University of Alberta

Acheulean Behavioural Variability: Evidence for Continuity or Change?

by

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of *Master of Arts*

Department of *Anthropology*

Edmonton, Alberta

Fall 2001

University of Alberta

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Title of Thesis: Acheulean Behavioural Variability: Evidence for Continuity or change?

Degree: Master of Arts

Year this Degree Granted: 2001

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Date: September 28, 2001

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Dedication

The dedication of this thesis goes to Mom, Dad, Lyle, Pamela, Nana and Misty.
Thanks for everything. I couldn't have done it without you!

Back Row: Arthur J. Jelinek, Geoffrey A. Clark, F. Clark Howell, Leslie G. Freeman, Lawrence H. Keeley and Jarrod E. Goldsmith.

Front Row: Kathy D. Schick, Manuel Ramon Morales, Margaret W. Conkey, J. Desmond Clark, Lawrence G. Straus and Victoria Cabrera Valdés.

Abstract

This thesis is a critical comparative review of published archaeological reports from sites located throughout Africa, the Middle East and Europe ranging in age from approximately 1.8 million to 200,000 years ago. These sites belong to the Acheulean, a period generally thought to have exhibited cultural stasis despite its long duration. It is possible that some aspects of hominid behaviour became more complex, particularly after 800,000 years ago during the Middle Pleistocene. Complexity in hominid behaviour can be measured by more extensive land-use patterns with greater accumulations and concentrations of artifacts and associated faunal remains. In order to document behavioural changes within the Acheulean, a number of variables were analyzed using data from 50 archaeological sites. The patterns exhibited signify that the Acheulean saw some degree of change and was not as static as researchers have previously suggested.

Acknowledgments

This thesis represents four years of my life. During this time, I have had the pleasure to meet a great many people, some of whom changed the way I view the world and deserve special attention here. I would foremost like to sincerely thank Professor Pamela R. Willoughby for her unsurpassed knowledge of anything remotely connected to archaeology, the other committee members, Dr. Julie Cormack for her no-nonsense work ethic, Dr. Ray Le Blanc ("there's enough material to get a masters thesis out of this, but the problem is where to take it from"), Dr. Ann McDougall and Dr. David Lubell. Sincere appreciation goes to Dr. Owen Beattie who helped me through some turbulent times, and all the Department of Anthropology staff (Liz Jobagy, Robin McClelland, Gail Mathew and Joanne McKinnon) for making my time here pleasurable. I have been extensively involved in many groups on and off campus and would like to pay special tribute to the HUB Community Association (HCA), Association of Graduate Anthropology Students (AGAS), and Orquesta Energia for all the gigs (Con Muchos Wevos). These organizations (among others) gave me an education not taught in school. I would also like to thank the soon to be Dr. Susan Steen for her friendship, all the graduate students who gave moral support and those who read parts of this thesis, Kriss Clement for getting me where I am, my older (and semi-retired) brothers Steven H. Orenbach and Darrell Diamond Cordes (congratulations on the wedding), Steven Maroof for the highly welcomed occasional talks, Matthew Doo Hong Kim for keeping me sane, my belly full of good food and drink and whose family treated me so well when I visited them in South Korea. To everyone else who made me laugh, thank you all and best wishes!

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Chapter 1
Introduction

To unearth something that was last held by a human or hominid countless thousands of years ago is rather like shaking hands with him...The sheer pleasure of finding an object so awesomely ancient remains with me, even after it may ignominiously end up in other hands as computer-fodder. MacRae (1998:14).

1.1 Introduction to the Acheulean

Through most of human prehistory before the introduction of agriculture, tools were made from organic materials such as bone and wood, as well as stone. Many stone artifacts (objects modified or displaced by hominids) are associated with members of the genus *Homo*. Relative to earlier hominids, they are characterized by brain expansion and flexibility in adaptation through increased reliance on technology. Technology can be defined as the intentional action of manipulating the natural environment to create materials that ease hominid adaptations including the manufacture and use of tools to make other tools (Isaac 1978b:144, 1986:235; Klein 1999:144; McGrew 1987; Noble and Davidson 1991, 1996; Susman 2000).

Palaeoanthropology is a multi-disciplinary field committed to the study of human evolution and to the documentation of our origins through fossil and archaeological remains. Palaeoanthropologists strive to understand how, where, when and why hominid species originated and developed, their adaptational abilities and evolutionary relationships. Within palaeoanthropology is a specialization known as Palaeolithic archaeology that focuses on the cultural past. Palaeolithic archaeology is the study of the earliest hominid archaeological evidence in the Old World beginning with the first identifiable lithic artifacts around 2.5 million years ago (mya) within the Pliocene Epoch until the end of the Pleistocene around 10,000 years ago (Figure 1.1).

Over the last 1.8 million years (or longer), global climate has oscillated between warm and cold phases. These environmental phases are identified through oxygen isotope ratios in deep-sea sediments and ice cores (Klein 1999:57; Shackleton 1975; Shackleton *et al.* 1995). Warmer periods, known as inter-glacials, are characterized by the retreat of ice sheets and rising sea levels, while colder periods or glacials, are characterized by advancing ice sheets and lower sea levels. Within glacials, colder phases are referred to as stadials, and warmer phases as inter-stadials. These colder phases occur approximately

every 100,000, 40,000 and 23,000 years as predicted by Milankovitch who suggested they were the product of changes in the orbit and axis of the earth (Berger 1992; Shackleton 1995). New evidence from ice cores suggest that the pace of climatic fluctuations increased around the Brunhes/Matuyama boundary 780,000 years ago (Servant 2001). The fluctuations of climate had a major influence on the biological evolution, speciation, and distribution many animals, including hominids (Cadman 1989; Vrba *et al.* 1995). The Pleistocene has been subdivided into three stages known as the Lower, Middle and Upper (Klein 1999:22-51) (Figure 1.1).

The Lower Pleistocene begins with the onset of the Olduvai Normal Subchron at 1.8 mya and lasts until 780,000 years ago when global magnetic polarity changed from south, (Matuyama Reversed Chron) to the north (Brunhes Normal Chron) for the last time (Baksi *et al.* 1992; Bassinot *et al.* 1994; Kappelman 1993). Shifts in magnetic polarity lasting hundreds of thousands or millions of years are known as chrons, while shorter shifts of opposite polarity within the chrons are known as subchrons (Klein 1999:50-53). The Middle Pleistocene lasts from the Brunhes/Matuyama boundary to the onset of the last glacial approximately 125,000 years ago. The Upper Pleistocene ends with the beginning of the Holocene warm period at 10,000 years ago (Figure 1.1).

It is within the Pliocene and Pleistocene that hominids began to produce flaked stone artifacts and occasionally acquire meat. The transport of artifacts and bones across the landscape resulted in accumulations of these materials that became identified as archaeological sites (Isaac 1971, 1975a:513-515, 1978a; Kroll 1994). Early archaeological sites are defined and identified when stones and bones are found together in fine-grained contexts where neither would occur naturally (Bar-Yosef 1995; J.D. Clark 1987; Isaac 1978c:238-239, 1983b; Roe 1982a:178; Stiles 1979:2). Assemblages are groups of artifacts found in direct or close association, usually in a discrete stratigraphic horizon (Table 1.1). In some cases, sites can include dozens of assemblages spanning hundreds of thousands of years. The pattern of association of these stone artifacts and bones can be used to understand early hominid behaviour, once taphonomic or site formation processes are considered (Binford 1983; Clark and Haynes 1969:407-408; Clark and Kurashina 1979a:105; Isaac 1986:224; Schiffer 1983:678). Taphonomy is the study of death assemblages, the processes by which animals and plants become part of the fossil record (Behrensmeyer and Hill 1980; Klein and Cruz-Uribe 1984; Schiffer 1987:260). Once natural causes operating at a site are determined and eliminated, artifact associations can then be used to reconstruct past human behaviour. In the context of archaeology, behaviour can be defined as any intentional or unintentional hominid activity. Identifying

behavioural resolution is perhaps one of the main goals of archaeological research.

The archaeological evidence from around 2.5 mya to 200,000 years ago belongs to the Lower Palaeolithic (Clark *et al.* 1984; Gowlett 1986; Isaac 1978c, 1984, 1986; Klein 1999:228-229). It is divided into two industrial complexes: the Oldowan between 2.5 and 1.8 mya, and the Acheulean, from around 1.8 mya to 200,000 years ago (Figure 1.1).

The Oldowan Industrial Complex exhibits the very first evidence of intentional and recognizable manipulation of stone in human prehistory (Davis 1978; Potts 1991; Toth and Schick 1986). The Oldowan is defined primarily by cores (pieces of rock from which flakes were removed), core tools (pieces of rock shaped by flaking and used as a tool, rather than the flakes) and detached flakes (pieces of rock removed from cores). Other Oldowan artifact forms include hammerstones (pebbles that were used to remove flakes) that often show evidence of pitting, polyhedrons (cores from which angular flakes were removed from three or more directions producing multifaceted cubes), scrapers (flakes with trimming along at least one edge on one surface), spheroids (rounded flaked stone balls and battered pieces) and choppers (cobbles with evidence of multidirectional flaking) (M.D. Leakey 1994; Schick and Toth 1994; Willoughby 1985). While the Oldowan was initially defined for Olduvai Gorge, Tanzania (M.D. Leakey 1971), similar core and flake industries exist at numerous Lower Palaeolithic sites throughout Eurasia and Africa (J.D. Clark 1998; Gabunia and Vekua 1995; Gabunia *et al.* 2000; Leng 1998; Schick 1994) and are termed "Mode 1" (J.G.D. Clark 1977:22). In its strictest sense, the Oldowan is restricted to Africa.

The Acheulean Industrial Complex existed from approximately 1.8 mya to 200,000 years ago. While the Acheulean begins in Africa at around 1.8 mya, its distinctive technology eventually spreads to other parts of the Old World including the Middle East (by at least 1.5 mya), South Asia (by at least 1 mya) and Europe (by at least 500,000 years ago). The Acheulean is primarily a bifacial stone working industry. Bifacial tools are manufactured by working a core or large flake from two directions to produce a sharp sinuous edge around much of the circumference. The most distinguishable artifact type of the Acheulean is the handaxe; a large cutting tool that can vary widely in size and form, although the most common shape is oval (teardrop). A handaxe is defined as any biface that usually converges to a point. Here, the more generalized and neutral term 'biface' will be used instead of the term 'handaxe' for two reasons. First, referring to a tool as a biface removes any aspect of functional connotation. Second, while all handaxes are bifaces, not all bifaces are handaxes (Debenath and Dibble 1994:131). Simply because a tool is worked bifacially does not necessarily make it a handaxe. Since lithic materials are the most easily preserved item in archaeological assemblages and because bifaces are so common in

Acheulean sites, the biface has become synonymous with the Acheulean (J.D. Clark 1987; J.G.D. Clark 1977; Gowlett 1986:252). In order for an assemblage to be classified as part of the Acheulean Industrial Complex, it was originally believed that bifaces must account for at least 40 to 60% of retouched tools (Bar-Yosef and Goren-Inbar 1993:70; Kleindienst 1961:40, 1962; M.D. Leakey 1971:270-271; Stiles 1979), even though this high percentage was lacking at the French type-site of St. Acheul (Bordes 1979; Roe 1981:74). Other artifact types found in Acheulean sites include cleavers (large flakes initially shaped like handaxes but having a natural flake edge perpendicular to the sides of the tool), picks (long axis tools with thick triangular cross-sections), cores from which flakes were removed, various retouched flakes such as scrapers, and the debitage or waste from artifact manufacture (J.D. Clark 1994:453; Kleindienst 1961, 1962; Ohel 1986a; Petraglia *et al.* 1999; Schick and Toth 1993:231-233). Changes in lithic technology within the Oldowan and Acheulean were in most cases gradual and perhaps progressive, leading to a greater variety of tool types and standardization (J.D. Clark 1994; Isaac 1986:233).

The incredible time span of the Acheulean has often been clouded in mystery since more variation in artifacts and fossil remains exist than is generally acknowledged (Franzen 1994b; Stringer 1984). The Acheulean "...domain is so poorly sampled and measured that the extent of its diversity is not known" (Gowlett 1998:63). As Gamble (1999, 2001:6) notes, it is the job of Palaeolithic archaeologists to not only interpret individual site data, but to relate it to a larger picture from which broader behavioural reconstructions over time and space can be made. The evidence for behavioural variability in the Acheulean archaeological record appears to be so slight that it has caused some researchers such as Klein (1999:337) to argue that little changed throughout its long duration.

1.2 The Problem

This thesis examines the issue of whether or not there is any evidence for change in Acheulean behaviour as determined from archaeological patterns, artifact accumulations and technology between 1.8 mya and 200,000 years ago. If an increasing range of cultural behaviours and complexity developed during the Acheulean as its makers spread into new regions, it probably was not a single period characterized by behavioural stasis. If no significant differences are found in Acheulean assemblages through space and time, then the idea of unchanging behavioural monotony could be supported. If the Acheulean did experience change, was it gradual or relatively sudden? The only way to address these questions is through an analysis of many sites and the patterns of

artifactual material within them.

1.3 Methods

This work is an exploratory data analysis of the published archaeological literature. It examines patterns over time and space and differs from other studies in that the whole geographic distribution of the Acheulean is being examined. Fifty sites and 92 assemblages from Africa (n=42), the Middle East (n=15) and Europe (n=35) ranging from approximately 1.8 mya to 200,000 years ago were chosen for analysis. Sites that had monographs or current publications complete with detailed artifact classifications were selected. While not every Acheulean occurrence has been examined in detail, these sites and assemblages provide a representative sample of Acheulean occupation throughout the Old World.

To aid in identifying behavioural variability in the Acheulean, a number of variables have been selected. A database was constructed to document site contents and general cultural information. This includes site name, date of discovery, location, estimated date of occupation, elevation and layout (e.g., open-air or cave). Contextual/preservational issues include assemblage formational processes, assemblage context, degree of assemblage disturbance and amount of artifact abrasion on the majority of artifacts. Of these issues, assemblage formational processes represented the major kinds of taphonomic issues that have acted on a site. Since water displacement has usually affected early hominid sites presumably due to hominid preference for occupation near water, the variable fluvial/alluvial processes has been used.[1] Assemblage context is defined as the depositional history of a site either remaining in primary (*in-situ*) context or secondary (derived) context. Primary context sites are places where little or no post-depositional disturbance has taken place. Secondary context sites are ones where disturbance masks the role of hominids in their creation. The degree of assemblage disturbance documents the force of taphonomic processes, while artifact abrasion examines the mechanical wear on the majority of artifact edges.

Other variables include the presence or absence of hominid fossil remains, fire, fauna, worked organic material, objects bearing traces of stone tool cut marks, as well as environment (either savanna/grassland or forested/woodland) at the time of occupation. Detailed information on the total numbers of artifacts, tools, utilized pieces and debitage were collected from assemblages at each site so that processes of tool manufacture,

[1] The term fluvial is generally used as a synonym for alluvial. Alluvial disturbance is described as the process and deposits of riverine environments (Waters 1996:115).

curation and possible site function could be established. Measures of relationships using Pearson's Chi-Square and graphical analysis using bar charts were done to examine possible associations. All variables were first analyzed in relation to each other to see if patterns emerge, but only those variables thought to show patterns through time and space are examined here. Where patterns were found believed to show change within the Acheulean, reasons have been proposed for their possible associations. The variable of time was essential to determine if any behavioural change occurred within the Acheulean, and if so, if change was gradual or sudden.

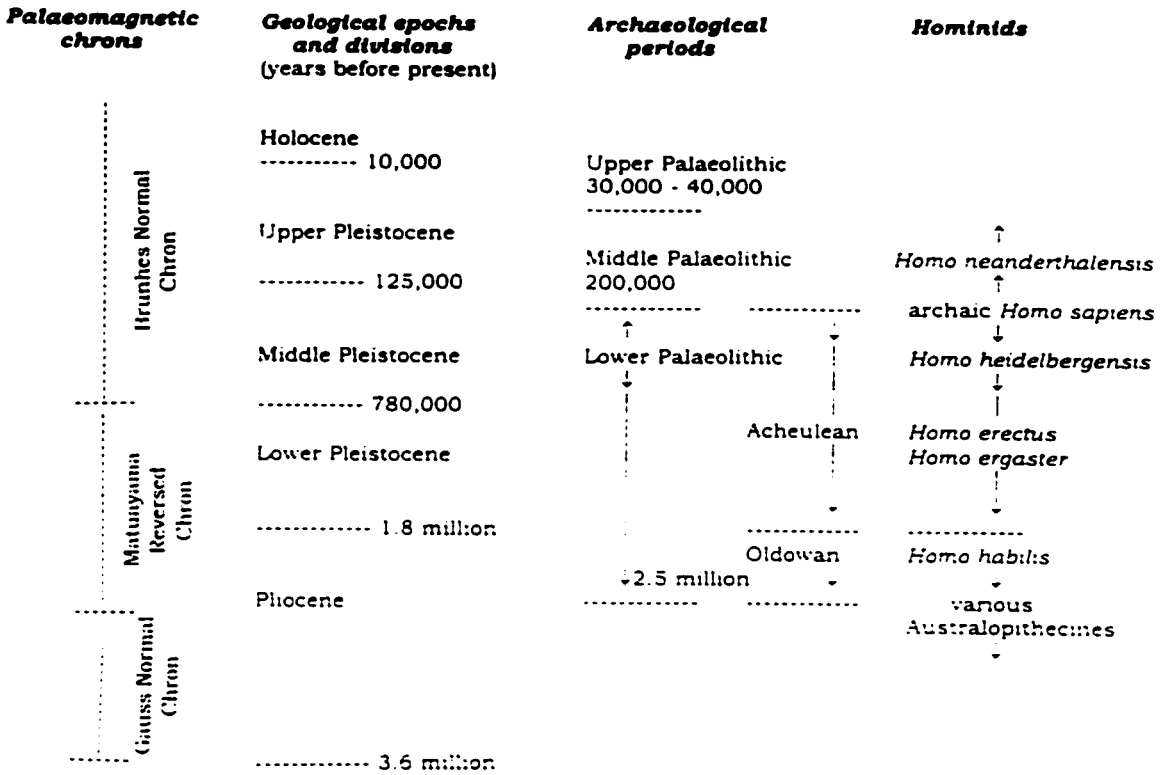
1.4 Organization

This thesis is divided into five chapters. The first three chapters review the Acheulean, its distribution over time and space, hominid associations, assemblage formational processes and technological and cognitive variation. Chapter 2 addresses what is known about the cultural history of the Lower Palaeolithic. Questions such as how, why, when and in which directions did early Acheulean hominids spread out of Africa into other regions of the Old World, and what kind of technology and adaptation did Acheulean hominids have will be examined. Chapter 3 outlines the ways in which Acheulean sites and technological variability have been explained, as well as possible cognitive abilities of Acheulean hominids. The last two chapters describe and analyze some variables to determine whether or not changes occurred during the Acheulean. Chapter 4 describes the variables, sites and assemblages examined and the results obtained. Chapter 5 reviews limitations of this research, and what information can be drawn from it. Some conclusions about Acheulean variability and suggestions for future work will also be made.

