הצלקות הנמוכה באתרים אלה, לבין נתוני העובי הגבוהים של כליהם, תצפית המיוחסת להיפותזה שאתרים אלה נושאים אופי של סדנאות ייצור (ראה להלן).

מיקומו ואופיו של הקצה הפעיל של הכלים הדו-פניים נחקר אף הוא, ונתגלה כי בקופיצים הוא כמעט לעולם לא עוצב בשברור. רוב הקצוות הפעילים של הקופיצים נוצרו מהמפגש בין הפן הונטראלי של הכלי, לבין צלקת גדולה, שעוצבה על חלקו הדיסטאלי של הפן הדורסאלי עוד על הגרעין הגדול - טרם הסרת הנתז ששימש כבלנק לקופיץ.

אתרי סדנאות (Workshops)

האתרים המשתייכים לקבוצה זו (Isimila K-19, STIK, Doornlaagte), מכילים כלים המתאפיינים בעובי רב ומפגינים סממנים טכנולוגיים של "איכות ייצור" ירודה יחסית, הווה אומר, מספר נמוך של צלקות, צלקות עמוקות וגסות באופן יחסי, קצה פעיל קצר ביחס להיקף הכלי, ועוד. בנוסף, מכלולי אתרים אלה מתאפיינים בריבוי נתזים גדולים, שאינם מראים סימני סיתות, ונתזי סיתות קטנים, שמקורם בתהליך הסיתות הדו-פני. חלקם הגדול של הכלים הדו-פניים באתרים אלה עונה על ההגדרה "כלי בלתי גמור" (pre-form). יחד עם זאת, בהשוואה לאתרים אחרים באזוריהם, אסטרטגיות ניצול חומרי הגלם באתרי הסדנאות - הן מן הבחינה הטכנולוגית והן מן הבחינה הטיפולוגית- דומות עד מאוד. סביר, אם כן, להניח כי בסדנאות אלה, יוצרו כלים דו-פניים מנתזים גדולים ש"יוצאו" לשימוש באתרים אחרים. השרידים, שנותרו בסדנאות, היו תוצרי הסיתות (גרעינים גדולים, נתזי סיתות דו-פניים ונתזים גדולים

בלתי מנוצלים) וכלים שננטשו לפני שבאו לידי גימור. אילולא הדמיון הטכנולוגי והטיפולוגי הרב בין אתרי הסדנא לבין שכניהם, ניתן היה לפרש את אופיים הגס של חלק מן הכלים כעדות להיותם "פרימיטיביים" או קדומים.

המורפולוגיה של הכלים הדו-פניים

בעבר, הוצעו שיטות טיפולוגיות שונות למחקר הכלים הדו-פניים. בולטות ביניהן שיטת Bordes (1961) למיון הכלים הדו-פניים מאירופה; שיטת Kleindienst (1962) למיון מכלולים מן האשלית המאוחרת של מזרח אפריקה; ושיטתו של Tixier (1965) למיון הקופיצים מאתרי צפון אפריקה. בחלקים רבים של העולם, שיטות אלו - במיוחד שיטת בורד - ממשיכות לשמש ככלי טיפולוגי עיקרי לסיווג כלים דו-פניים. במקביל, פותחו גישות נוספות, הכוללות את שיטת Roe (1964, 1968) שנוצרה לתיאור אבני היד של בריטניה, שיטה שהורחבה אחר כך כדי להקיף את מכלולי הכלים הדו-פניים (בעיקר הקופיצים) מאפריקה (Roe 1994, 2001).

לאחרונה, דנו Adams and Adams (1991) בגישות הטיפולוגיות השונות המשמשות במחקר הארכיאולוגי, והדגימו כי כל שיטת מיון טיפולוגית היא לגיטימית, כל עוד היא משרתת את המטרה לשמה נוצרה. מה היא אם כן תרומתה של הטיפולוגיה במחקר הכלים הדו-פניים העשויים על נתזים גדולים.

המורפולוגיה של אבני היד

כיום, רווחת במחקר אבני היד הדעה, כי כלים אלה מראים שונות מורפולוגית רבה, הן בתוך אותו מכלול עצמו, והן ביחס למכלולים אחרים. איורים 135 – 141 מציגים את צורתן של כל אבני היד השלמות, שנדגמו מן המכלולים, במטרה לבחון הנחה מקובלת זו. מבחינת האיורים נראה כי הרוב המוחלט של אבני היד המוצגות כאן, הן בעלות צורת "טיפה", וכי ניתן לכלול אותן בטווח הצורות המיוצג באיור 142. זאת ועוד, אבני יד מעוגלות או סגלגלות נדירות מאוד באתרים שנדגמו, למעט באתר של מעיין ברוך. גם כאשר הייתה סטייה מצורת הטיפה המקובלת, היא לא הגיעה לכלל מורפולוגיה שונה במהותה, אלא נשלמה בעיצוב פחות שיטתי ומדויק של אותה הצורה עצמה. כל זאת למרות שצורות כגון משולש, עיגול, מרובע, חצי סהר ורבות אחרות יכלו אף הן לענות על הדרישה לקצה פעיל שימושי ויעיל. העובדה שהסתתים האשליים הגבילו את עצמם למגוון כה קטן של צורות מורה שהללו נתפסו בעיניהם כמתאימות ביותר ליצירת אבני היד. Jones (1994) הדגים שבחירה זו נבעה מן הרצון של הסתתים האשלים להגיע

לניצול מרבי של אורך הקצה הפעיל של הכלי ביחס למסתו, תוך התחשבות במגבלות הסיתות. התמונה העולה מהצגת צלליתן של כל האבני היד שנדגמו יחדיו היא כי השונות המורפולוגית בתוך ובין מכלולי האשלית המבוססת על נתזים גדולים היא מינימאלית ולכן אין הצדקה לחלוקתן לטיפוסים טיפולוגיים נוסח Bordes או Kleindienst.

במכלולים מן האשלית הסופית, או מן התרבות המיקוקית של אירופה, השונות המורפולוגיות הרבה שבין אבני היד, הבאה לידי ביטוי במגוון הרחב של הטיפוסים המיוצגים בהן (אבני יד מיקוקיות, סכינים, אבני יד משולשות, אבני יד עגולות ועוד) מדגישה את האחידות הצורנית באשלית המבוססת על נתזים גדולים. ייתכן כי ניתן לייחס משמעות כרונולוגית לעליה זו בשונות הטיפולוגית/מורפולוגית, ולטעון כי היא מאפיינת מכלולים אשליים סופיים.

המורפולוגיה של הקופיצים

איורים 148 – 151 מציגים זה לצד זה את כל הקופיצים השלמים ממבחר האתרים שנדגמו. בניגוד לאבני היד, הקופיצים שוברו פחות בשלב עיצובם, ועל כן מאפשרים תצפיות מפורטות על הטכנולוגיה ששימשה לייצורם, ועל דרכי ביטוייה במורפולוגיה שלהם. שני גורמים עיקריים השפיעו על המורפולוגיה של הקופיץ: מתודת הגרעין ששימשה בייצורו, ואסטרטגיית בחירת הבלנק שהיה הבסיס להפיכתו לקופיץ. לדוגמא, הקופיצים מאתרי נהר ה Vaal עוצבו ברובם בטכנולוגיה של ויקטוריה ווסט, ששיוותה להם בסיסים מחודדים המעוצבים בשברור זקוף, וקצוות פעילים רחבים וקמורים (Sharon and Beaumont 2006).