Table 1.1 Levels of Classification

Attribute	An individual feature or calculated metrical value of an object such as length, width, number of flake scars, etc.
Artifact	A single object intentionally modified or displaced by hominids.
Assemblage	A group of artifacts found in direct or close association with each other.
Industry	A group of related assemblages.
Industrial Complex	A group of related industries.

Figure 1.1 Geological, archaeological and hominid time line



Chapter 2
The Acheulean in Time and Space

2.1 The Acheulean in Time

The Palaeolithic is subdivided into three periods (Lower, Middle and Upper) based on gross technological changes from 2.5 mya to 10,000 years ago. The Lower Palaeolithic begins during the Pliocene Epoch at the start of the Matuyama Reversed Chron. It lasts until artifact changes heralding the Middle Palaeolithic (described below) begin around 200,000 years ago. The Lower Palaeolithic is further sub-divided into the Oldowan, from approximately 2.5 to 1.8 mya, only known in Africa, and the Acheulean, from 1.8 mya to 200,000 years ago found within and outside of Africa.

The Oldowan is characterized by core and flake artifacts: chunks of rock from which flakes are detached, and detached pieces. Oldowan tools are believed to have been produced for *ad hoc* activities where sharp edges were required, presumably for slicing and cutting (Isaac 1986:226; Klein 1999:235; M.D. Leakey 1978:4-10; Toth 1982, 1985). Oldowan hominids used stone-on-stone (hard hammer percussion), as well as the bipolar technique (using a fixed anvil on which rocks were placed upon and struck by another rock). These actions resulted in material that was not very standardized in shape. However, it is evident that Plio-Pleistocene hominids understood basic principles of fracture mechanics since a variety of raw material such as quartz was employed in Oldowan sites that often are unpredictable for flake detachment (Ludwig and Harris 1998:94). For an Oldowan site to be identified, it would have to contain cores and flakes, possibly faunal remains; perhaps some even with intentional lithic modification marks, be situated in fine grained deposits where neither would normally be found and date to between 2.5 to 1.8 mya.

Identifying any tool tradition before the Oldowan is extremely controversial, though there are claims for pre-Oldowan industries (Dennell 1998; Kibunjia 1994). Kibunjia (1994) believes that the Oldowan could very well represent a end-point on the technological continuum that began with simpler tool forms in the late Pliocene, or what he has labeled as the Omo Industrial Complex. Pre-Oldowan assemblages would have to be more than 2.5 million years old, contain lower densities of core and flake artifacts than those found in Oldowan assemblages, less bone surface modification marks and less reduction of cores. Such sites are scarce, but can include artifacts from Member F in the Shungura Formation, Omo, Ethiopia, the Senga 5A site in Eastern Congo, and the Nachukui Formation in West Turkana (Harris *et al.* 1987; Kibunjia 1994; Merrick 1976; Merrick and

Merrick 1976). With the advent of better dating techniques, more in-depth studies of site setting and typology and the further identification of formational (taphonomic) processes, documenting technological traditions earlier than the Oldowan might be possible. Until then, the Oldowan Industrial Complex remains the first accepted hominid technology (J.D. Clark 1988:244; Cook 1980; Gowlett 1978:351; Howell *et al.* 1995:78; Newcomer 1971; Potts 1991; Stiles 1979:2-3; Toth and Schick 1986).

Developed Oldowan is used to describe African assemblages later than the Oldowan that contain slightly more technologically complex tools in terms of greater reduction processes. Along with Oldowan core tools, there are new types, including small flake tools, spheroids and subspheroids (Davis 1978:44-48; M.D. Leakey 1971:269). Proto-bifaces, pointed choppers from which flakes were removed bifacially also appear for the first time (Callow 1994:253). These proto-bifaces tend to be produced on cores rather than the large flakes which are the hallmark of the African Acheulean (Callow 1994:253; Chavallion *et al.* 1979:90; J.D. Clark 1975:608-628; Isaac 1969; M.D. Leakey 1975:482-486; Potts 1991:155; Schick and Toth 1993:231-237). The term 'Developed Oldowan' was coined by Mary Leakey for assemblages found in Bed II at Olduvai Gorge (M.D. Leakey 1971, 1975). They have also been identified at other sites such as Chesowanja, Kenya (Harris and Gowlett 1980) and Swartkrans Cave Members 1 to 3, South Africa (J.D. Clark 1993).

The Acheulean Industrial Complex existed from around 1.8 million to 200,000 years ago and the technological characteristic of the biface can be found throughout Africa, the Middle East, South Asia and Europe (Asfaw *et al.* 1992; J.D. Clark 1994, 1998). While the Acheulean begins in Africa, it is only after 1.5 mya that sites are found in the Middle East, and after about 1 mya in South Asia. As discussed below, Europe appears to only have been occupied by hominids sometime after 780,000 or even 500,000 years ago. The Acheulean is seen as more technologically complex than both the Oldowan and Developed Oldowan since bifaces demonstrate preconceived design norms and greater expression of symmetry (Isaac 1986:233; McPherron 2000; Roe 1994a; Wynn 1995). Design norms can be defined as the mental ability to replicate a predetermined shape of tool while symmetry indicates the ability for more precise control over raw material to produce the same amount of reduction and subsequently of shape on either side of a long axis.

Artifacts moved throughout the landscape by hominids can provide information about early human behaviour (Davidson and Noble 1993; Gibson and Ingold 1993; Gowlett 1986:244-247; Schick 1992:2; Toth and Schick 1993). Perhaps the most significant change in the utilization of resources in hominid evolution was the more successful

acquisition of meat through hunting or scavenging and the transport of lithic materials across the landscape. An early example of meat-eating behaviour and transportation of both faunal and lithic materials to a central communal place has been observed at FxJj-50, east of Lake Turkana, Kenya (Isaac 1984; Isaac *et al.* 1980; Rogers *et al.* 1994), in Beds I and II at Olduvai Gorge and the sites of Gadeb and the Middle Awash, Ethiopia (Bunn and Kroll 1986:444; J.D. Clark 1987:823, 1988:268; Isaac 1972b:410-411, 1978b; Keeley and Toth 1981; McNabb 1998:21; Plummer and Bishop 1994; Potts 1988, 1991; Stanford and Bunn 1999; Stiles 1991; Toth 1985). Various functions for Acheulean artifacts have been proposed (see Section 3.2.1) but perhaps the most evolutionary advantageous technological innovation was the use of stone flakes to process an animal carcass. Eliminating the need to wait in a dangerous area along with competitive scavengers such as large felines was a revolutionary behavioural breakthrough (Bilsborough 1986:215).

Over time in the Palaeolithic, the distances over which hominids traveled to collect raw materials tend to increase (Jelinek 1977; M.D. Leakey 1971; Ronen 1982). Where lithic outcrops were not immediately available, hominids brought either finished or unfinished tools with them for future use, an action known as curation (Bamforth 1986; Binford 1973, 1979:263; Odell 1996). Hominids transported materials a few kilometres in the Lower Pleistocene, as far as 20 kilometres in the Middle Pleistocene and more than 100 kilometres in the Late Middle Pleistocene (Bar-Yosef 1975:592; Bond 1948; M.D. Leakey 1971; McNabb 1998:21; Nash 1996; Roebroeks and Hennekens 1990:292-293; Turq 1992).

Oldowan, Developed Oldowan and Acheulean sites show differences in where they tended to have been occupied in the environment. Prior to 1.6 mya, African sites appear in and along the shores of lake margin habitats and around seasonal sandy streams/ banks/channels perhaps because a variety of resources could be easily exploited. During the Acheulean, caves were occupied for the first time and sites are found further inland occupying hilly areas, mountain passes and intermontane valleys at higher elevations (Isaac 1975a:516-518; M.D. Leakey 1971:259; Marean 1989:575).

2.1.1 Temporal Subdivisions of the Acheulean

There is variation in assemblage form and technology within the Acheulean, therefore different subdivisions are commonly used.

The Early Acheulean (approximately 1.8 mya to 800,000 years ago) represents industries with cores and flakes (similar to the Oldowan) but with a larger component of bifaces and slightly more complex reduction methods then those found in Developed

Oldowan assemblages as soft hammer manufacturing techniques were starting to be used. Core-choppers, polyhedrons, spheroids, crude (sometimes quite large) bifaces, picks, heavy-duty scrapers, unworked flakes and smaller tools are also known (Bar-Yosef 1994a:225; Bordes 1968a; Breuil 1939; J.D. Clark 1994; Commont 1908; Grahmann 1955:560; L. Leakey 1951). Early Acheulean sites are only known from Africa. It is generally assumed that *Homo erectus* or *Homo ergaster* (an African variant of *Homo erectus*) was the hominid responsible for the production of Early Acheulean assemblages. *Homo erectus* had very robust bones with long and low (generally angular) skulls with a slight sagittal keel and an average cranial capacity of between 775 to 1,225 cc (Brauer 1992; Delson *et al.* 2001; Klein 1999:283-287; McHenry 1994b). *Homo erectus* also exhibits modern body proportions for the first time (as evidenced by the Nariokotome skeleton from West Turkana, KNM-WT 15000) and generally had long, slender bodies believed to have been adapted to tropical environments (Walker and Leakey 1993). A growing body of evidence shows that the earliest forms of *Homo erectus* appear in East Africa (KNM-ER 3733 and KNM-ER 3883 from East Turkana, Kenya) approximately 1.8 mya (Asfaw *et al.* 1992; Bunn *et al.* 1980; Walker 1994; Walker and Leakey 1978; Wood 1994). Hominid skeletal remains of *Homo erectus* have been found in direct association with other Early Acheulean African sites such as Tighenif, Sidi Aberrahman, Konso, and Olduvai Gorge Beds II and IV (Asfaw *et al.* 1992; J.D. Clark 1994; M.D. Leakey 1971; Walker 1994).

The Middle Acheulean (approximately 800,000 to 400,000 years ago) is known from sites in Africa, the Middle East, South Asia and Europe. The technology is characterized by soft-hammer (bone and wood) retouch on bifaces presumably after hard hammer percussion was used. Other tool types also emerge such as larger proportions of various retouched flake tools including borers, backed knives, notches, side scrapers, end scrapers and burins, as well as pieces with intentional blunted edges, presumably for holding (Schick and Toth 1993:231-233). The Middle Acheulean provides some of the first evidence for the emergence of archaic *Homo sapiens*, a hominid with a larger and rounder cranium than *Homo erectus*. The Levallois technique (further discussed in Section 3.2) which involves the removal of flakes along the peripheral edges of a core that has been previously modified so as to produce a flake of predetermined size, is first recognized in the Middle Acheulean (J.D. Clark 1994:464). This method produces more standardized end-products in both the flake and core that are easily distinguishable in all stages of reduction (Klein 1999:411; Roe 1981:78, 1982a:183-184, 1982b:326). While *Homo erectus* is often cited as the maker of the Acheulean Industrial Complex, later hominids such as archaic *Homo*

sapiens also produced Acheulean materials (see Figure 1.1) (Aguirre 1994; Aiello 1993; Bar Yosef and Belfer-Cohen 2001:20; Clark *et al.* 1994; Mellars and Stringer 1989; Rightmire 1994, 2001; Schick and Toth 1993:261). Two sites where archaic *Homo sapiens* and Acheulean tools have been found in direct association are Elandsfontein, South Africa (dated to between 700,000 and 400,000 years ago) and Swanscombe, England (dated to between 400,000 and 300,000 years ago) (J.D. Clark 1994; Conroy 1997:283-343; Conway *et al.* 1996; Franzen 1994a; Klein 1988; Klein and Cruz-Uribe 1991; Stringer and Hublin 1999).

The Upper Acheulean (approximately 400,000 to 200,000 years ago) exhibits generally smaller, more symmetrical and refined bifaces than earlier ones (J.D. Clark 1994; Gilead 1970; Otte 1992:48; Tuffreau 1982:146). Upper Acheulean assemblages contain both unprepared and modified flakes, occasional choppers and chopping tools as well as Levallois flakes (Bar-Yosef 1975:582-583; J.D. Clark 1975:633-641; de Lumley 1975:796-798; Hours 1975; Jelinek 1982a:103-104; Schick and Toth 1993:270). Examples of Upper Acheulean sites include Avivim (Ohel 1990) and Holon in Israel (Porat *et al.* 1999:337; Yizraeli 1967), Wadi Qalkha, Jordan (Henry 1995a), Kissufim, Western Negev (Ronen *et al.* 1972), El Castillo, Spain (Bischoff *et al.* 1992) and Pontnewydd Cave, Wales (Green 1984b). The term 'Epi-Acheulian' has been used for assemblages where bifaces of Acheulean type are very rare (in most cases representing under 1% of the lithic material) and where Levallois flakes are well represented (Tuffreau 1982:143). Some Levallois industries can in some cases be transformed into what is known as the 'Mousterian of Acheulean Tradition' or MTA (after the French Mousterien de Tradition Acheuléan) simply on the basis of the presence of a few bifaces (Bar-Yosef 1994a:226; Bhattacharya 1977:66). MTA assemblages contain the same kinds of artifacts as seen in Acheulean sites, but with small heart-shaped or cordiform bifaces, more Levallois products and retouched flakes (Klein 1999:424-427).

During the Final Acheulean (approximately around 200,000 years ago), hominids manufactured artifacts using a variation on the general biface theme. Smaller retouched tools become more frequent. Many regional names have been proposed for Final Acheulean sites based on minor technological variations. The Tayacian has been defined from southwestern France for assemblages with flake implements and some evidence of the Levallois prepared-core technique (Rolland 1986:145, 1988:178-179). Amudian, Pre-Aurignacian and Jabrudian assemblages are known from Middle Eastern sites with rare bifaces and high proportions of blades, retouched tools (such as end-scrapers) and complete flakes, and are believed to post-date the Tayacian (Bar-Yosef 1998:265-269; J.D.

Clark 1975:633-641; Jelinek 1982a). The Acheulean of Yabrudian facies (otherwise known as the Acheuleo-Yabrudian or Mugharan Tradition) is temporally restricted to the transitional phase of the Lower to Middle Palaeolithic around 200,000 years ago in the Northern and Central Levant. It is characterized by the occasional use of the Levallois technique and the distinctive Quina retouch that produces relatively little debitage. Many side scrapers are also found in Acheuleo-Yabrudian assemblages, as well as a particular type of biface, the Micoquian that is distinguishable from other biface assemblages by its retouch (Bar-Yosef 1982:31-32, 1994a:257, 1998:265; Copeland 1983:91; de Lumley 1975:795-796; Jelinek 1982a; Laville 1982). The terms 'Stellenbosch' and 'Fauresmith' were once used to denote the Final Acheulean in Southern Africa characterized by small bifaces in savannah environments (McBrearty *et al.* 1996:564; Volman 1984). But Humphreys (1969, 1970) concluded, based on raw material studies, that those bifaces were not distinct from Acheulean ones and thus did not warrant separate industrial status. The Sangoan has for many years been considered an adaptation to forested or tropical environments in central Africa (Hume 1976:262; McBrearty *et al.* 1996:564; Rightmire 1996:35; Wymer 1986:104). It includes heavy-duty core tools such as core axes, picks, heavy-duty scrapers, and small cutting and scraping tools (Cormack 1996; McBrearty 1988). Many tools are believed to have been used for the manipulation of wood and other non-lithic substances. With them, it would be possible for hominids to live in areas that had high rainfall such as tropical forests or woodlands (J.D. Clark 1960, 1970a:108-112, 1982a, 1982b:243-244, 1988; Deacon 1975:562-563). However, McBrearty (1988, 1992) has found possible evidence of grassland environments at the Sangoan sites of Simbi and Muguruk in Western Kenya, casting doubt on the belief that the heavy-duty tool technology of the Sangoan was solely an adaptation to forested environments.

It is possible that technological change from Acheulean to Middle Palaeolithic occurred at slightly different times and in different ways according to raw material variability as hominids adapted to various environmental conditions. The most significant changes that can be observed between the Acheulean and Middle Palaeolithic are the gradual disappearance of the diagnostic large bifacial Acheulean tools and the increased appearance of retouched flakes and smaller standardized flake tool elements from Levallois cores (Bar-Yosef 1994a; J.D. Clark 1982a, 1988:236-238; Dibble and Mellars 1992; Dibble and Rolland 1992; Klein 1999; Mellars 1990; Sheppard and Kleindienst 1996:189; Willoughby 1993, 1996a). *Consistent* use of Levallois technology is generally thought to have ushered in the Middle Palaeolithic or Mousterian Industrial Complex, named after

the Le Moustier rockshelter in southwestern France (Bar-Yosef 1975:593; J.D. Clark 1988:236-237; Copeland 1995; Klein 1999:407-420; Mithen 1996b:122-123; Ohel 1990; Roe 1981:80; Ronen *et al.* 1972; Shea 1988, 1993; Tuffreau 1982:139; White and Pettitt 1995:33-34; Willoughby 1996b). The beginning of the Middle Palaeolithic may also mark a significant change in the utilization of resources attributed to more intense hunting ability than in the Acheulean (Gamble 1999).

Another technological feature that has historically served to distinguish the Acheulean from the Middle Palaeolithic has been the appearance of blades after 200,000 years ago. Blades are flakes that are twice as long as they are wide with unprepared single platforms produced by either hard hammer percussion or indirect percussion on a prismatic core. Blades, or something on its way to becoming a blade, can also be present in Acheulean sites such as in the Kapthurin Formation at Lake Baringo, Kenya (Bar-Yosef and Kuhn 1999; McBrearty *et al.* 1996). Items with possible stylistic and symbolic capacities also appear in Middle Palaeolithic sites for the first time such as the use of red ochre (Wreschner 1982), the manufacture of unifacial scrapers from marine shells as well as shell necklaces at Mousterian sites along the Mediterranean coast of Italy (Chase and Dibble 1987; Stiner 1993).

There are very few sites that conclusively show the Acheulean to Middle Palaeolithic transition (Mellars 1990; Mellars and Stringer 1989). One, however, is Tabun Cave in Israel. The lowest archeological sequence at Tabun, Level D or Acheulo-Yabrudian, contains artifacts of both Acheulean and Levallois type as well as blades, while the higher levels contain many typical Middle Palaeolithic artifacts with a preponderance of scrapers and points (Garrod and Bate 1937; Jelinek 1982a, 1982b; Klein 1999:429-431). The material at this site perhaps indicates that the Acheulean to Middle Palaeolithic transition was gradual and technology was not the defining feature separating the two phases. Other sites that may show continuity are found in the Hunsgi Valley, India (Paddayya 1982) and the later sequences at Melka Kunture, Ethiopia (Chavaillon *et al.* 1979).

The Middle Palaeolithic comes to a close around 50,000 to 30,000 years ago with the beginning of the Upper Palaeolithic. The Upper Palaeolithic is associated with modern *Homo sapiens* who occupied most types of environments and engaged in symbolic actions such as art, producing prismatic blades and produced many other tools on materials such as bone, antler and ivory (Bolus and Conard 2001; Ray 1982; Sackett 1988:413; Schick and Toth 1993:228). It is perhaps only during the Upper Palaeolithic where a single hominid species was living on earth.

2.1.2 Acheulean Dating Techniques

It is necessary to estimate the age of Palaeolithic sites before determining if any patterns emerge through time. Artifact typology, lithostratigraphy (the sequences of rocks or sedimentological strata units) and biostratigraphy (the relationship of fossil remains to particular stratigraphic levels) have all been used as means of relative dating, broadly determining the order of events. The law of superposition states that when a layer overlies another, the lower layer can generally be assumed to have been deposited first (Renfrew and Bahn 1994:90).

In the early 20th century, techno-typological analysis based on form and elaboration of bifaces was commonly used to date Acheulean deposits (Ashton and McNabb 1994; Callow 1986b; Cook and Jacobi 1998a; Gilead 1970; Howell 1978:205; Isaac 1975b:886, 1978b:145; King and Oakley 1936; McNabb 1996b:35-36; Roe 1970:342; Woodcock 1986:33; Woodman 1998:154; Wymer 1991). It was generally believed that larger bifaces produced by hard hammer percussion were older than smaller, more symmetrical ones produced by soft hammer percussion. For instance, *bout coupé* bifaces made by soft hammer percussion throughout the United Kingdom are believed to be restricted to Upper Acheulean or Early Middle Palaeolithic technologies (Debenath and Dibble 1994:165-167; Roe 1981:250-252; Shackley 1977:333). They are cleaver-like in appearance and bifacially worked around their entire circumference. Cleavers are large U-shaped bifaces with one sharp natural edge (Schick and Toth 1993:232).

Acheulean sites are abundant throughout the Levant region, but the range of tool types discovered such as Levallois flakes/cores and blades makes it difficult to use only bifaces as chronological indicators (Goren-Inbar 1985:24-26; Lamdan 1982). Santonja and Villa (1994:86-88) note that many sites belonging to the Middle Pleistocene in Iberia have been dated by the presence or absence of specific tool types. This is a practice that should only be used when other dating techniques are impossible because a site yielding bifaces may not necessarily be Acheulean, and *old looking* stone tools (perhaps large, unstandardized and made by hard hammer percussion) may not necessarily be extremely old (Yi and Clark 1983:198). Gaudzinski *et al.* (1996:328), perhaps prematurely, even goes so far as to write that "[o]nly the bifaces [from the Middle Pleistocene site of Kärlich-Seeufer in Germany] place the whole assemblage in an Acheulean context." Shackley (1983:196) has used the term 'handaxiform' to refer to artifacts found throughout Mongolia that appear to resemble classic Acheulean bifaces, but in some cases date to the end of the Pleistocene or even Holocene. With the apparent problems of placing assemblages, or more specifically artifact types into chronological frameworks, Leslie Freeman (1975:734) wrote

that "...typology is a fickle mistress, especially when abused."

When context is adequate, relative chronological frameworks using sedimentology and river terrace sequences that measure the rate of fluvial accumulation can be used (Bar-Yosef 1994a:225, 1995; Bridgland 1994, 2000; Gaillard *et al.* 1986; Goren-Inbar 1995; Kappelman *et al.* 1997; Lewis 1998; Roe 1981; Santonja and Villa 1994:50-51; Scott 1998:112; Shackelton 1975; Woodcock 1986; Wymer 1986:103-104). Problems arise with these methods since water does not deposit sediments in a strictly horizontal manner and other factors of depositional disturbance such as natural earth movements, trampling and hominid and animal activity can also distort the evidence. It may also be possible to place sites into comparative chronological frameworks for climate reconstruction when warm and cold environmental fluctuations through ice cores or deep sea cores can be identified.

Pleistocene sites are often relatively dated by means of biostratigraphical sub-divisions based on micro- and macro-faunal analysis from different regions (Avery 1995; Janossy 1975; Kahlke 1975; Klein 1999:24-32). If the remains of animals at one place are the same as those from another radiometrically dated site, they may be of the same age. This reasoning applies to only those species that are distinctive to particular times and places. Biostratigraphical information has also made it possible to conclude that Acheulean hominids in South and East Africa tended to favour sites located close to water since many animal species which generally live near water (such as hippos) have been found in Acheulean sites (Deacon 1975:547; Klein 1983:30, 1988; M.D. Leakey 1971; Phillipson 1993:50-51).

Chronometric dating methods based on radioactive decay of certain isotopes give numerical ages in years (Roebroeks *et al.* 1992:553). The most popular absolute techniques for dating Acheulean sites are outlined by Aitken (1995), Klein (1999:33-47) and Singhvi *et al.* (1998). Since volcanoes have occasionally blanketed parts of East Africa with ash, preserving archaeological material in stratified deposits, methods for dating ash layers rich in potassium are appropriate (Bishop 1978a; Boaz 1979, 1994; Gowlett 1990; Howell 1978; Isaac 1975a, 1975b; Jolly 1978; L. Leakey 1951; M.D. Leakey 1971, 1994; R. Leakey 1989; Leakey *et al.* 1964; Robertshaw 1990a, 1990b:78; Schick and Toth 1993:83-89; Shackleton 1978). Potassium-argon (K-Ar) measures the rate of radioactive decay from ^{40}K to ^{40}Ar in volcanic rocks which occurs at a half-life of 1.25 billion years (Klein 1999:36-37).[1] Another technique using $^{40}Ar/^{39}Ar$ requires that lasers be used to produce intense heat to release argon from small particles of volcanic rock; it is normally a more precise method than

[1] A half life is the time it takes for half of a radioactive parent isotope to decay into a daughter isotope.

conventional K-Ar dating (Deino *et al.* 1998). Fission-track dating measures the returning rate of ^{238}U after volcanic glass such as obsidian becomes cooled from extreme heat (Morwood *et al.* 1998; Wagner 1996). Upon cooling, microscopic tracks start to form along the surface of volcanic material and can be counted by acid etching in a laboratory (Klein 1999:38). Uranium-series dating measures the decay rates of various forms of isotopes such as ^{235}U, ^{238}U and ^{232}Th on spelothems (flowstone that comprises travertine deposits of calcium carbonate from water dripping from the ceiling of a rockshelter or cave), stalagmites and stalactites (Waters 1996: 241-243; Schwartz 1992; Szabo 1986).

Thermoluminescence (TL) and optically stimulated luminescence (OSL) can be used on buried sediments and artifacts such as flint that have been heated or exposed to light and then buried. These two methods can be used to date material between around 300,000 and 50,000 years ago (Gladfelter *et al.* 1993; Klein 1999:47; Porat *et al.* 1999; Waters *et al.* 1997). Electron spin resonance (ESR) is a method whereby an amount of natural environmental uranium radiation is detected from animal tooth enamel. This method is very appealing since teeth are usually well preserved in archaeological sites (Falgueres *et al.* 1997; Porat and Schwarcz 1994; Schwarcz *et al.* 1988a, 1989, 1994). When available, several absolute methods are usually undertaken simultaneously in order to bracket the known date of a site and also to check the accuracy of other methods.

2.2 The Acheulean in Space

As Gowlett (1998:59) has noticed, there has been a trend for each generation of Palaeolithic archaeologists to become more regionally specialized since it is difficult to understand Acheulean diversity on a global scale. As there are always more sites being discovered, it is increasingly difficult to follow the current literature. With the understanding that hominids adapted to different resources through time and space, archaeologists seem to be becoming more focused on local sequences and problems. However, relating information to a larger picture is essential to provide an understanding on the global distribution of hominids, especially Acheulean hominids since by the end of the Middle Pleistocene they occupied many regions throughout the Old World. A significant aspect of this thesis has been to observe Acheulean distribution across the Old World. The following section briefly examines where Acheulean or contemporary archaeological sites are found.

2.2.1 Africa

The African Acheulean can be subdivided into three geographical areas: east, south and north. West/Central Africa does not seem to have any Acheulean evidence, and researchers do not know if hominids even lived in this part of Africa at this time. While Acheulean hominids likely did not inhabit heavily forested or desert-like conditions (Isaac 1975) as is found in contemporary West/Central African regions, it is possible they occupied these parts of Africa during times when vegetational changes favored larger faunal biomasses. Different species of hominids are known to have emerged throughout eastern and southern Africa during the Late Pliocene/Early Pleistocene including various forms of australopithecines such as *Australopithecus boisei* and *Australopithecus robustus* as well as *Homo habilis* and *Homo erectus* (Harris 1983; Klein 1983; R. Leakey 1989). With the possible exception of South Africa, no other geographical area in the world has matched the fossil and archaeological finds of East Africa for documenting hominid origins where the most extensive archaeological work has been undertaken. The 1960s were the beginning of an explosion in archaeological research in East Africa that resulted in Coppens (1978:501) to dub this time as the hominid rush. The Shungura Formation west of the Omo River, the Hadar region in Ethiopia (at the site of Gona) (Harris and Semaw 1989), east of Lake Turkana (Koobi Fora) in Kenya (Harris and Herbich 1978; Harris and Isaac 1976; Kibunjia 1994; Leakey and Leakey 1978; Walker and Leakey 1978) and Olduvai Gorge, Tanzania (Leakey *et al.* 1964; M.D. Leakey 1971) became centres for studying early hominid evolution throughout the Plio-Pleistocene. All of these areas represent open-air archaeological occurrences.

By 1975, at least 500 Acheulean sites in South Africa have been recorded (Deacon 1975:552). Since that time, many more have been found. Many australopithecine specimens have been discovered in the numerous infillings of fissures, sinkholes, and limestone cave deposits or breccias in South Africa such as Sterkfontein and Swartkrans (Brain 1981; Butzer 1974; Clarke 1994; Howell 1978:154-185; Klein 1999; Kuman 1998). Isolated Acheulean artifacts are also found in later levels at these sites. Open-air Acheulean sites are also relatively common in South Africa.

While today most parts of North Africa are very dry, this region has produced some evidence for early hominid occupation since during some periods of the Pleistocene it was much wetter and could have supported larger numbers and kinds of fauna (Vrba 1995). North African sites have yielded some Oldowan (or pebble-culture) material (Freeman 1975:732; Sahnouni 1998:2-4). Acheulean sites are known throughout the Maghreb in North Africa and the Sahara including Ain Fritissa Spring, Ain Hallouf, Bear Cave, Cap

Chatelier, Casablanca (Thomas 1 Quarry Unit L), Qued el Khemis, Rhino Cave, Sidi Zin, Sidi Aberrahman and Tighenif (J.D. Clark 1982b:237-241; Raynal *et al.* 1995, 2001). In a review of the earliest occupation of Casablanca, it has been suggested that hominids only began to settle the area after the beginning of the Middle Pleistocene but much more extensively after 500,000 years ago (Raynal *et al.* 1995). Many isolated bifaces have been found on the surface in the Nile valley in Egypt and the Sudan, as well as along the Atlantic coast in West Africa suggesting that Acheulean populations occupied northeast and northwest Africa (Bar-Yosef 1998; J.D. Clark 1982b:239; Singer and Wymer 1978:16-19).

2.2.2 Middle East

According to Bar-Yosef (1975:582, 1994a:222), most Acheulean sites throughout the Middle East were excavated long ago. While research has been sporadic in the Middle East due to regional conflicts, more than 170 Acheulean sites have been recorded in the Central and Northern Levant (Hours 1975). A comprehensive account of known and excavated Acheulean sites throughout the Middle East and surrounding area is provided by Bar-Yosef (1998). An important contribution of Middle Eastern Palaeolithic archaeology is uncontroversial evidence for some of the earliest *Homo erectus* populations outside of Africa. 'Ubeidiya, located in the Jordan valley and dated to 1.5 mya is especially informative as there is preferential selection and usage of raw materials for certain finished tools (Bar-Yosef 1975:592; Bar-Yosef and Goren-Inbar 1993; Tchernov 1987). Many of the Acheulean sites throughout the Middle East were located along valley or mountainous regions and were open-air occurrences (Copeland and Hours 1989).

At Dmanisi, Georgia, *Homo erectus* remains have been recently found associated with pebble-core industries dated to 1.77 mya suggesting that some hominids may have left Africa before the development of the Acheulean (Brauer and Schultz 1996; Gabunia and Vekua 1995; Gabunia *et al.* 2000; Ljubin and Bosinski 1995). Dmanisi is an important site to document possibly the first migration of early hominids out of Africa (see section 2.4).

2.2.3 Europe

Lower Palaeolithic occupation in Europe is extremely varied (Roebroeks and Kolfschoten 1995). Absolute dating techniques for most sites throughout England have proved futile since material suitable for those methods are lacking (Gibbard 1994). Many sites have been provisionally placed within the Acheulean on the basis of biostratigraphical dating techniques and technological attributes of artifacts (Carbonell *et al.* 1999a:123).

Archaic *Homo sapiens* of the Late Middle Pleistocene are known to have occupied most of continental Europe, including much of southern England and the Iberian Peninsula (Aldhouse-Green 1998; Bermudez de Castro *et al.* 1997; Butzer 1986; Harding 1993; Mithen *et al.* 1992; Roe 1968a, 1981, 1995; Roebroeks and Kolfschoten 1995; Rolland 1998; Santonja and Villa 1994; Saville 1993; Villa 2001).

The majority of open-air Acheulean sites from Europe date to after 400,000 years ago, although there are some sites estimated to have been occupied earlier. A belief in the initial occupation of European sites only after 500,000 years ago has been referred to as the 'short chronology' (Roebroeks and Kolfschoten 1994), while evidence earlier than this time supports a 'long chronology' model. Many Portuguese sites centered around the Tagus Valley and the Lis Basin are believed to date to before 650,000 years ago (Cunha 1994). In Greece and the Balkans, there are Middle Pleistocene sites that contain Acheulean assemblages, such as Asprochaliko, Epirus, Eu-Tyrrhenian, Kokkinopilos, Vasilaki and Yarimburgaz Cave (Bailey *et al.* 1992; Darlas 1995; Higgs 1964, 1966; Reisch 1982; Runnels and van Andel 1993a:199-201, 1993b). Italy has evidence of Acheulean occupation at Torre en Pietra (dated to 434,000 years ago), Anagni in Latium (dated to roughly 458,000 years ago) and ten other sites listed by Villa (2001:117). The sites of Castel di Guido, Pofi and Visogliano, contain hominid skeletal remains that are morphologically similar to both *Homo erectus* and archaic *Homo sapiens* (Biddittu *et al.* 1979; Condemi and Mallegni 1994; Fedele 1978; Mallegni and Radmilli 1988; Piperno and Segre 1982). While it is generally accepted that Acheulean assemblages post-date the earliest "Mode 1" (core and flakes) in Africa and Europe (J.D. Clark 1994), Villa (2001:122) has recently argued that the opposite is possible in Italy. Sites such as Mount Piggiolo (dated by palaeomagnetism and three ESR dates to around 800,000 years ago) and Venosa Notarchirico (dated between 700,000 and 600,000 years ago by TL and K-Ar) have levels with and without bifaces. With the excavation of Level TD6, Gran Dolina, Spain, dating between 990,000 and 780,000 years ago, the idea of a pre-Acheulean sporadic occupation of Europe has gained support (Carbonell *et al.* 1995, 1999a).

2.2.4 Asia

Lower Palaeolithic sites are extremely rare in Asia (Petraglia 1998:360-365). When Acheulean hominids spread from Africa, they likely passed through India, so there is growing awareness that Acheulean occupation in India is much more diverse than previously thought (Corvinus 1998; Gaillard *et al.* 1986; Korisettar and Petraglia 1998:8-9; Korisettar and Rajaguru 1998; Mishra 1992; Mishra *et al.* 1995; Misra *et al.* 1982;

Mohapatra 1981; Paddayya and Petraglia 1993; Sankhyan 1997). Many Acheulean sites have been noted in India, sometimes in dense concentrations such as over 100 sites in the Hunsgi Valley alone (Paddayya 1982, 1989; Petraglia 1998:355). Future work excavating Acheulean sites throughout India and surrounding areas would probably prove to be very rewarding.