עם זאת, צורתו של הנתז שנבחר לשמש כבלנק היוותה אף היא גורם משמעותי שהכתיב את צורתם של חלק ניכר מן הקופיצים. נתזי הבלנקס הוסרו במגוון רחב יחסית של צורות, ומתוכן בחר הסתת את הצורות שנראו בעיניו כעונות על הדרישות (מבחינת גודלן וצורתן, ומבחינת אורכו ואיכותו של הקצה הפעיל) להפוך לקופיצים. גם אם נמצא שצורתו של בלנק לא הלמה את זו של הקופיץ ה"קלאסי", היותו בעל קצה פעיל ארוך ואיכותי הכריעה את הכף לטובת הפיכתו לקופיץ. נתזים בעלי קצה פעיל מתרחב, מתחדד, נטוי (דמוי גיליוטינה) ודומים להם לא נדחו על הסף, והם נוכחים במכלולים רבים.

ניתן לחתום את הדיון במורפולוגיה של הקופיצים, בניסיון לענות על השאלה מה היא הצורה "הקלאסית" של קופיץ אליה שאפו הסתתים האשליים. מכלול הקופיצים מן האתר של Isimila K-14 כולל קופיצים

רבים, המתייחדים בעבודה הרבה שהושקעה בעיצובם. סתתי הקופיצים באתר זה היו בעלי מיומנות טכנולוגית גבוהה ביותר, ועיצבו את צורתם של הקופיצים תוך שליטה מלאה בכל ההיבטים המורפולוגיים של הכלים (איור 156). ניתן אם כן לטעון כי מגוון הצורות הבא לידי ביטוי בקופיצים מאתר זה מייצג את הצורות האופטימאליות שאליהן שאפו הסתתים, או את הדגם המחשבתי (mental template) של ה"קופיץ המושלם", שאליו היה התוצר הסופי צריך להידמות.

המורפולוגיה של הכלים הדו-פניים – דיכוטומיה של קצה פעיל

כפי שהודגם לעיל, ניתן לאשש את החלוקה המורפולוגית של Isaac (1977), הקובעת כי הכלים הדו-פניים מאתרים אפריקאיים (או, במקרה שלנו, מאתרים המבוססים על נתזים גדולים) משתייכים לשתי קבוצות צורניות בלבד: אבני יד וקופיצים. לעומתו הגדיר Roe (1968) שתי קבוצות של מכלולים מאתרי הפליאולית התחתון באנגליה, על סמך צורות אבני היד שנמצאו בהם: הקבוצה המחודדת והקבוצה המעוגלת. איור 159 מציג מודל המסביר את השונות הצורנית הזאת, ומסתמך על ההנחה כי שתי צורות עיקריות של קצה פעיל היו נדרשו לשימוש בידי האשלים, האחת מחודדת (שעוצבה בד"כ בשברור), והשנייה רחבה, דקה וחדה (קצה קופיצי). כל הכלים הדו-פניים מתאפיינים בבסיס מעוגל. קצה פעיל מחודד, בצירוף בסיס מעוגל, יצרו יחדיו אבן יד דמוית טיפה. קצה ישר ורחב, בצירוף בסיס מעוגל, יצרו יחדיו את הצורה הקופיצית. באתרים בהם לא סותתו קופיצים, יוצרו אבני יד רחבות ומעוגלות כמענה טכנולוגי לצורך בקצה פעיל רחב. בחלק מהאתרים הללו נוצר צורך בקצה פעיל רחב חד ודק כאחד. לשם כך, הסירו הסתתים האשליים נתז בהתזה רוחבית אופיינית (tranchet), אשר העניקה לאבן היד הרחבה קצה פעיל דמוי זה של הקופיץ (Matskevich 2006; Roberts and Parfitt 1999; Rollefson *et al.* 2005; White 2006).

המודל שהוצג לעיל מאפשר לנו להניח כי במכלולים עשירים בקופיצים נצפה למיעוט של אבני יד מעוגלות ורחבות (איורים 135 – 141). אתר בולט בו נפוצו אבני היד העגולות, הוא מעיין ברוך, אתר שלא התבסס על טכנולוגיית נתזים גדולים, וקופיצים נמצאו בו בכמויות זניחות. גם מערת טאבון, אשר אף היא לא הייתה מבוססת על נתזים גדולים, הראתה שכיחות גבוהה של אבני יד רחבות (ראה דיאגראמת הצורות של Roe – איור 161).