Both bifaces and core and flake tools are known to have formed an integral part of all Acheulean periods in South Asia (Ghosh 1982; Jayaswal 1982:138-143; Petraglia 1998; Petraglia *et al.* 1999; Sharma 1977). The Acheulean workshop site of Isampur, India, is gaining wider attention because of the discovery of dense accumulations of artifacts representing all stages of production (Paddayya *et al.* 1999, 2000; Petraglia *et al.* 1999). Singi-Talav in the Didwana region of the Thar Desert, India, has revealed many lithic artifacts (including around 120 bifaces) believed to represent a minimally disturbed site. Based on core and flake tools, the large and thick bifaces and the absence of Levallois technique, Singi-Talav is believed to date to within the Early Acheulean (Gaillard *et al.* 1983, 1986; Misra *et al.* 1982). There have even been claims for extremely early sites in Pakistan and surrounding regions. The site of Riwat, near Rawalpindi, has been estimated to be at least 2 million years old based on palaeomagnetism and fission-track dating. Pabbi Hills, Pakistan, and Kuldara, Tajikistan, date around 1.5 to 1.0 mya and 850,000 years old respectively by palaeomagnetism (Dennell 1998:296-297; Dennell *et al.* 1994; Keller *et al.* 1977; Petraglia 1998; Petraglia *et al.* 1999; Ranov *et al.* 1995). Some Middle Acheulean sites dated to 600,000 years ago include Bori in the state of Maharashtra, India, and Dina and Jalalpu both in the Jhelum basin, Pakistan (Dennell 1998:297; Mishra *et al.* 1995; Rendell and Dennell 1985). An Upper Acheulean site in Central India, Bhimbetka, has over 19,000 artifacts, 30% of which are shaped tools and small Levallois and discoidal cores were found (Misra 1987; Petraglia 1998:353). While scarce, Acheulean sites are known from Iran and Nepal (Corvinus 1990, 1998; Hume 1976; Mohapatra 1981; Singer and Wymer 1978). A very weathered and worn isolated Acheulean biface was uncovered 35 kilometres southeast of Tabriz, Iran, by Singer and Wymer (1978:23-25) suggesting occasional Acheulean occupation.

Most Acheulean East Asian sites lack bifaces altogether. Instead, lithic industries dominated by cores, core tools and flakes (similar to the core and flake "Mode 1" industry) predominate (Bartstra 1982; Bosinski 1982:168; Etler and Tianyuan 1994; Hutterer 1976; Jacobson 1979:475-476; Klein 1999:230-235; Luchterhand 1978:410-412; Pope 1989:53, 1993:57; Schick 1994; Schick *et al.* 1991: Tieu 1991:91; Valoch 1982:197). Almost 60 years ago, Movius noted that there was a technological disparity between Acheulean

assemblages of the Western Old World and these chopper-chopping tool assemblages of the Eastern Old World. Choppers are pebbles or cobbles that have been flaked in one direction while a chopping tool has been bifacially worked (Schick 1994:572). To account for these different technologies in different parts of the Old World, Movius suggested separate lines of cultural evolution on either side of what became known as the 'Movius line' (Movius 1944, 1948) (Figure 2.1). Since the Movius Line was proposed, archaeologists have attempted to refute the notion that Acheulean bifaces are not found in East Asia (Keates 1994, 1996). Bifaces believed to be from Lower Palaeolithic sites are known from Java, Indonesia (Soejono 1982), Chon-Gok-Ni in Kyuang-Ki province, South Korea (Yi and Clark 1983:183-184) and various sites within China (Barnes 1993:48; Bartstra 1976:76-99; Huang 1989; Ranov *et al.* 1995; Schick 1994). More evidence is required before it is widely accepted that bifaces were, on occasion, a technological part of the tool kit in East Asia.

At least four explanations have been proposed to account for the general lack of bifaces and for the presence of unifacial and seemingly not very complex chopper-chopping assemblages in East Asia. These explanations include local raw material variability (Leng 1998), hominids moving out of Africa without (or before) the Acheulean was widely used (Swisher *et al.* 1994), and regional environmental adaptations (Pope 1995). A fourth suggestion is that hominids in East Asia only started producing bifaces in the Late Pleistocene (Keates 1994).

It is possible that the lithic industry of eastern Asia developed into chopper-chopping tools when adequate stone resources, in the form of accessible outcrops, were not available for the continued manufacture of Acheulean assemblages (Pope 1988; Schick and Dong 1993). With the recent discovery of many large (in most typological respects seemingly typical) Middle Pleistocene bifaces in the Bose Basin, South China, dated to 803,000 +/- 3,000 years ago, the presence of an Acheulean has achieved some credibility, but only when hominids discovered suitable raw materials (Yamei *et al.* 2000). This theory assumes that biface technology was developed before hominids moved into East Asia.

However, hominids could have radiated out of Africa before Acheulean technology became known. The first *Homo erectus* populations to leave Africa could have been manufacturing core-chopping tools and, due to environmental/climate fluctuations, become isolated and separated from later groups who developed Acheulean technology (Bar-Yosef 1994a:255, 1998:227, 246; Clarke 1994:190-191; Keates 1994; Leng 1998; Pope 1995; Schick and Dong 1993; Schick and Toth 1993:277; Solecki 1985; Swisher *et al.* 1994). Such could have been the case for the early site of Dmanisi, Georgia (Gabunia *et al.* 2000).

Chopper-chopping tools could have been regional adaptations to tropical and heavily forested environments that provided tools in highly perishable natural organic materials such as wood or bamboo (Pope 1989, 1993, 1995; Pope and Keates 1994:533-536; Toth *et al.* 1992). From the predominantly heavy-duty industry composed of crude bifaces, core scrapers, coarse flakes, choppers and chopping tools in Nepal (e.g., Gadari in the Dang Valley and Satpati near Benighat), it has been proposed that an adaptation to wood or bamboo was practiced, a suggestion also proposed for similar sub-Saharan African assemblages (J.D. Clark 1993; Corvinus 1995, 1998; Jahren *et al.* 1997; Watanabe 1985). Microwear analysis of both bone and stone artifacts dating to earlier than 1 mya by Jahren *et al.* (1997) at the site of Donggutuo, Nihewan Basin, North China, was highly successful in differentiating between bone and bamboo use suggesting that perishable materials were an essential technological part of hominid adaptations in the area.

Hominid populations in East Asia may never have made bifaces until late in the Pleistocene (Bartstra *et al.* 1988; Keates 1994; Pope 1995:501-502). Pope and Keates (1994:556-558) show that all East Asian assemblages with small numbers of bifaces could belong to the Upper Palaeolithic rather than the Acheulean. The only way that this idea can be tested would be to have suitable material to conduct radiometric dating or have positive archaeological evidence of hominid skeletal remains in direct association. However, the evidence thus far does not permit a definitive answer.

Many Lower and Middle Pleistocene *Homo erectus* sites exist throughout southeast Asia and it was in this part of the Old World where the species was originally defined (J.D. Clark 1998; Etler 1996; Howells 1981; Isaac 1978b:145; Itihara *et al.* 1994; Pope 1983, 1994; Pope and Keates 1994; Sigmon and Cybulski 1981; Swisher *et al.* 1994). Many sites of Acheulean age here have been dated by biostratigraphy, lithostratigraphy and palaeomagnetism as materials suitable for chronometric dating techniques are rare or absent (Korisettar and Petraglia 1998:9-11; Pope *et al.* 1986). Some of the early Chinese sites believed to date to 1.15 million years old are Lantian, Yuanmou and Yunxian, all associated with *Homo erectus* cranial remains (An and Ho 1989; Chen *et al.* 1997; Leng 1998:424-425; Zhou *et al.* 1982). Donggutuo and Xiaochangliang, both in the Nihewan Basin about 150 kilometres west of Beijing, China, were re-investigated in 1988 and 1990 where many chert and quartz flake artifacts were found. These two sites were dated to 1 mya by palaeomagnetism and biostratigraphy (Keates 1994; Leng 1998:422-424; Schick *et al.* 1991).

2.3 Early Acheulean Adaptations in Africa

Up to 1.8 mya, hominids are only found in Africa. *Homo erectus* emerges around this time along with many other animal species when forested regions and zones of tropical climate shrank, and savannas and deserts expanded (Bar-Yosef 1995; Calvin 1990; DeMenocal 1995; Foley 1994; Jablonski *et al.* 2000; Kappelman *et al.* 1997; Maglio 1975, 1978; Partridge *et al.* 1995; Reed 1997; Rolland 1998:191-193; Spencer 1997; Turner 1992a, 1992b, 1994; Vrba 1985, 1993, 1994, 1995, 1996; Vrba *et al.* 1995). Rapid adaptations to fluctuations in environmental conditions might have been essential for the evolutionary success of *Homo erectus* populations (Cachel and Harris 1998:121-127; Franciscus and Trinkaus 1988; Spencer 1997:222-224). Some researchers see *Homo erectus* as a 'weed' taxon possessing generalized abilities to adapt and thrive in marginal habitats and environments (Cachel and Harris 1995). An opposing view is presented by Deacon (1998:27) who argued that Acheulean hominids were terrain specialists not able to adapt to changing environmental conditions and that they adapted specifically to living in valley-bottom wetland habitats. However, the archaeological record shows that Acheulean hominids occupied almost all possible site locations including hill tops, plateaus, oases, caves and valleys. They can be considered terrain opportunists able to occupy and exploit a variety of resources in different environments (Petraglia and Korisettar 1998). When a species can adjust to environmental stimuli by using technology, a greater range of environments can be occupied (Vrba 1980:247).

A significant technological breakthrough that might have enabled hominids to venture into new environmental and geographical regions was the successful use of fire. It has generally been assumed that sometime within the Lower Palaeolithic "hominids were already possessor[s] of fire of which, although they were probably unable to make it, they were successful users" (J.D. Clark 1987:825). Fire provides protection from carnivores, can be used for cooking meat by creating more digestible elements and the killing of parasites as well as creating social cohesion and allowing a greater range of exploitable environments through warmth (Bellomo 1994:175; Clark and Harris 1985; Clark *et al.* 1984:425; Pennisi 1999; Rolland 1998:203; Stahl 1984). Before fire usage became widespread, early hominids must have relied on a variety of plants and easily accessible underground items such as legumes, rodents, worms and grubs as evidenced from primate observation (Peters and O'Brien 1981, 1984; Wrangham *et al.* 1999).

Some very early and controversial claims for the use of fire (in the form of burnt materials, charcoal residue or hearths) exist for African sites prior to 1 mya. These include Swartkrans in South Africa at about 1.4 mya (Brain and Sillen 1988), Chesowanja, Kenya,

about the same time (Clark and Harris 1985; Gowlett *et al.* 1981, 1982; Harris *et al.* 1981; Ludwig 2000) and possibly Koobi Fora around 1.6 to 1.3 mya (Barbetti 1986; Barbetti *et al.* 1978, 1980; Bellomo 1994; Harris 1978:485-490; James 1989:2-3). As James (1989) has written, any purported evidence for human control over fire prior to 400,000 years ago needs to be rigorously re-examined in light of many natural processes that have been found to mimic intentional hominid use. For instance, while fire has been claimed for the site of Zhoukoudian in China (Movius 1948; Watanabe 1985), Binford and Ho (1985), Binford and Stone (1986:467) and Weiner *et al.* (1998) all believe that post-depositional processes could have mimicked the effects for evidence of fire at this site.

Having a versatile, opportunistic and generalized adaptation pattern, coupled with Acheulean lithic technology and fire may have made *Homo erectus* evolutionary successful, whereas other species (such as some forms of large carnivores and perhaps even other species of hominids) could not cope with changing environmental conditions (Brain 1981; Cachel and Harris 1998; Garcia and Arsuaga 1999:423-425; McHenry 1994a; Rogers *et al.* 1994; Rolland 1998:202-203; Turner 1994:245). During environmentally unstable times, hominids might have been forced to compete in similar niches with other predators and scavengers, increasing confrontational pressure.

From examining African faunal assemblages, it has been concluded that *Homo erectus* was well adapted to compete with other carnivores and scavengers for meat (Arribus and Palmqvist 1999; Blumenschine *et al.* 1994; Bunn 1986; Bunn and Kroll 1986; Cavallo and Blumenschine 1989; Gamble 1998a; Hartwig-Scherer 1994; Henry 1995b; Mann 1982; Rightmire 1991; Selvaggio 1994; Speth 1989). According to Marean (1989:560), "[h]igh predation pressure and the need to switch from a passive to confrontational scavenging or hunting strategy may have contributed to the rapid increase in body size from *Homo habilis* to *Homo erectus* and the closely coincident shift in stone tool technology." Group size, defensive technological adaptations (using thorned branches and projectile throwing behaviour) and increased body size and physical strength may have evolved primarily for protection (Blumenschine 1987; Cachel and Harris 1998:111-116; Calvin 1990; Grine 1985; Kappelman 1996; Kortlandt 1980; Lewis 1997; Marean 1989:575; McHenry 1994a; Oliver 1994).

High nutritional faunal elements (such as hind limbs) have been uncovered in many archaeological sites suggesting early access to carcasses since choice skeletal parts are most often selected first by carnivores and scavengers (Blumenschine *et al.* 1994). At many sites such as Mwanganda, Malawi (Clark and Haynes 1969), Elandsfontein, South Africa (Klein and Cruz-Uribe 1991), Ariendorf, Germany (Turner 1998), Torralba and

Ambrona, Spain (Freeman 1975, 1994), El Castillo, Spain, and level TD6, Gran Dolina, Spain (Bermudez de Castro 1996b; Diez *et al.* 1999; Made 1999), hominids are believed to have been directly responsible for the faunal accumulations. In order to identify hunting as opposed to scavenging in the archaeological record, the greatest meat-bearing parts of a carcass should be represented (Klein 1980; Klein and Cruz-Uribe 1984; Lupo 1998). A possible example of hunting can be found at the site of La Cotte de St. Brelade, Jersey (Callow 1986a; Callow and Cornford 1986; Scott 1986a, 1986b). Skeletal remains of mammoth and woolly rhinoceros were found to be systematically stacked along the inner cave walls according to species and body part representation that almost conclusively points to a single hunting episode.

It appears likely that Acheulean hominids occasionally acquired meat, perhaps through scavenging rather than hunting. Even if Acheulean hominids were capable of actively hunting game, it was likely not on the same behavioural level as modern hunter/gatherers, especially those living in Arctic conditions who subside primarily on meat and use tools much more technologically complex then that used during the Acheulean. Opportunistic hunting of small game animals and omnivorous subsistence strategies form the diet of most recent and modern hunter/gatherers such as the Hadza and San whose hunting success rate is often not very high (J.D. Clark 1975:641-648; Lee 1968; Peters and O'Brien 1981; Sept 1994; Stahl 1984; Tanaka 1976; Vincent 1985). Thus, it should be reasonable to assume that early hominids subsisted mostly on vegetarian foods. Perhaps Acheulean hominids supplemented their diet with fish as seen from aquatic animal remains in Bed II at Olduvai Gorge if they were intentionally accumulated (Stewart 1994) or the occasional scavenged, or perhaps hunted, animal. According to some researchers (Binford 1987; Chase 1988; Klein 1987, 1988:32), it is difficult to demonstrate hunting earlier than the Upper Pleistocene. "If it is fair to project backwards from the Middle Stone Age, Acheulean people were probably very ineffective hunters" (Klein 1983:32). When fauna is found in close proximity with stone tools, hominids can be assumed to have been a factor in their accumulation only when other site formation agents are eliminated (Clark and Haynes 1969; Isaac 1978c). When no faunal remains are present, use-wear on stone tool edges can suggest that meat was processed by the examination of microscopic physical breakage of chipped edges (Briuer 1976; Brose 1975; Keeley 1980; Keeley and Toth 1981; Odell 1980).

Use-wear analysis of stone tools has made huge progress since it was first used by Sven Nilsson (1787-1883) who was interested in explaining subsistence economies of prehistoric populations. He examined wear patterns on prehistoric artifacts and compared

them to ethnographic specimens to determine their function (Keeley 1980; Olaussen 1980:48; Semenov 1964; Trigger 1989:80). About 125 years later, J. Sonnenfeld (1962) explained how microwear studies could identify intentionally butchered material. Use-wear analysis has been applied at several sites dating to the Lower and Middle Pleistocene. Out of 54 artifacts from the Lower Pleistocene site of Koobi Fora, Kenya, nine showed clear evidence of use-wear characteristic of butchery practices (Bunn 1981; Keeley and Toth 1981). More recently, Sahnouni (1998:78) found use-wear (in the form of microscopic striations and polishes) on several lithic pieces from the site of Ain Hanech, Algeria, while Carbonell *et al.* (1999c:675-683) found positive evidence of use-wear on 8.9% (n=24) of the lithic material recovered from level TD6, Gran Dolina, Spain.

Identifying cutmarks on bone can determine the degree to which hominids butchered animals and was first used on Lower Palaeolithic materials by Keeley (1980) at the site of Hoxne, England. Few bones in Acheulean sites exhibit evidence of cutmarks, while others have been damaged by carnivores and scavengers. Without conclusive evidence of cutmarked bone and intentional physical displacement, it is difficult to determine if hominids were involved in their accumulation. The processing and dismemberment of hominids by other hominids may have occurred throughout the Pleistocene. If hominid bones were treated in similar ways as butchered animal bones, skeletal patterning can theoretically provide evidence for cannibalism. Through microscopic analysis, stone tool cutmarks have been identified on hominid bone remains where ligaments would have been attached (Arens 1979; Askenasy 1994). The earliest hominid cannibalism practices are possibly found at Sterkfontein, Member 5, South Africa, dating to the Plio-Pleistocene where a cranium of early *Homo* or late *Australopithecus africanus* exhibits three distinct groups of cutting strokes on the right side of the face (Pickering *et al.* 2000). At level TD6, Gran Dolina, Spain, hominid bones were found inter-mixed with faunal material. A quarter of all hominid remains within TD6 had cutmarks reflective of defleshing operations (Bermudez de Castro *et al.* 1999b:697; Fernandez-Jalvo *et al.* 1999:592). There are claims that some *Homo erectus* populations (around 500,000 to 300,000 years ago) intentionally altered hominid corpses either through defleshing, dismemberment or bone fragmentation. Possible evidence for these behaviours can be found at sites outside of Africa such as Bilzingsleben, Germany, Castel di Guido, Petralona, Pofi, Italy, Vértesszöllös, Hungry, as well as at Bodo, Ethiopia, where a hominid cranium dated to around 600,000 years ago has provided evidence of intentional defleshing (Ullrich 1994; Villa 1992; White 1986). While natural processes including carnivores or scavengers should not be ruled out, it seems cannibalistic

tendencies, while rare, may have been a small part of Lower and Middle Pleistocene hominid behaviour (White 2001). Studies attempting to distinguish hominid tooth marks from those made by other non-hominid carnivores might help to solve this problem (Oliver 1994).

Once Acheulean hominids were able to occupy similar adaptational niches as carnivores and scavengers through the use of fire and greater abilities (in either technology or body size) to accumulate faunal material were they able to spread out of Africa (Bar-Yosef and Belfer-Cohen 2001; Rightmire 1988; Rose and Marshall 1996). Increasing meat acquisition led to the development of larger brains and bodies within the modern range (Cachel and Harris 1998:113; Krantz 1968; Lewin 1993:129-140; Speth 1989), and a larger body enabled hominids to forage over greater distances (Holliday 1997; Rightmire 1995:486).

2.4 Colonization of Eurasia

When and in which direction did hominids colonize regions outside of Africa? Hominid occupation of Eurasia is generally acknowledged to have successfully occurred sometime after 500,000 years ago and is associated with interglacial environments and innovations such as control over fire (Bar-Yosef 1998:269; Gamble 1995; Roebroeks 1994; Roebroeks and Kolfschoten 1994). At this time in Africa, *Homo erectus* was beginning to be replaced by archaic *Homo sapiens*, which was distinguished by larger and rounder brain cases (Klein 1999; McBrearty *et al.* 1996:563; Rightmire 1996:35; Stringer 1986:59).

Some Mediterranean sites show that prior to the Middle Pleistocene, initial sporadic attempts at colonization occurred (Rightmire 1995:488; Turner 1994:246). Lower Palaeolithic artifacts and hominid remains come from Dmanisi, Georgia, dated to the Olduvai Normal Subchron between 1.95 to 1.77 mya (Gabunia and Vekua 1995; Gabunia *et al.* 2000). Based on reversed polarity, Isernia, Italy, is believed to be older than 780,000 years ago (Coltorti *et al.* 1981, 1982). Another site in Italy, Ceprano, is claimed to be at least 800,000 years old based on archaeological deposits occurring under a sandy volcanic gravel associated with *Homo erectus* remains (Ascenzi *et al.* 1996, 2000). Le Vallonet, France, is said to be more than 900,000 years old, thus standing as one of the oldest in Europe (de Lumley 1975). However, others think that it contains no conclusive evidence of hominids, since the "archaeological" materials could have been formed naturally within the cave (White 1995). During the summer of 1996, I helped to analyze many non-human bone pieces from Le Vallonet while working at the nearby cave site of Le Lazaret, France. Many were small, often unidentifiable, fragments that had been modified by porcupines

with no seemingly intentional hominid manipulation (Goldsmith 1996). Very recently a new hominid species, *Homo antecessor*, has been defined from Gran Dolina, Level TD6, at Atapuerca, Spain. Associated with pebble and flake tools, it is believed to have originated from *Homo ergaster* in Africa and shares morphological characteristics with both later African and European hominids (Bermudez de Castro *et al.* 1997, 1999a, 1999b). If any of the above sites are accepted as evidence for early occupation, (as well as the other sites listed by Carbonell *et al.* 1999a:123), they can be seen as possible short-term footholds throughout Eurasia.

A popular theory for the colonization of Eurasia is that of three waves of hominids spreading out from Africa at different times (Straus 2001). The first wave (around 1.8 mya) involved *Homo erectus* who manufactured core choppers and crude bifaces. The second wave (around 1.4 mya) consisted of perhaps *Homo erectus/ Homo ergaster*. The third wave of archaic *Homo sapiens* occurred around 780,000 years ago associated with changing environmental conditions caused by an increased frequency of glacials (Bar-Yosef and Belfer-Cohen 2001; Rightmire 2001; Saragusti and Goren-Inbar 2001; Servant 2001). Given that early dates exist for European and southeast Asia occupation, it might not be unreasonable to suggest that Eurasia could have been occupied at the end of the Lower Pleistocene. Due to the discovery of more sites dated to immediately after the Middle Pleistocene, hominid expansion into Europe may have occurred at least 280,000 years earlier than the generally accepted date of 500,000 years ago (Roebroeks and Kolfschoten 1994, 1995b).

In which direction did hominids leave Africa to colonize the Old World? Debates rage over whether they spread through northeast Africa and the Middle East, or northwest Africa and the Straits of Gibralter in the Iberian Peninsula. Evidence of early hominid occupation has been found in both areas. If *Homo erectus* populations migrated from Africa to Eurasia through the Middle East, then this natural land corridor has the potential for many other Early Acheulean discoveries (Bar-Yosef 1998:230-232; Rightmire 1991; Roe 1983b:440-441; Rolland 1998:206). Tchernov *et al.* (1994:328) wrote that "[t]he Levant remains the only potential corridor for human migrations out of Africa. These were as a rule associated with biotic dispersal events, mainly of large mammals." If hominids travelled from Africa through the Middle East following animal migrations and then to southwestern Europe, they would have likely brought the technique of making large bifacial tools on flakes with them.

Comparative studies of blanks for biface production can be beneficial to determine where certain kinds of technology originated (Straus 2001:93). Methods of artifact

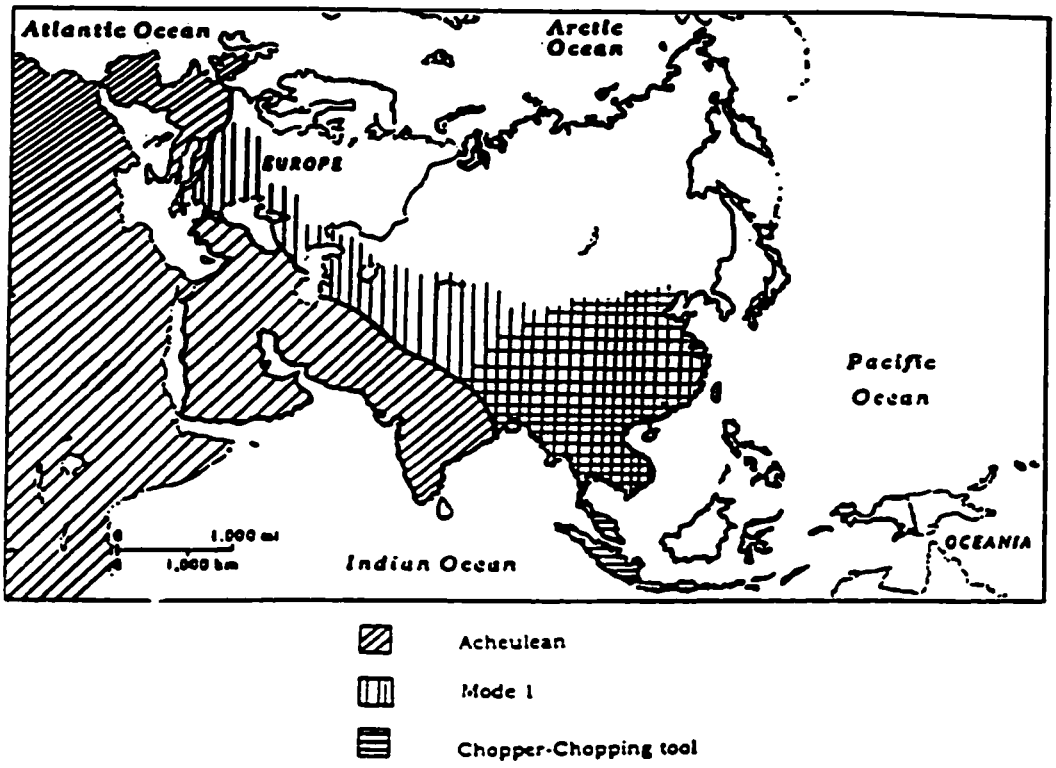
production vary within and throughout the Acheulean. In the Early Acheulean, African bifaces were made from cores whereas in the Middle to Upper Acheulean they were increasingly made from large flakes (J.D. Clark 1994; Toth and Schick 1986). The production of bifaces on flakes would suggest that hominids originated from East Africa, then spread to the Middle East and beyond. The technological feature of hominids producing bifaces on flakes has led some researchers to propose that sites discovered out of Africa with this tradition were created by African immigrants (Bar-Yosef and Goren-Inbar 1981, 1993; Freeman 1975:672; Gilead 1973:73; Goren-Inbar and Saragusti 1996:26; Goren-Inbar *et al.* 2000:946; Saragusti and Goren-Inbar 2001). Bifaces made on flakes are almost uniquely African, with the exception of Spain, southern France, and Gesher Benot Ya'aqov, Israel. Throughout Europe, bifaces were made from cores rather then flakes perhaps indicative that Acheulean hominids in Europe did not interact with Acheulean hominids from Africa or the Middle East, or that raw material differences can account for technological differentiation (Cranshaw 1983; Isaac 1977b; Robinson 1986; Roe 1968b, 1994a:149).

Based on biface technology from western Europe, it has been proposed that some hominid populations crossed into the Iberian Peninsula directly from North Africa rather than through the Middle East (Bhattacharya 1977:381; Raposo and Santoja 1995). Do both North Africa and the Iberian Peninsula belong to the same Acheulean tradition? Freeman (1975:672), Howell (1966:134,137) and Rolland (1986:124) point out that bifaces in both places tend to be manufactured on large flakes rather than cores, as elsewhere in Europe. Even if their bifaces are similar, the two regions seemed to have developed distinct and interrelated lithic technologies during the Lower Palaeolithic (Freeman 1975:662). Rolland (1986) believes that the hominids who passed over the Straits of Gibraltar adjusted their tool kit to take advantage of differing raw materials. This adaptation produced what is known as the Tayacian in southwestern France, where large unretouched flakes were used for finished tools. If the Tayacian is believed to be a local variant of the Acheulean from Africa, one would expect bifaces to be manufactured from large flakes. However, even if hominids travelled through the coastal route along the Straits of Gibraltar, archaeological evidence would be difficult to find due to changing sea levels.

Until more archaeological work is conducted, the Middle East remains the popular route of dispersal (Akazawa *et al.* 1992; Bar-Yosef 1994a; Freeman 1975:733; Rolland 1998; Santonja and Villa 1994:88-89; Straus 2001; Tieu 1991:100). There is much potential for further discoveries of sites of contemporaneous Acheulean age throughout

Eurasia. Since large areas still lie unexplored, statements about the Acheulean within one region may not be true for another (Dennell 1998; Gowlett 1998:63; Villa 2001:122). The Acheulean shows some variability within hominid species and technological complexes through time.

Figure 2.1 Biface/chopper-chopping tool distribution in the Lower Palaeolithic



Modified from Schick (1994:571).

Chapter 3
Explaining Acheulean Variability

[I]nterpret context before culture and never put all your bifaces in one basket.
Ashton and McNabb (1992:168).

Changes in the Acheulean over time and space can be examined by documenting the locations that hominids occupied, the technology they practiced and the cognitive processes exercised in tool production. The natural processes that modified archaeological sites must also be identified to determine the role of hominids in their formation.

3.1 Natural Site Formation Processes

As Schick (1992:6) notes, the majority of Acheulean sites were excavated before a full appreciation of site formation processes existed. Generally it is a combination of site formation processes that affect Lower Palaeolithic archaeological assemblages with water disturbance, bioturbation and disturbance by biological processes (Waters 1996:104) as the most prevalent processes (Schick 1986). Natural processes can destroy, displace or alter archaeological material and create confusing distribution patterns (Behrensmeyer 1978; Behrensmeyer and Hill 1980; Behrensmeyer *et al.* 1986; Bunn 1991; Collcutt 1986; Flenniken and Haggarty 1979; Gifford-Gonzales *et al.* 1985; Klein and Cruz-Uribe 1984:3-10; Klein *et al.* 1999; Marean *et al.* 1992; Schick 1992; Schiffer 1987, 1995; Shipman 1981; Stern 1993; Western 1980). As McNabb (1998:16) notes, archaeological sites are in many cases a "homogenized assemblage of artefacts. The recognition of behaviour...takes on the qualities of a contextual minestrone; chunk it all in then give it a stir." A way to get around this problem is to determine the extent of disturbance (context) and the processes that cause patterned artifactual associations.

The context of a site is determined by studying the spatial distribution of artifacts and other remains. Primary (or *in-situ*) sites represent areas where hominids used and discarded materials and where little subsequent disturbance has taken place. They are associated with fine-grained deposits that gently buries artifacts and bones (Bar-Yosef and Inbar 1993:190; J.D. Clark 1998:447-448; Schiffer 1987:199; Tringham *et al.* 1974). All phases of stone artifact reduction sequences may be present, as measured by refitting studies, including a full range of artifact (stone and bone) sizes suggestive of little post-depositional movement (Bermudez de Castro *et al.* 1999b:696; Carbonell *et al.* 1999b; Diez *et al.* 1999; Mallol 2000).

Assemblages classified as secondary are those that had been subjected to some sort of taphonomic disturbance, so that the place of final burial is not the original place of deposition (Petraglia and Potts 1994:229; Schiffer 1987:199). Due to the immense time involved, many Lower Palaeolithic sites have been disturbed and represent secondary deposits (Bar-Yosef 1994a:254; Bridgland 1998; Roe 1998; Wymer 1986:104). Deposits having been disturbed can still provide understandings of early hominid behaviours once those processes have been accounted for.

Documenting the kinds of sedimentary matrix in assemblages as well as artifact sizes can give indications as to the degree of assemblage disturbance. Artifacts deposited in silt and clay size particles would have been covered by slow-moving water, while greater concentrations of sand and gravel would normally be associated with artifacts disturbed by faster moving water (Shackley 1974, 1978) (Table 3.1). Larger grain sizes and artifacts will more likely be represented and perhaps even clustered together if flow velocity was strong, while smaller grain sizes and artifacts will survive if flow velocity was light (D. Boaz 1994; Boaz and Behrensmeyer 1976; Fahnestock and Haushild 1962; Hansen 1980; Menard 1950; Petraglia and Potts 1994; Potts 1988:65-69; Schick 1986:46-55; Shackley 1978). When a wide size range of tool and faunal types are experimentally subjected to fast-moving water, it is usually the smaller pieces (debitage and light skeletal parts such as ribs and vertebrae) that will be transported longer distances. In an analysis of archaeological materials east of Lake Turkana, Harris (1978:424-435) found a separation between smaller cores, flakes and skeletal pieces than those from larger (greater than 10 cm in maximum dimension) and heavier skeletal pieces and lithic materials. Assemblages will be differently affected by water flow velocity depending on the size and shape of artifacts. Occasional flooding may cause artifacts and grain size particles (particularly gravel) to become displaced or oriented in the direction of fluid flow in either a horizontal or vertical manner, a process known as imbrication (Isaac 1983a:238; Klein 1999:337; Schick 1986, 1987; Schiffer 1987; Waters 1996:27-28). At Kalambo Falls, Zambia, Schick (1992:17) noticed that greater densities of large artifacts (such as bifaces) tended to concentrate towards the southern end of an excavation trench and were inclined in a particular direction, while the northern section of the excavation seemed to contain an assortment of debitage. This size distribution is probably indicative of a flow trajectory throughout the site from south to north and accounts for *natural* artifact patterning within an occupational area. If both debitage-sized and larger artifacts are found in close proximity in an archaeological deposit, then fluvial processes could not have been dramatic and the degree of depositional disturbance was probably low.

Schick (1992:23) wrote that "[o]nce we turn more of our attention and energies to more of the less spectacular but better preserved sites, we should develop a better understanding of behavior patterns of Lower and Middle Pleistocene hominids." Small areas (5-10 m^2) with few artifacts in minimally disturbed contexts are known as 'mini-sites' (Isaac and Marshall 1981:106). Analyzing low density mini-sites was championed by Isaac (1977a:73) who excavated the Lava Hump Site (LHS), about 2 kilometres from the Main Site at Olorgesailie, Kenya. He was convinced that archaeologists had become mesmerized by spectacular concentrations of artifacts and tended to neglect smaller areas of material that could be in better context. John Gowlett (1986) re-excavated DK, in Lower Bed I at Olduvai Gorge because it preserved numerous Oldowan artifacts. Gowlett (1986:251) wrote that "the Olduvai sites must carry more weight than Hadar, Omo or East Turkana, where small numbers of tools...limit our judgement". While more lithic materials will undoubtedly aid our knowledge of typology, manufacturing processes and reduction sequences, more attention needs to be focused on primary context mini-sites to observe how hominids interacted with each other and the environment. Work in low density areas has been continued by Rogers and Harris (1992) and Rogers *et al.* (1994) in the Okote Member, Koobi Fora Formation, East Turkana. Duinefontein 2, South Africa, can also be considered a mini-site since only 817 artifacts (of which 770 are debitage) have been uncovered. Many of the faunal remains at Duinefontein 2 were found to be almost all fresh and unweathered and in near-perfect anatomical position suggesting primary context. This site can be used to examine the role of carnivores as 355 (33%) of all the faunal remains display unmistakable evidence of tooth marks (Klein *et al.* 1999). If discrete actions such as particular episodes of tool making or butchering can be identified in primary context mini-sites, they may provide indications of stone knapping or animal consumption behaviours, or the activities of other carnivores and scavengers.