דיון ומסקנות

הגדרתה של האשלית המבוססת על נתזים גדולים (Large Flake Based [LFB] Acheulian)

נראה כי ניתן להגדיר את האשלית המבוססת על ייצורם של נתזים גדולים (LFB Acheulian) כשלב נפרד ברצף התרבותי האשלי. הקריטריונים הבאים מאפיינים את המכלולים המשתייכים לשלב תרבותי זה:

1. באתרי ה-LFB, הטכנולוגיה העיקרית, ששימשה להפקתם של בלנקס לעיצוב כלים דו-פניים, הייתה הסרתם של נתזים גדולים מגרעיני ענק. טכנולוגיות הפקה אחרות היו זניחות.
2. בכל אתרי ה- LFB הופגנו בקרה ושליטה טובים על חומר הגלם המסותת. טכנולוגיות גרעין מגוונות, מתוחכמות ויעילות שמשו להפקת הנתזים - במקרים רבים יותר ממתודה אחת לאתר.
3. באתרי ה-LFB ניתן לראות בברור שהסתתים העדיפו חומרי גלם גסי-גרגר (בזלת, סלעים מטמורפיים ודומיהם) על פני חומרי גלם דקי-גרגר (צור, אובסידיאן ודומיהם). העדפה זו לא נבעה ממידת זמינותו של חומר גלם נתון בקרבת האתר.
4. בהתבסס על מחקרי האשלית באפריקה, הגדירה Kleindienst (1962) "נתז גדול" כנתז, אשר ממדיו עולים על 10 סנטימטרים - הגדרה שאוששה על-ידי מחקר זה.
5. אלמנט עיקרי בעיצובם של מרבית הכלים הדו-פניים במכלולי ה-LFB היה שברור מינימלי של הפן הונטראלי לצורך הפחתת עובייה של גבשושית הנקישה (האזור העבה ביותר ברובם של הנתזים).
6. באתרים אשליים מטיפוס LFB תהיה תמיד נוכחות משמעותית של קופיצים "אמיתיים" (העשויים על נתז, ובעלי קצה פעיל שאינו מעוצב בשברור). באתרים אשליים שאינם נמנים על שלב זה, לא יעלה אחוזם של הקופיצים על אחוז אחד מן הכלים הדו-פניים.
7. במכלולי ה-LFB, העשירים בקופיצים, יהיו נדירות אבני היד העגולות ורחבות הקצה הפעיל. כך עולה ממודל הדיכוטומיה של הקצה הפעיל, שהוצג לעיל.

תפוצתם הגיאוגרפית והכרונולוגיה של אתרי האשלית המבוססת על נתזים גדולים (LFB)

עקב הרזולוציה הנמוכה של המידע הארכיאולוגי, ובעטיו של המחסור בכרונולוגיה אבסולוטית ומהימנה עבור רוב האתרים האשליים בעולם, יכולתנו לדון בנושאי התפוצה הגיאוגרפית ובכרונולוגיה של תרבות זו מוגבלת. כאן אנסה להציג סכמה כללית, אשר מאגדת את המידע הזמין מתוצאותיו של מחקר זה:

ניתן להגדיר שלב תרבותי הקרוי אשלית קדומה. אתרי האשלית הקדומה (הקודמת לתעשיות הנתזים הגדולים) ניתנים לזיהוי באפריקה ובלבנט, והם מתאפיינים בכלים דו-פניים, שכוללים אבני יד גסות וגדולות, פיקים וטריהדראלים. כמו כן, נושאים הכלים מעט צלקות עמוקות, ועיצובם גס ביחס לכלים מאוחרים יותר. בין האתרים מתקופה זו, אשר מתוארכים לגיל עתיק יותר ממיליון שנים לפני זמננו, ניתן למנות את עובדייה, ישראל (Bar Yosef and Goren-Inbar 1993), Konso Gardula, אתיופיה (Asfaw *et al.* 1992), Sterkfontein Cave, דרום אפריקה (Kuman and Clark 2000), Thomas Quarry 1, מרוקו (Raynal *et al.* 2001) ואתרים נוספים במזרח אפריקה (Isaac 1997; Roche 1995).