3.2 Technological Variation Within the Acheulean

Not all archaeological assemblages during the Acheulean were made in the same way as several contemporary non-biface industries have also been identified. Understanding why and where these non-biface industries emerged may enable one to look at patterns in the Acheulean over time and space.

The Levallois production method involves flaking cores in predetermined ways to produce standardized flake or blade tools and involves a sequence of production events. Levallois production was first developed in the Middle Acheulean where many flake tools were being made, sometimes on the debitage of biface roughouts. A biface roughout could

be a failed biface production attempt or an intermediate stage of manufacture used for other flaking activities. Tuffreau (1982:142) suggests that the "Levallois technique was born from the transformation, perhaps accidentally, of handaxes into cores."

By the end of the Lower Palaeolithic, hominids had been manufacturing bifaces for well over one million years. If the process of manufacturing Acheulean bifaces occasionally and accidentally produced Levallois flakes, then why is there no evidence of these types earlier in time? A way to test this idea would be to compare the production methods of Early and Upper Acheulean bifaces to determine if Levallois flakes can be detached from both. Perhaps only at the end of the Lower Palaeolithic, when biface production became more complex through greater reduction and symmetry, would Levallois-like materials be produced. Levallois flakes and cores could have been unintentionally produced through the thinning of relatively thick biface butts in areas where raw material was not easily located (Bradley and Sampson 1978:115-120, 1986; Tuffreau *et al.* 1997:230-231). Where raw material was scarce, hominids could have re-flaked cores and bifaces for use. However according to Newcomer (1984:158), hominids who occupied Pontnewydd Cave, Wales, continued to produce bifaces and Levallois products in whatever raw material was locally available and do not appear to have recycled old lithic artifacts. It is difficult to believe that Levallois tools are by-products of biface manufacture because Levallois technology is not found in sites dating to earlier than the Middle Pleistocene.

All northwestern European Middle Pleistocene assemblages without bifaces or Levallois pieces have been called Clactonian (Ashton and McNabb 1992:167; Roe 1981:70-74; Singer *et al.* 1973; White 2000:8; Wymer 1974). Clactonian assemblages contain a large proportion of cores as well as crude and heavy flakes with poor retouch. Clactonian cores often appear unstandardized in shape and have deep flake-removal scars since only hard hammer percussion was used (White 2000). Hard hammer percussion generally resulted in less control over flakes than soft hammer percussion where bone, antler or wood was used for smaller, more precise flaking (Jones 1994).

There are at least three explanations for the existence of the Clactonian. (1) Clactonian assemblages could be the products of different hominid species from those who made and used bifaces (White 2000); (2) They could be an *ad hoc* expedient technology influenced by abundant raw material availability (Wenban-Smith 1998); (3) Clactonian sites could be specialized Acheulean activity areas where bifaces were not used or needed (Ohel 1979).

The first assumes that the hominids who made Clactonian tools were of a different species of *Homo* than those who regularly made and used Acheulean ones. Hominid remains are so rare in Clactonian sites that no definite conclusion can be reached (Wymer *et al.* 1993b:219). Clactonian assemblages could instead be a kind of *ad hoc* expedient technology based on abundant raw material availability for tool production (Gowlett 1998:63; Mithen 1994, 1996a; Wymer 1992:578-579). According to Jones (1994:297), hominids would have been much more casual with the use and discard of stone when they were close to raw material outcrops. Clactonian tools may have been produced on the spur of the moment in northern Europe, since it is a flint-rich landscape (Wenban-Smith 1998:90-95). But this idea fails to explain why debitage of Acheulean biface manufacture is found in some Clactonian sites.

The Clactonian could have been a distinct activity type within the Acheulean (Ohel 1977, 1979). Ohel (1990:84) argues that Clactonian occurrences are places where Acheulean hominids conducted preliminary flaking activities since there is usually much debitage present. Since bifaces and their by-products are known to be found in some Clactonian sites, it is no longer feasible to argue that the Clactonian was entirely distinct from the Acheulean (Ashton *et al.* 1994; Matyukhin 1980; McNabb and Ashton 1992; Weber 1981). In Britain (at sites such as Barnfield, Caddington, East Farm Barnham, Hoxne, the Lower Gravels at Swanscombe and the type-site for the Clactonian, Clacton-on-Sea), bifaces and biface-thinning flakes (characteristic flakes resulting from biface manufacture) have been discovered (Ashton and McNabb 1994:183-185; Ashton *et al.* 1994; Conway 1995; Gladfelter 1975:246-251; McNabb 1996a; McNabb and Ashton 1992; Waechter 1971; Wenban-Smith 1998:93). As Gowlett (1998:63) adds, "[i]n Britain, the older generation of archaeologists tend to maintain the distinction between two traditions, whereas a younger generation argues that the Clactonian and Acheulean are two facies of one technology." Perhaps this is due to the way Clactonian sites were excavated throughout the early to mid-20th century. If small flake artifacts were not entirely collected prior to the 1960s, it would be simple to conclude that debitage is lacking. When debitage became increasingly important to understand hominid tool behaviours (particularly with the younger generation of archaeologists), it was found that Acheulean debitage was acknowledged to come from Clactonian sites.

3.2.1 Acheulean Biface Function

A major area of Lower Palaeolithic research is to infer the function of artifacts (Carbonell *et al.* 1999a; Mallol 1999:403). Tool forms may represent preferred shapes best suited for specific reasons. According to Ludwig and Harris (1998:87-89), the first appearance of stone tools represent sophisticated manual dexterity and must have met some need. Oldowan tools are not very attractive "for archaeologists with a bent towards art history, but in functional adaptative terms...may have been perfect for the task on hand" (Isaac 1978b:142). Many Oldowan stone tools were most likely cores for flake removal, or heavy-duty butchering/battering tools (Toth 1985). These first stone tools were likely used to acquire meat since flakes detached from Oldowan cores could have been easily used to process animal carcasses (Isaac 1986:229; McGrew 1987). As Early Pleistocene hominids became more familiar with manufacturing techniques and raw materials, more complex and economical tool forms may have emerged (J.D. Clark 1980).

Acheulean hominids had a broad and flexible approach to the manufacture of bifaces since they could be made in almost any raw material (White 1998b). Even with minor variations in shape, size and weight, there are surprisingly similar morphological and technological characteristics in biface form across vast time and space. Over the years, many biface classifications have been created (Bordes 1988; Debanath and Dibble 1994:137-171; Roe 1968b; Wymer 1968). These have proved useful in documenting the kinds of artifacts found, but do little to explain why they occur in specific areas or what possible function(s) they served. Bifaces may be representative of basic adaptational behaviours, although identifying what they were used for remains problematic (Bartstra 1982; Bleed 1986; J.D. Clark 1994; Jones 1994:271; Korisettar and Petraglia 1998; McPherron 2000; Paddayya 1989; Roe 1981; Vaughan 1998; Yamei *et al.* 2000). If biface production and distribution can be directly related to hominid behaviour, then what are the function(s) of the biface? Six possible widely speculated functions have been proposed using experimental, ethnographic and theoretical studies: projectile weapons, butchering implements, digging/wood-working tools, cores for removing flakes, objects used for sexual selection pressures, or objects for multi-tasking.

Bifaces could have been used as specialized projectile weapons to kill or immobilize animals, thus widening the spectrum of hominid predatory abilities (Calvin 1982, 1983, 1990, 1993; Churchill 1994:20; Darlington 1975; Goldsmith 1998; Isaac 1987; Jeffreys 1965; O'Brien 1981, 1984). Incapacitating animals from a distance would have been evolutionary advantageous since close combat with carnivores, scavengers and other hominids must have been costly in terms of personal injury (Calvin 1990:177; Isaac 1987;

Read 1989:177-182). Projectile use could be one of the oldest techniques that hominids mastered since it has been occasionally noted in chimpanzee behaviour (Goodall 1964). Early hominid anatomical studies support the concept that overarm throwing could have been practiced (Calvin 1982; Napier 1962). While this theory is often dismissed due to the lack of archaeological evidence (Kleindienst and Keller 1976), it remains feasible.

Bifaces may also have been highly curated carcass processing/butchering tools (Ashton and McNabb 1994:189; Jones 1980; Mitchell 1995; Schick and Toth 1993:258-260; White 1994:4, 1998a:102). As Isaac (1986:233) stated, perhaps one of the reasons why bifaces become common in many African populations ca. 1.5 mya is that they either represented better adapted, more efficient tools for some tasks that had previously been carried out with Oldowan artefacts, or that new behaviours (e.g., hunting) were emerging at this time requiring new tools. Both Frison (1989:777-779) and Huckell (1979) have conducted butchery experiments on elephants and found that large bifaces work well for the removal and cutting of muscles, ligaments and tough skin. Thick sharp edges rather than the tip are the most important part of the tool for disarticulation. While bifaces have been found in close association with skeletal fragments of large animals at sites such as Torralba and Ambrona, Spain (Freeman 1994; Freeman and Butzer 1966), there generally appears to be an inverse correlation between bifaces and bone refuse. Sites with many bifaces (such as at Olorgesailie level DE/89 B and Isimila) have only small quantities of faunal material. While this pattern might represent a real association, it can likely be attributed to poor bone preservation (Binford 1972; Clark and Haynes 1969; Cole and Kleindienst 1974; Deacon 1975:556-557; Hansen and Keller 1971; Isaac 1975a, 1977a:88). Further butchery experiments and subsequent microscopic analysis of biface edges are essential (Freeman 1978b:88-89; Keeley 1980, 1993; Keeley and Toth 1981; Mitchell 1995, 1997, 1999; Shipman *et al.* 1981; Toth 1987).

Bifaces could also have been digging implements for the acquisition of plants and tubers or for wood and bark processing (J.D. Clark 1975:644, 1982b:236). At Member 5 at the Extension Site at Sterkfontein, South Africa, a biface has been uncovered with microwear on the tip characteristic of hacking motions from wood-working, rather than butchery (Binneman and Beaumont 1992; Isaac 1977a:88-89; Kuman 1998:176-178). Bone fragments believed to be evidence of digging activities for roots, bulbs, tubers or termites have been found at the early hominid sites of Swartkrans, South Africa (Backwell and d'Errico 2001; Brain 1982:695-705, 1993; Brain and Shipman 1993; Robinson 1959). If hominids used perishable materials for digging activities, they may also have used stone occasionally as well.

Bifaces may also be cores from which flakes were removed (J.D. Clark 1982a:248; Kelly 1988:718; Morrow 1996; Morrow and Morrow 2000; Toth 1985). However, as Wynn (1995:12) notes, most biface lateral edges appear to mirror their opposing side and hominids did not need to retain symmetrical edges for the purpose of flake removal. Many bifaces from Late Acheulean sites also have thinning flakes that would have been too small to have served any use.

Some researchers see the Acheulean biface as a product of sexual selection pressures. Kohn and Mithen (1999) examined the peculiar role that bifaces could have played during mate choice and have suggested that larger and better-made bifaces could be indicative of male reproductive fitness. The analogy of a peacock tail was used by Kohn and Mithen (1999:521) as a means to visually show-off good genes, thus, "the manufacture of a fine symmetrical handaxe [could] have been a reliable indicator of the hominid's ability to secure food, find shelter, escape from predation and compete successfully within the social group." Viewed in this way, the ability to make refined bifaces can be seen as the ultimate goal in Acheulean male social behaviour. Kohn and Mithen (1999:523) wrote that *Homo erectus* males might have focused more attention towards display behaviours in order to attract mates by producing conspicuously large bifaces. Females might have focused on manufacturing more practical, less refined bifaces. The theory of bifaces being produced as a response to sexual selection or as prestige items is almost impossible to prove since social ramifications of Acheulean hominids through the manufacture of bifaces has not been studied in detail. While highly amusing, this theory is perhaps the least accepted for what the Acheulean biface might have been used for.

The last possible function of the biface is that it was a multi-purpose tool combining some of the roles presented above (Keeley 1980:160-161; Lewin 1993:141-144; Ohel 1987). This last function is highly regarded in lieu of accepting some, or all of the other alternatives. Whatever the case, for any object to be repeatedly manufactured for over one million years, some basic functional need was met (Binford 1989:57; Draper 1985:5; Wynn 1995).

3.2.2 Acheulean Biface Style

Identifying style within Acheulean bifaces has been problematic. Was tool form and shape determined by functional and raw material constraints or by culturally transmitted group ideals? Each of these ideas will now be examined. A growing number of archaeologists argue that tools achieved their form because of raw material preferences,

availability and functional activity differences. The ultimate shape of a biface may have been determined by following the paths of least resistance with no cultural input (Ashton and McNabb 1994:187; 1996:236; Callow 1994; Gowlett 1996a, 1996b; Jones 1979, 1994; McPherron 1994, 2000; Movius 1978; Petraglia 1998:372-373; Pipeno and Segre 1982; Sackett 1982; Schick 1994; Stiles 1991:15-17, 1998; Toth 1985; Villa 1983; White 1994:15). The closer to raw material sources, the larger the bifaces, while conversely, if hominids had to travel farther distances to acquire raw material, smaller tools with greater utilization could be expected (Austin 1994:125; J.D. Clark 1980, 1988:295; Straus 1980). Jones (1994) collected raw material used by early hominids at Olduvai Gorge, and then manufactured replicas of various tool types. He concluded that some raw materials (such as fine-grained lava including phonolite, basalt or trachyandesite) were easier to work for larger tool forms, while granular material such as quartzite and chert were more often used for smaller, light-duty tools.

Raw material availability could have been the most important aspect for style in Lower Palaeolithic tools. If raw material sources had large pieces, tool forms can generally be expected to be larger in dimension than when smaller raw material was found. Bifaces might have achieved their shapes when hominids attempted to produce tools with heavy duty cutting edges. Such a tool could be repeatedly used or resharpened before its abandonment. In England, round ovate biface forms seem to have been manufactured when raw material from flint or chalk deposits was locally available. More pointed forms seem to have been preferred when the raw material was collected from gravel terraces (White 1994). Where ovates predominate (Boxgrove, Slindon and Lavant) over pointed forms (the Upper and Middle Gravels at Swanscombe and Red Barns), the former are more often refined to achieve the maximum amount of cutting edge (Ashton and McNabb 1994:185-187; Gamble and ApSimon 1986; McPherron 1995:58-60; Wenban-Smith 2000; White 1994:9; White and Pettitt 1995).

When variation in artifact types is a consequence of use, or where a choice was made among functionally equivalent alternatives, terms such as isochrestic style and activity facies explanation of variability have been proposed (Isaac 1975b:885; Sackett 1977, 1982, 1986a, 1986b, 1990). Desmond Clark (1982b:236) wrote that in "hunter/gatherer societies, form and function must be related and if this is so, then the form of the tool can be expected to reflect the purpose for which it was used." Following Jelinek (1977) and elaborated by Lindly and Clark (1990:233-234), the term "palaeoculture" is used to define hominid adaptations in lithic technology without regard to any predetermined symbolism. Thus, if the Acheulean biface represents evidence of

palaeoculture, then it developed in response to certain functional demands without engaging in any intentional symbolism. It seems likely that the symmetrical shape of a biface was retained over hundreds of thousands of years due to its functional efficiency rather than intentional culturally shared aesthetic style (Goldsmith 1997a:68, 1997b, 1998).

Another concept of style is one where hominid groups or individuals can visually differentiate themselves and their material objects from those of other cultural groups. This implies that community-wide symbolic styles or standards existed (Bar-Yosef 1975:592-593; Bordes 1960, 1970, 1972; Bradley and Sampson 1986:29; Cole and Kleindienst 1974:353; Conkey and Hastorf 1990:2; Gowlett 1996a; Roe 1964, 1968a, 1981, 1998:41; Stiles 1979:2; White and Dibble 1986:51; Wiessner 1983; Wollheim 1979; Wright 1977). Since only minor differences in shape exist from most of the Olorgesailie material and the British Late Acheulean site of Wolvercote, it is believed these assemblages were made by knappers who practiced similar reduction strategies (Gowlett 1998:61; Roe 1981:118-130; Tyldesley 1986a, 1986b). Bifaces or other tools produced as products of culturally shared traditions exhibit what is known as adjunct form (Sackett 1986a, 1990:33). Objects produced through adjunct form are where two knappers in a single group could have used different techniques to achieve the same purpose (Wymer 1986:105).

Through more detailed examinations of biface attributes across time and space (e.g., Roe 1994a), it may be possible to observe whether or not variations in assemblages are representative of either functional raw material constraints or were culturally determined. Combining both the activity facies explanation of variability and adjunct form, Kleindienst (1961:44) believes that variability in artifact shape across larger regions and through time was more likely to be related to functional differences, while variation in short time span sites were due to stylistic cultural differences. While it is almost universally accepted that symbolic behaviour was well in place by the beginning of the Upper Palaeolithic if not before (Chase 1991; Duff *et al.* 1992; Lindly and Clark 1990; Marshack 1976, 1996), aesthetic properties of Lower Palaeolithic artifacts are more difficult to infer because cognitive abilities of early hominids are poorly understood (Isaac 1972a:181-186).

3.3 Cognitive Abilities of Acheulean Hominids

Examining technological features of artifacts as a way to infer mental abilities of Acheulean hominids is gaining wider acceptance as a research method (Isaac 1986; Gibson 1993; McPherron 2000; Mithen 1996b; Noble and Davidson 1996; Wynn 1993, 1995; Wynn and Tierson 1990). According to Robson Brown (1993:233), archaeologists are in a unique position to study early hominid cognition because "[w]e have before us in lithic evidence the actual physical expression of specific cognitive processes." Since artifacts are the intentional result of decision-making processes (Cormack 1994:362), by examining what factors are involved in their acquisition, production, reduction and discard, it should be possible to interpret some of the cognitive abilities of early hominids (Byrne 1998; Chase 1994; J.D. Clark 1994:465; Lake 1998; McNabb 1998:16; Stiles 1979:1).

While it is common to stress that final biface shape reflects cognitive abilities and is a consequence of intentionality, known as the finished artifact fallacy (Davidson and Noble 1993:365; Gowlett 1984, 1986; Mithen 1994; Wynn 1979, 1991, 1995), McPherron (1994, 1995, 2000) argues that biface shape was not necessarily intentional. Through replication studies, he concludes that various shapes could represent only phases in a continuous reduction sequence and are not necessarily indicative of a final end product. Continuous reduction in artifacts could explain why in many Acheulean sites such as Olduvai Gorge and throughout England, a variety of biface shapes exist.

Archaeologists have examined individual knapping behaviour and reduction strategies through artifact refitting: the practice of reconstructing cores from the debitage, flakes and tools found in deposits. The provenience of these pieces in the deposits shows the steps involved in manufacturing sequences and the transportation of items across the landscape. The goal of refitting is to observe discrete production events from one specific time and place (J.D. Clark 1982b:236; Cziesla 1990:596-597; Cziesla *et al.* 1990b:2; Eickhoff 1990; Floss and Terberger 1990; Gamble 1998a:107; Kuhn 1991, 1994; Patterson 1990; Schafer 1990; Stapert and Krist 1990:386-394; Vaquero 1999). At the British site of Barnham, St. Gregory, England, a group of flakes have been successfully refitted onto a core (Ashton and Dean 1998:67). Refitting was so successful at Barnham that it revealed lithic reduction sequences amounting to "ten minutes of somebody's time, spent at the edge of a river, over some 400 kya. As such, it is a rare reflection of the individual we so commonly ignore" (Ashton and Dean 1998:71).

Refitting can provide indications of natural formation processes or intentional artifact removal (Petraglia *et al.* 1999). Post-depositional disturbance can be documented if most of the material has been affected in similar ways, such as the winnowing of smaller

lithic pieces or the preferential weathering on surfaces of larger objects (Arts and Cziesla 1990; Ashton and Dean 1998:67; Cziesla *et al.* 1990a; Symens 1986; Toth 1982). If sites preserve very small pieces of lithic material, they could be representative of a workshop or quarry area. Workshop areas are places where hominids produced lithic artifacts, while quarry areas are places where raw material was acquired.

The issue of cognition of early hominids has been extensively studied by Wynn (1979, 1981, 1993) who used Piagetian child developmental stages to postulate that early hominids were able to grasp the concepts of tool production. The study of how artifacts were made, used, resharpened and abandoned is known as the 'châine operatoire' or operational sequence of events leading to the final end-product (Austin 1994; Bar-Yosef and Meignen 1992:163-176; Geneste *et al.* 1990; White 1994; White and Pettitt 1995). The manner in which lithic tools are made is known as a reduction sequence and consists of raw material acquisition, manufacture, use, re-use and discard. At all these stages, it may be possible to reconstruct decision making, and thus cognitive processes.

The stages of a reduction sequence will now be summarized. First, a hominid is made aware for the need of a particular shape of tool in order to fulfill an objective (Isaac 1978c:227). Second, a choice of raw material is selected to achieve that form of tool. Third, flakes are removed following a combination of blank size, raw material properties, the ability of the knapper or traditional practices (Bradley and Sampson 1986:30). After manufacture and use, the artifact would have either been immediately abandoned, resharpened, or curated for future use. Some kind of accuracy is needed in order to shape nodules whose form, weight and orientation is constantly shifting with the removal of flakes. "By this we may understand that the individual is able actively to organize past reactions and experiences relating to a particular event" or events (Robson Brown 1993:242). This conceptualization of events is one of the hallmarks of human intelligence. Stiles (1998) examined raw material use by Oldowan hominids at Olduvai Gorge, Tanzania, and concluded that certain kinds of material were purposely selected, manufactured, and then transported over several kilometres for future use. While it is feasible that studies involving non-human primates can be potentially useful to describe technologies and subsistence behaviours of early hominids, Acheulean activities and stone tool manufacture such as resource acquisition and displacement are much too complicated than any observed range of contemporary ape behaviour (Gowlett 1984). While some stone artifacts (such as simple unretouched flakes) can be made by primates, the latter lack the cognitive processes and skills required to undertake a lithic reduction sequence (Bar-Yosef 1994b:107; Boesch 1993; McGrew 1987; Toth *et al.* 1993;

Westergaard 1995; Westergaard and Suomi 1994, 1996; Wynn 1981:537; Wynn and McGrew 1989). Early hominids who made Acheulean tools likely possessed the mental abilities of preconceived ideas (in the form of a need that would have helped to be met through stone tool use), actions through selective transportation of materials and events prior to them actually being carried out (Stiles 1998:145).

Did Acheulean hominids have the capabilities in the form of learned traditions, preconceived mental templates (the thought processes of observing what a finished tool should look like before actually engaging in reduction) and appreciation to produce symmetrical biface forms? According to some researchers they did (Megarry 1995:182-187; Roe 1994a; Vaughan 1998; Wynn 1979, 1981, 1985, 1991:200; Wynn and Tierson 1990). Since symmetrical Acheulean bifaces can be both striking and captivating in their appearance to the modern eye, perhaps early hominids also found them appealing. Producing symmetrical bifaces necessitates a preconceived idea of what an optimal tool should look like.

While the study of lithic reduction sequences is often the only way in which cognitive abilities of early hominids can be reconstructed, other evidence might be present. Claims of red ochre or mineral paint in Acheulean contexts has been postulated to represent evidence of symbolic behaviour (Klein 1999:441-442; Ullrich 1994:257, 1996). Early use of red ochre is suggested for Acheulean sites such as Becov in the Czech Republic dated to around 250,000 years ago, Gadeb, Ethiopia and Terra Amata, France (Clark and Kurashina 1979b:35; Marshack 1981; Wreschner 1980). However, Butzer (1980) and Noble and Davidson (1996:211) note that these early claims could be natural occurrences originating without regard to hominid involvement. Some Palaeolithic archaeologists argue that Acheulean hominids were not able to engage in symbolic activities (Bar-Yosef 1994a; Klein 1987).

There are some rare examples of flint bifaces that contain a marine shell in the centre (Megarry 1995:187; Noble and Davidson 1996:209-210; Oakley 1981). While choosing a piece of flint with a shell might be either intentional, accidental or simply luck, having the manual dexterity to shape a biface around it represents a level of cognition and skill not often attributed to Acheulean hominids. Since decorative objects are also rare in the Middle Palaeolithic (Kuhn and Stiner 1998), one has to be even more cautious for earlier periods (e.g., Mania and Mania 1988).

Examining the kinds of formational processes that have been at work must be understood before any cultural or cognitive conclusions can be drawn from archaeological sites (Kroll 1981; Pettitt 1997; Schiffer 1972). The following chapter compares the evidence

across time and space from a number of assemblages in order to see if any change can be found within the Acheulean.

Table 3.1 Wentworth grain-size classification

Clay	Particles with a diameter of less than 0.0039 mm.
Silt	Particles with a diameter of between 0.0039 and 0.0625 mm.
Sand	Particles with a diameter of between 0.0625 and 2 mm.
Gravel	Particles with a diameter of more than 2 mm.

After Waters (1996:20-21).

Chapter 4
Analysis of Data

Sticks and stones will break bones, but we will rarely find them.

This chapter will summarize the variables measured and patterns of relationships among some of them to observe if there was any change within the Acheulean. The sites and assemblages examined are listed in Table 4.1 and are described in more detail in Appendix 1. Section 4.1 describes the individual variables measured, why they were chosen and how they can be used to infer cultural complexity. Section 4.2 examines pairs of variables believed to show patterns in the Acheulean. The last part of Section 4.2 examines the inter-relationship of variables using Pearson's Chi-Square.

Since this study relied on published sources, reports with detailed artifact classifications or recently obtained chronometric dates were preferred. In sites with more than one archaeological level, assemblages that revealed something of unusual interest such as hominid skeletal remains or perishable organic materials were selected for analysis. The 50 sites examined, ranging from 1.8 mya to 200,000 years ago throughout Africa, the Middle East and Europe were subdivided into 92 individual assemblages. Site locations and age estimates are shown in Figures 4.1 to 4.6. Sixteen African sites (with 43 assemblages) including 10 from East Africa, three from South Africa and three from North Africa, 12 Middle Eastern sites (15 assemblages) and 22 European sites (34 assemblages) were chosen.

4.1 Variables

In order to observe if any change occurred over time and space within the Acheulean, a series of variables were constructed using the published literature (Table 4.2) including estimated age, date of site discovery, location, elevation and the site layout (open-air or cave). Since it has only been realized in the last 25 years that many natural processes can distort behavioural resolution, identifying how assemblages can be affected in these ways must be included. Information on assemblage formational processes, assemblage context, amount of artifact abrasion and degree of assemblage disturbance was also collected.

Other variables that will provide information about hominid behaviour include the presence or absence of faunal and hominid skeletal remains, cutmarked bone (bone bearing traces of stone tool cutmarks), worked organic material and fire. The number of artifacts, tools, bifaces, utilized material, debitage, Levallois material, kinds of

manufacturing techniques, artifact curation and possible site function were also noted, as well as the environment at the time of occupation (Table 4.2). Some data from the above variables that could not be conclusively placed into the present or absent category as based on the published literature have been included under the heading of missing.

Age of assemblage

Observing change within the Acheulean is only possible by examining estimated age of each assemblage. While assemblages were originally subdivided into 200,000 year intervals, it was found that less categories was more appropriate for further analysis. Age ranges were grouped into three phases of the Acheulean described in Section 2.1.1. These include Early Acheulean, dated to between 1.8 mya and 800,000 years ago (n=13 or 14.1%), Middle Acheulean, dated to between 800,000 to 400,000 years ago (n=43 or 46.7%), Upper Acheulean, dated to after 400,000 years ago (n=34 or 37.0%) or missing (n=2 or 2.2%) (Table 4.2). It is possible that hominid manipulation of the environment became more complex through time, or that hominid populations increased, enabling one to identify more behaviours and sites throughout the Acheulean.

Date of site discovery

The date of site discovery or when the first excavations were undertaken was originally subdivided by decade but due to small sample size it was recoded into three categories: sites discovered prior to 1900 (n=13 or 14.1%), between 1900 and 1949 (n=19 or 20.7%), 1950 or after (n=43 or 46.7%) and missing (n=17 or 18.5%) where data could not be determined (Table 4.2). The category of sites discovered in 1950 and later was used since chronometric dating was developing at this time, revolutionizing the whole time-line of palaeoanthropological research. The large number of sites discovered after 1950 is expected, since it was only during the 1960s that extensive palaeoanthropological work began, especially in East Africa (see Section 2.2.1). This variable was chosen since it might show how archaeological techniques and results have changed through time and will be useful to understand the biases of conducting a study such as this where artifacts were selectively kept in earlier excavations. The earliest work on an Acheulean site was undertaken by John Frere in 1797 at the site of Hoxne, England, where the great antiquity of the hominid species was first scientifically observed (Trigger 1989:87-89).

Site location

Site location was divided into three values representing Africa (n=42 or 45.7%), the Middle East (n=15 or 16.3%) and Europe (n=35 or 38.0%) (Table 4.2). The variable of site location was essential in order to observe the distribution of sites across space during the Acheulean.

Site elevation

Many reports did not include any information on site elevation. Originally, this variable was divided into 18 different categories but it was felt that grouping assemblages would provide better resolution for statistical analysis. Assemblages were divided into: 0 to 499 m above sea level (n=20 or 21.7%), between 500 and 1,499 m (n=11 or 12.0%), 1,500 m and over (n=5 or 5.4%) and missing (n=56 or 60.9%) (Table 4.2). It was believed that site elevation could provide information on hominid adaptational abilities through time as hominids became more successful at occupying a variety of sites in various elevations.

Site layout

Differences in hominid behaviour might be found according to site layout (either open-air or cave). Acheulean open-air sites were usually located close to a variety of natural resources including raw material, easily accessible foods, protection, but most importantly water (Isaac 1978c). The image of early hominids residing in caves is a popular one but belongs to later Middle Palaeolithic times (Aldhouse-Green 1998:140). The majority of sites (n=84 or 91.3%) examined here were open-air occurrences, while cave sites (n=8 or 8.7%) were not greatly represented due to sample size (Table 4.2).

Assemblage formational processes

The primary kinds of formational processes that have acted on each assemblage were noted. Most of the assemblages examined (62 or 67.4%) were subjected to some degree of water displacement as determined from the literature, while 13 assemblages (or 14.1%) could not be assessed. A variety of non-fluvial formational processes have been grouped together as other (n=17 or 18.5%) including debris flow/colluvial/soil creep, glacier, aeolian, spalling, trampling and hominid activity (Table 4.2). Grouping a variety of formational processes together seemed appropriate because of the small sample size used and showed that the majority of Acheulean assemblages were in some way affected by water disturbance.

Assemblage context

Depositional histories of each assemblage have been divided into either primary (n=40 or 43.5%) or secondary (n=40 or 43.5%); 12 assemblages (13.0%) had no information and have been grouped under the category of missing (Table 4.2). Assemblages in primary context will more often provide better behavioural resolution than assemblages in secondary context where material has been moved from their original point of deposition (see Section 3.1). Assemblages can be concluded to be in primary or secondary context depending on the kinds of sediments and the sizes of particles associated with artifacts.

Amount of artifact abrasion

As determined from published sources, the amount of mechanical abrasion on the majority of artifacts was noted. Assemblages were grouped into fresh to light abrasion (n=49 or 53.3%), medium to great abrasion (n=21 or 22.8%) and missing (n=22 or 23.9%) (Table 4.2). Through microscopic analysis, it is possible to determine the degree to which edges of artifacts were mechanically rounded due to the kinds and forces of assemblage disturbance. With medium to great abrasion, it can be expected that stronger fluvial processes have been acting on the assemblage than in the case of artifacts with fresh to light abrasion. Assemblages with greater abrasion can normally be assumed to have had heavier amounts of disturbance and thus would most often not be in primary context (Ashton and McNabb 1996:204) (Table 4.3).

Degree of assemblage disturbance

Degree of assemblage disturbance can be defined as the product or measure of taphonomic processes. This variable has been grouped into none to little (n=58 or 63.0%), medium to great (n=23 or 25.0%) and missing (n=11 or 12.0 %), as determined from the literature (Table 4.2).

Fauna

The association of faunal remains within Acheulean sites can lead to information concerning diet and behavioural adaptations of Pleistocene hominids who probably occasionally extracted marrow and processed meat as food sources (Goren-Inbar *et al.* 1994:109; O'Connell *et al.* 2000). In this thesis, 73 assemblages (or 79.3%) contained faunal remains, 17 (or 18.5%) did not and two (or 2.2%) could not be determined (Table 4.2). The variable of fauna can also provide information on site formation processes. If

the extent of faunal breakage and accumulation can be determined to have been caused by carnivores, hominids or both, observations pertaining to factors of site formation processes can be concluded.

Site environment

While hominids likely emerged in the savanna regions of eastern and/or southern Africa over 2 to 3 mya (M.G. Leakey 1995), different hominid species are known to have adapted to other environments over time. By the end of the Acheulean, hominids occupied a variety of environments such as savanna, grasslands, forests, woodlands and inter-mountain valleys perhaps to take advantage of animal migration routes and lithic material resources (Binford 1984; Diez *et al.* 1999: 644-649; Rollefson 1981; Valdes and Quiros 1992:107). The variable of environment has been subdivided into forested/ woodland (n=34 or 37.0%), savanna/grassland (n=33 or 35.9%) or missing (n=25 or 27.2%) (Table 4.2). Environment at the time of deposition can sometimes be elucidated by examining the geological and micro-faunal component. Micro-mammals are especially informative as they adapt much quicker to climatic fluctuations than larger animals, but usually become incorporated in an archaeological assemblage through non-hominid activities (Vrba *et al.* 1995). Environments throughout the last 3 million years are known to have been different than today. Many Eurasian Lower Palaeolithic sites seem to have been occupied during warm interglacial conditions, indicating that Acheulean hominids could not inhabit cold environments (Roebroeks 1994).

Hominid remains

The presence of hominid remains in association with faunal or lithic materials is of key importance since when a fragment of a hominid is uncovered, it has the potential to challenge commonly accepted opinions of human evolution. Hominids that could be associated with Acheulean artifacts are: robust forms of australopithecines, *Homo erectus, Homo ergaster,* archaic *Homo sapiens* and *Homo neanderthalensis*. Hominid remains were grouped into whether or not hominid fossils were present (n=20 or 21.7%) or absent (n=72 or 78.3%) in assemblages (Table 4.2) rather than by specific taxon as there will always be much heated debate and continuous re-classification concerning the correct classification of hominid skeletal remains (Ascenzi *et al.* 2000; Clarke 2000; Franzen 1994a, 1994b; Rightmire 1990).

Cutmarked bone

If microscopic cutmarks, striations or polishes can be identified on lithic, hominid or faunal remains, then they may show evidence for intentional dismembering or defleshing operations (Gorman and Mitchell 1995; Jensen 1988; LeMoine 1994; Moss 1987; Schultz 1992). This variable consisted of present/possible (n=34 or 37.0%) and absent (n=58 or 63.0%) (Table 4.2). Microscopic research on stone tool edges and faunal material began in the 1960s, (Semenov 1964) with a surge of research in the mid 1970s to mid 1980s (Anderson 1980; Keeley 1974, 1977, 1978, 1980; Odell 1975, 1980, 1988). As hominids became more successful at competing with carnivores and scavengers in the accumulation of animal remains (see Sections 2.3 and 2.4), it should be possible to document increasing utilization of faunal materials through the appearance of stone tool cutmarks.

Worked organic material

Use-wear analysis has been instrumental in the identification of intentional marks on organic material (Bhattacharya 1977:380; Freeman 1978a; Hare 1980; Steguweit and Mania 2000). Early examples of modified wood can be found at Schoningen, Germany, where throwing/stabbing spears have been dated to between 400,000 to 380,000 years ago (Dennell 1997; Thieme 1997). While preservational issues play a large part in the amount of organic material uncovered in assemblages, it should be possible to witness an increase in organic tools over time as hominids were becoming more capable of utilizing and manufacturing such materials. Only 22 (or 23.9%) assemblages contained intentionally worked organic material compared to 70 (or 76.1%) that did not (Table 4.2).