בשלב השני, הופיעה התרבות האשלית המבוססת על הנתזים הגדולים (LFB). אתריה הקדומים ביותר נתגלו במזרח אפריקה (Gowlett 1980; Isaac 1977; Leakey and Roe 1994). החל מתקופה זו, ועד לשלבים הסופיים של האשלית, אפיינה תרבות ליתית זו חלק גדול מן האתרים האשליים באפריקה דרומית לסהרה. האתרים האשליים המאוחרים של Kalambo Falls (Clark 2001) ו- Isimila (Howell *et al.* 1962) ללא ספק שייכים לשלב תרבותי זה. גם באתרים אשליים בספרד ובפורטוגל היה שימוש בנתזים גדולים, וניכר דמיון טיפו-טכנולוגי בין אתרים אלה לבין האתרים הצפון אפריקאיים, שנחקרו כאן. זמינות המידע הכרונולוגי עבור אזורים אלה הוא חלקי ביותר, ומקשה על בנייתו של רצף תרבותי מבוסס.

בלבנט, אתר גשר בנות יעקב (תאריך: שלבים איזוטופיים ימיים 18-20) הוא אתר יחידאי, שמייצג את האשלית מטיפוס LFB ומספק נקודת אחיזה לכל דיון בתפוצתה הגיאוגרפית ובכרונולוגיה של תרבות זו מחוץ לגבולות אפריקה. כל האתרים האשליים האחרים באזור שייכים בבירור לאשלית המאוחרת, אשר סממניה היו: שימוש בלעדי בצור כחומר גלם, והיעדרותם של קופיצים. בנוסף, עוצבו שני פני אבני היד בשברור אינטנסיבי. הדוגמאות מתרבות זו, שנחקרו כאן (מעיין ברוך וטאבון), אף הראו שכיחות גבוהה של אבני יד אובליות, בהתאם למודל הדיכוטומיה של הקצה הפעיל.

אתרים אשליים מטיפוס LFB דווחו בקווקז (Lioubine 1998), ונוכחותם מתועדת היטב בהודו ובנפאל (Petraglia 2006). המידע לוקה בחסר, ומגביל את יכולתנו לדון במשמעותה הכרונולוגית של תפוצה גיאוגרפית זו.

תעשיות אשליות מטיפוס LFB נעדרות לחלוטין מאירופה שמעבר להרי הפירנאים. נראה כי התעשיות האשליות של אירופה המערבית שייכות כולן לשלבים המאוחרים של התרבות האשלית. העדויות מראות כי תאריכן הקדום ביותר הוא כחצי מליון שנה לפני זמננו. הן התבססו על צור כחומר הגלם העיקרי לייצורם של אבני היד, קופיצים נעדרים מהן כמעט לחלוטין ונתזים גדולים אינם גורם עיקרי בהפקת הבלנקס בהן.

התמונה הכללית שניתן לשרטט עבור העולם האשלי היא כדלהלן: באפריקה, דרומית לסהרה, נשלטה האשלית עד סופה על-ידי תעשיות הנתזים הגדולים. בלבנט, וייתכן שגם בצפון אפריקה, הוחלפו התעשיות האשליות מטיפוס LFB באשלית המאוחרת, שנטשה את הפקת הנתזים הגדולים וייצור הקופיצים. עם זאת, מרכיבים רבים, כגון ייצור אבני היד, ששמרו על גודלן ועל צורתן, נשתמרו. נשאי התרבות האשלית, שכבשו את אירופה שמעבר לפירנאים, הביאו עימם תרבות אשלית מאוחרת, השונה מהאשלית מטיפוס LFB. תרבות זו התבססה באנגליה כבר כחצי מליון שנים לפני זמננו (Roberts and Parfitt 1999). את זמנו של חילוף תרבותי זה ניתן להציע בהסתמך על שני יתדות כרונולוגיים. מחד, השינוי מאוחר לתאריכו של אתר גשר בנות יעקב (600 אלף שנה באתר של NBA-GBY), ומאידך, תרבות זו הייתה מבוססת היטב בבריטניה כבר לפני כחצי מליון שנה (תמונה 168).

הערכת היכולות הטכנולוגיות בתרבות האשלית

טכנולוגיית ייצורם של הכלים הדו-פניים משמשת אומדן בידי החוקרים להערכת היכולות השכליות של הסתתים האשליים, ולהגדרת המאפיינים התרבותיים של התקופה. רמתם הקוגנטיבית של בני התקופה, והשלכותיה על האבולוציה של האדם, הם נושאים מרכזיים במחקר כיום. חלק זה של הדיון יוקדש להערכת היכולות הטכנולוגיות של האשליים, על סמך תוצאות מחקר זה .

אסטרטגיות ניצול של חומרי גלם

איכותם, צורתם וזמינותם של חומרי הגלם באתרים השונים לא הגבילו את הסתתים האשליים. כמו כן, הם לא סבלו ממחסומים טכנולוגיים, או ממחסור בידע, ביכולת, או בכושר המצאה. הם התאימו את מתודת סיתות הגרעינים הגדולים לצורה ולגודל של חומרי הגלם, אשר היו בנמצא בכל אתר ואתר. היכולת לייצר נתזים גדולים ממגוון גדול של צורות, איכויות וגדלים של חומרי גלם הייתה ללא ספק גורם משמעותי בהתפשטותם של הסתתים האשליים על פני טווח גיאוגרפי נרחב ביותר.

טכנולוגיית הגרעינים הגדולים

העקרונות הטכנולוגיים של שבע מתודות הגרעין השונות, שתוארו בפירוט לעיל, שונים מהותית זה מזה, אך כולם אפשרו לייצר מספר גדול של בלנקס, תוך זמן קצר ובהשקעה מועטת של עבודה. הדבר נותן הסבר חלקי למספר העצום של הכלים הדו-פניים, שנמצאו בחלק מן האתרים האשליים. ברוב האתרים נצפה שימוש בו-זמני ביותר ממתודת גרעין אחת. באתר גשר בנות יעקב, למשל, שימשו חמש מתודות יחדיו (טבלה 20). טכנולוגיות הגרעין האשליות אפשרו שליטה מראש בצורתו של הנתז המופק. ניתן למצוא בהן את ניצני המתודות, שהפכו למרכזיות ברצף הארכיאולוגיה העולמית, במיוחד את ראשיתה של טכניקת לבלואה, שאפיינה את תקופת הפליאולית התיכון.

אסטרטגיות בחירת הבלנק

בחירת הבלנק המתאים מתוך המצאי, שעמד לרשותו של הסתת, הבטיחה שצורתו של הכלי הסופי תהיה מתאימה ופונקציונאלית ככל האפשר, ללא השקעה מוגזמת של עבודה וזמן. עדות אחת לבחירת הבלנקס נצפתה במחקר כיווני ההתזה של הנתזים הגדולים. הוכח כי באתרים שונים, היו לסתתים העדפות מיוחדות לגבי הכיוון שממנו הותזו הנתזים. בחלק מן האתרים השקיעו הסתתים אנרגיה רבה בתכנון צורתו הסופית של הבלנק, וכך חסכו עבודה בשלב עיצובו של הנתז לכלי. באתרים אחרים, העדיפו הסתתים להשקיע פחות אנרגיה בשלב ייצורם של הנתזים הגדולים מגרעיני הענק, ושילמו על כך בעבודה נוספת בשלב העיצוב.

שלושת תת-הנושאים האחרונים, שנידונו כאן, מצביעים על הרמה הטכנולוגית הגבוהה של כלי החיתוך האשליים הגדולים, על כושר המצאתם של הסתתים האשליים, על הסתגלותם למשאבי הסביבה, על יכולתם לתכנן שלבים רבים של כליהם מראש ועל יעילות שיטות הסיתות ששימשו אותם. כל אלה מעידים על רמה קוגניטיבית הגבוהה מזו המיוחסת לנושאיה של התרבות האשלית בדרך כלל.

צורתם וגודלם של הכלים הדו-פניים מנקודת מבט רחבה

בחינת גודלם של הכלים האשליים הדו-פניים מראה כי למעלה מ-90% מהם נמצאים בטווח שבין 10-20 ס"מ באורכם המרבי. זאת ועוד, 50% מאבני היד מתרכזות בטווח המרכזי של 5.3 ס"מ, 50% מהקופיצים מתרכזים בטווח של 4.1 ס"מ. מדדי הגודל האחרים (רוחב, עובי, היקף ומשקל) תואמים תמונה זו. בניגוד למחקרים אחרים, התמקדה עבודה זו דווקא **בדמיון** הרב בין גודלם של הכלים, שיוצרו

בטכנולוגיות גרעין שונות, מחומרי גלם שונים ומקורם אתרים רחוקים זה מזה. אימוצה של זווית ראיה רחבה מראה כי הסתתים האשליים עיצבו את כליהם לתוך טווח מצומצם מאוד של גדלים. גם בצורתם מראים הכלים טווח שונות קטן להפתיע. על כן, אין הצדקה לשימוש בחלוקה הטיפולוגית הנקוטה בחלק גדול מן המחקרים.

איננו יודעים בביטחון למה שימשו הכלים הדו-פניים, אך הדעה המקובלת על רוב החוקרים היא שהם שימשו לביתור בעלי חיים גדולים. כחוקרים מודרניים, קשה לנו להסביר את העובדה כי כלים דומים כל כך יוצרו במשך מאות אלפי שנים, על פני טווח של אלפי קילומטרים, ללא שינוי ניכר בהם. הסתתים האשליים עיצבו את כליהם כך שלא יחרגו מטווח מינימאלי של גדלים וצורות. **הם היו גמישים מאוד מן הבחינה הטכנולוגית, אך גילו שמרנות גדולה מאוד מן הבחינה הטיפולוגית.** נראה כי צורתם וגודלם של הכלים נבעו מצירוף של הצורך הפונקציונאלי שהם מילאו (הקצה החד של כלי חיתוך גדולים אלה הוא סיבת קיומם, ואיכותו וצורתו של קצה זה הם הגורם המכתיב את צורתם וגודלם של הכלים הדו-פניים), עם שימור מסורת תרבותית שהכתיבה צורה מסוימת לכלים אלה.

ניתן לזהות גל של הגירה אנושית, ממקום התפתחותה של התרבות האשלית ה- LFB באפריקה, אל מחוץ ליבשת זו. גל הגירה זה נשא עימו את מסורת ייצור הכלים הדו-פניים המעוצבים על נתזים גדולים עד להודו במזרח, ולספרד בצפון-מערב. יצרני הכלים הדו-פניים התאימו את עצמם לסביבות המשתנות, שפגשו, ופיתחו שיטות לניצולם של חומרי גלם בעלי צורה ותכונות שונות אלה מאלה. צורתם וגודלם של הכלים נשמרו קבועים כתוצאה משילובם של צרכים פונקציונאליים דומים מחד, ושמרנות תרבותית ארוכת שנים מאידך. עם זאת, ראוי לזכור כי בסופן, בהרף עין גיאולוגי, נעלמו התעשיות האשליות כולן, והוחלפו בכל מקום על-ידי תעשיות הפליאולית התיכון. תעשיות אלו שייכות גם הן למסורת סיתות ארוכת שנים, מכלוליהן דומים מאוד זה לזה מבחינת הטכנולוגיה והטיפולוגיה שלהן והן אינן נופלות מן התרבות האשלית גם בתפוצתן.