Fire

Was human control over fire a common phenomena in the Acheulean? While evidence for fire prior to around 400,000 years ago is highly controversial (James 1989) due to many natural taphonomic processes that can often distort the evidence (see Section 2.3), twenty three assemblages (25.0%) had possible evidence of fire, while 69 (or 75.0%) did not (Table 4.2). Fire usage can be indicated ands assessed through an examination of soil for traces of charcoal, bone that has been subjected to heat, and lithics that have fractures known as potlids induced by high temperatures (Barbetti 1986; Bellomo 1994; Callow *et al.* 1986; Cartwright 1986; James 1989).

Number of artifacts, tools, bifaces, utilized material and debitage

Many different categories have been developed over the years in order to document the range of artifacts within Acheulean assemblages. It is not surprising that artifact classification systems are not consistent between site reports (e.g., Bordes 1961, 1988; Isaac 1977a; M.D. Leakey 1971; Roe 1968b; Woodcock 1981:6-9). While this thesis initially followed the artifact classification of Glynn Isaac (1977a:233-236), who differentiated artifacts into categories of shaped tools, miscellaneous trimmed artifacts, utilized pieces, debitage and manuports, it soon became apparent that it had to be modified to accommodate different artifact classifications used in other reports and thus the terminology of Mary Leakey (1971:3-8) was also used. The Leakey classification enabled artifacts classified under different systems to be categorized. For example, Isaac (1977a) included spheroids (battered or rounded cobbles) under utilized pieces if they showed evidence of flaking or battering, while Mary Leakey (1971:4-6) included them under the larger category of tools. Miscellaneous trimmed artifacts of Isaac (1977a) have been placed into the broader category of utilized (or slightly worked) material here.

The number of stone artifacts per assemblage was calculated and grouped into categories numbering between 1 to 499 pieces (n=25 or 27.2%), 500 to 2,499 (n=35 or 38.0%), 2,500 and over (n=23 or 25.0%) with nine (or 9.8%) missing (Table 4.2). Tools were grouped into categories numbering between 1 to 199 pieces (n=49 or 53.3%), 200 and over (n=26 or 28.3%) with 17 (18.5%) missing (Table 4.2). Bifaces were grouped into categories numbering between 1 to 49 pieces (n=40 or 43.5%), 50 to 99 (n=15 or 16.3%), 100 and over (n=13 or 14.1%) with 24 (26.1%) missing (Table 4.2). Utilized material was grouped into categories numbering between 1 to 49 pieces (n=25 or 27.2%), 50 to 199 (n=17 or 18.5%), 200 and over (n=14 or 15.2%) with 36 (39.1%) missing (Table 4.2). Amount of debitage (flakes, chips and chunks) was grouped into categories numbering between 1 to 499 pieces (n=33 or 35.9%), 500 to 1,999 (n=22 or 23.9%), 2000 and over (n=24 or 26.1%) with 13 (14.1%) missing.

Amount of Levallois material

The percentage of Levallois material in relation to the tool category of each assemblage was divided into categories of none (n=72 or 78.3%), rare to some (n=10 or 10.9%), medium to great (n=4 or 4.3%) with six (6.5%) missing (Table 4.2). Assemblages classified as having rare to some Levallois products were those where the entire Levallois count was between 1 to 9% of the total percentage of tools. Assemblages that had medium to great Levallois counts were those where Levallois products amounted to 10%

or greater of the entire tool industry.

Artifact manufacturing techniques

The manufacturing techniques for the majority of artifacts in each assemblage were noted. The kinds of reduction methods have been grouped into hard hammer (n=18 or 19.6%), soft hammer (n=4 or 4.3%), a combination of both (n=30 or 32.6%) with 40 (43.5%) assemblages for which no determination can be made (Table 4.2). Hard hammer is defined as freehand stone on stone or bipolar percussion (a method by which a stone is placed upon an anvil and hit with another stone). Soft hammer is the use of bone, antler or wood for reduction processes. In preliminary reduction, particularly of bifaces, hammerstones are generally used, while in the shaping and final modification, soft-hammer percussion was often preferred (Jones 1994; Wynn 1995). It is possible that differences in manufacturing procedures can be witnessed through time as hominids became more proficient at using soft hammer percussion to produce more refined, symmetrical and smaller tools. Hard hammer percussion was predominantly used to make bifaces in the Early Acheulean, while soft hammer was becoming more dominant after this time (J.D. Clark 1994).

Artifact curation

Intentional resource movement can be examined by the degree with which hominids moved raw materials and tools throughout the landscape or kept items for future use, known as curation (Binford 1973, 1979, 1982). The action of manufacturing and using tools for immediate use at one spot is defined as expedient. Either curation or expedient behaviour can be determined from the amount of debitage uncovered within a site and refitting studies. Sourcing raw material to determine which geological outcrop they originated from can be used to conclude that hominids transported tools or raw material from one location to another. Curation can generally be concluded if many finished tools with little debitage are found suggesting tools were not made at the site but carried in, refitting studies are unsuccessful and natural formation processes are considered light. An example of curation can be seen at Koobi Fora, Kenya. In the Okote Tuff complex at Koobi Fora, no stone tools were found, but many cutmarked bones were discovered. Bunn (1994:263) concluded that early *Homo erectus* carried stone into areas where butchering of an animal carcass was carried out. The tools were then removed when the task was finished presumably to be re-used elsewhere.

Curation is believed to be exhibited in 10 assemblages (or 10.9%), while expedient behaviour has been found in 41 assemblages (or 44.6%). In 21 assemblages (or 22.8%), a combination of both curated and expedient behaviours were found as concluded by the association of debitage and some finished tools, while 20 assemblages (or 21.7%) were missing.

Site function

Site function was an essential variable to examine as much comparative information can be obtained between sites varying widely in both time and space. Hominids tended to occupy landscapes close to a variety of natural resources such as food, water and raw materials (Binford and Binford 1966:267-269; J.D. Clark 1975:641, 1987:816; Hill 1994:325; Mithen 1996b:132-134; Potts 1988:45). Upon examining site formational processes, particular functional activities can be postulated through the kinds, amounts and spatial distributions of artifacts (Bar-Yosef 1975:595-597; J.D. Clark 1975:624; Dibble and Mellars 1992; Dibble and Montet-White 1988; Wiessner 1983:173-174). Site functions were grouped into lithic modification areas (n=6 or 6.5%), animal modification areas (n=14 or 15.2%) or a combination of both lithic and animal modification areas (n=66 or 71.7%) with six assemblages (or 6.5%) missing (Table 4.2).

Assemblages designated as lithic modification areas are quarry and factory sites and are comparable to Type A sites as defined by Isaac (1971, 1978a, 1984) where lithic artifacts are present but no bone (Table 4.4). Quarry sites are places where hominids gathered and tested raw material for use at the outcrop. In some instances, tools might be found but there should be no faunal remains. Factory sites are places where raw material was brought to be made into tools. Factory sites usually contain lots of debitage and little or no faunal remains. It is possible that the lack of faunal remains are a consequence of preservational issues since they do not survive as long as flakes.

Sites with evidence of animal modification are comprised of both single and multiple animal hunting/butchering episodes (Table 4.4). Single hunting/butchering sites contain evidence that at least one (usually large) mammal was processed and is comparable to Isaac's Type B classification (Isaac 1971, 1978a, 1984). Normally this kind of site can be identified from lithic artifacts in close association with a carcass and characteristic butchering/disarticulation marks on some of the bones. Single hunting/butchering sites could represent areas where meaty parts of a carcass were intentionally removed to be consumed elsewhere. Multiple animal hunting/butchering sites show more than one (usually large) mammal having been exploited and are usually associated with

lithic artifacts. This type of site is similar to Isaac's Type C or campsite classification (Isaac 1981, 1978a, 1984). When combined, lithic and animal modification areas are otherwise known as living sites or home bases (Table 4.4). The term "living site" includes the association of animal bones generally interpreted to have been the result of food refuse and might contain residues of stone-knapping such as waste flakes, cores and perhaps some conjoinable objects and tools in various stages of reduction. Living floors, occupation floors or activity areas are distinct levels where a range of activities were carried out, or where one or several tasks (such as butchering or tool manufacture) can be identified in a seemingly restricted location within a site (Chavaillon *et al.* 1979:91; J.D. Clark 1987:825; Isaac 1984; Price 1978:1).

4.2 Analysis of Paired Variables

Variables that can be used to show patterns in the Acheulean are reviewed here. Section 4.2.1 will describe some of the variables that are believed to have some association of interest through time, followed by other variables that can be used to argue that the Acheulean was not a period of behavioural stasis (Section 4.2.2). Section 4.2.3 examined pairs of variables that were found to be statistically relevant through Pearson's Chi-Square measure of significance.

4.2.1 Associations Between Variables Over Time

The variable "assemblage date" was essential to identify behavioural patterns over time in the Acheulean. Site location and estimated age of each assemblage showed a predictable pattern, that is that since hominids originated in Africa the oldest sites were found here (Figure 4.7). Since there is still debate at the time of first European occupation (as discussed in Section 2.4), this data supports an initial occupation of before 500,000 years ago.

As Stanley Ambrose (2000) has mentioned, there is a tendency for Middle Stone Age hominids to occupy sites in higher elevations as those sites are more often closer to rock outcrops than sites of lower elevation. It is feasible that Upper Acheulean hominids understood that sites of higher elevation normally are places where rock suitable for tool manufacture can be found since many later Acheulean sites are located in similar elevations as Middle Stone Age sites (Figure 4.8).

Substantiating what kinds of sites predominate through time is difficult due to low sample size. It appears that only after 400,000 years ago did hominids began to use caves on a more regular basis, perhaps as a response to environmental adaptations throughout

Eurasia (Figure 4.9).

Over time, the presence of fauna in sites increases, particularly after 800,000 years ago (Figure 4.10). It is feasible that the increase in faunal material may represent more intense faunal acquisition through either hunting or scavenging. Perhaps this pattern can be explained by more recent excavations producing larger numbers of faunal remains than in older excavated sites where bone was generally discarded. While prior to 800,000 years ago savanna/grassland environments were preferentially chosen, the number of assemblages within forested/woodland environments increase over time (Figure 4.11). This can possibly be explained by the movement of hominids out of Africa into more heavily forested regions of Eurasia after 800,000 years ago.

Assemblages less than 800,000 years old contain slightly more evidence of intentionally cutmarked bone (Figure 4.12) and worked organic material (Figure 4.13) than earlier assemblages. With more data, it is possible that these patterns would have been enhanced since hominids after 800,000 years ago are believed to have been more systematic in their exploitation and displacement of fauna through more intense dismembering and defleshing operations and utilization of perishable materials than earlier times (Isaac 1984).

It was expected that age of assemblages and evidence of fire would be related since fire is generally thought to be required to colonize the European continent (Klein 1983:33; Stapert and Johansen 1999). While evidence for fire in most Acheulean sites is tenuous at best, it is only during the Upper Acheulean (400,000 to 200,000 years ago) where more sites show evidence for fire in association with artifacts (Isaac 1977a:94; James 1989; Schick and Toth 1993:215-216,280; Straus 1989). It was found that fire becomes only slightly more common over time (Figure 4.14). It must be stressed that only one quarter of assemblages contained potential evidence for fire. A larger data set might have shown a stronger pattern.

There seems to be a gradual increase in the number of artifacts (Figure 4.15), but particularly tools (Figure 4.16), within assemblages over time. As discussed below, with more artifacts there will necessarily be more tools, utilized material and debitage. Isaac (1972b:404) attributes the rise in the gross abundance and densities of artifacts through time to increasing sedentary habits and the greater reliance and subsequently the importance of stone tools whose production could have become a habitual past-time. An increase in the quantities of artifacts over time can be argued to show increased exploitation of the natural environment or larger hominid populations.

It was predicted that the amount of Levallois material would increase proportionately with time, since it is generally thought to be indicative of Upper Acheulean manufacturing traditions (Klein 1999:411). Since no assemblages have evidence of Levallois materials prior to 800,000 years ago, this variable is a good chronological marker to observe change in the Acheulean (Figure 4.17).

Kinds of manufacturing techniques seem to change through time (Figure 4.18). Hard hammer percussion is used almost exclusively in assemblages prior to 800,000 years ago, with both hard and soft hammer percussion becoming more common after this time. According to J.D. Clark (1994), the change from hard hammer to soft hammer manufacturing techniques distinguishes the Early Acheulean from the Upper Acheulean. However, it is possible that this pattern could be due to unequal representation of sample size since only six assemblages for which evidence of manufacturing techniques are known date to earlier than 800,000 years ago.

After 800,000 years ago, there is a noticeable increase in assemblages that show evidence for both expedient and curated behaviours as hominids exploited a variety of resources (Figure 4.19). It is feasible that a larger sample size would have shown that curated behaviours become more common through time as hominids were more capable of potentially planning for future events.

After 800,000 years ago, there is more evidence of hominids occupying areas for specific or single-activity functions (Figure 4.20). These include lithic and animal exploitation and a combination of both, exhibited at what are otherwise known as living sites/home bases.

4.2.2 Other Associations of Interest

Date of site discovery can be used to observe how archaeological interests have changed through time. As discussed in Section 2.2, much palaeoanthropological research began in the 1960s, a pattern observed in this research (Figure 4.21). Over time, with the understanding that assemblages in primary context can provide better behavioural information than assemblages in secondary context, more concentrated effort to find primary context assemblages began after 1950 (Figure 4.22). Similarly, more sites with less disturbance and less artifact abrasion were excavated after the 1950s because archaeological techniques and methods were beginning to address such issues by this time.

In the early years of Palaeolithic archaeology, little attention was placed on explaining change within archaeological populations and collecting entire artifact

assemblages (Renfrew and Bahn 1994:35; Willey and Sabloff 1993). More hominid remains (Figure 4.23), increasing evidence of fire (Figure 4.24), worked organic material (Figure 4.25) and cutmarked bone (Figure 4.26) were found after 1950 as it became known that such archaeological material can provide pertinent information about hominid behaviours. Many of the artifacts preserved in early collections can be attributed to collector bias. In other words, treasure hunters, amateur collectors and early archaeologists were not interested in collecting all remains, but rather only concentrated on preserving recognizable and unmistakable tools such as bifaces that were more aesthetically pleasing than unstandardized chips or chunks. More artifacts (and consequently tools, bifaces, utilized material and debitage) have been recovered from sites examined after 1950 (Figure 4.27).

When site location and site environment was examined, a pattern also emerged (Figure 4.28). The majority of assemblages in Africa are believed to have been in savanna/ grassland habitats as concluded in published reports, while the majority of European assemblages came from forested/woodland ones. It is possible that the successful occupation of Europe was a consequence of hominids adapting to new environments during the Middle Pleistocene (Avery 1995:474; M. G. Leakey 1995; Vrba 1985; Vrba *et al.* 1995).

As fluctuations in temperature in Europe can be more severe than in Africa and the Middle East, perhaps control over fire was a prerequisite for hominids living there. From the data, evidence for fire usage is only slightly more apparent in European sites than both African and Middle Eastern ones (Figure 4.29). Without more conclusive findings, fire can be tentatively concluded to have been at least one factor for early European occupation.

A relationship seems to exist between site elevation and artifact curation (Figure 4.30). Assemblages located at lower elevations appear to have a greater amount of expedient manufacture, while sites of higher elevations more often show a pattern of curated manufacture. Perhaps hominids curated materials to higher elevation areas where observation of game could have been undertaken or otherwise were places where raw materials could not be easily collected.

The only kind of site function determinable for assemblages over 1,500 m in elevation appears to be living sites where a variety of tasks were carried out (Figure 4.31). At lower elevations, it appears more single function activities such as lithic or animal exploitation were conducted. Sites of higher elevation may have been close to a variety of resources and thus more favourable for longer term occupation.

Both Gamble (1986:153) and Rolland (1981) note that bifaces are generally rare in caves throughout the Acheulean. This pattern is difficult to adequately show since few cave sites were examined here (Figure 4.32). A possible reason why bifaces might be rare in cave sites could be that the range of activities undertaken with bifaces (Section 3.2.1) were not done within the confines of a cave setting, but rather in other parts of the environment.

Curation or expedient behaviour can be seen from examining which kinds of site layouts were chosen. Six out of seven cave sites (85.7%) showed evidence for expedient behaviours (Figure 4.33). Perhaps hominids who occupied caves manufactured tools in some cases in, or directly near the cave itself as opposed to the manufacture of artifacts elsewhere and transporting them to a cave setting. Hominids tended to manufacture tools out of whatever raw material was locally available, including the walls of caves.

It seems that hominids tended to use caves for a variety of different functions, as seven out of eight cave sites (87.5%) were defined as living sites with evidence for both lithic and animal exploitation, as opposed to 59 out of 80 open-air assemblages (73.8%) (Figure 4.34). This pattern, however, could be due to the small number of cave sites identified and thus may not necessarily represent Acheulean behaviour in respect to caves.

Assemblage context and fire is an expected association (Figure 4.35). Positive traces of fire were present in 50% more cases when assemblages were in primary, as opposed to secondary context. A reason for this is that charcoal residue can very easily dissolve through the effects of natural taphonomic disturbance. While fire can be concluded to have been used through an analysis of soil color and texture changes in archaeological sites, evidence for hominid involvement can be misleading when assemblages are found in secondary context (Bellomo 1994; Binford and Ho 1985; Binford and Stone 1986). In other words, it would be more difficult to show if fire was present if an assemblage has been disturbed.

There appears to be greater resolution in site function when assemblages are in primary context because a greater range of behaviours can be identified (Figure 4.36), especially if artifacts had been subjected to microscopy and refitting analysis. Usually sites that are in secondary context reveal very little evidence of refitting and therefore evidence of discrete hominid behaviours (Catt *et al.* 1978).

When assemblages had no to little disturbance and fresh to light artifact abrasion, there was a much greater chance that artifactual patterns could be identified then when assemblages had medium to great disturbance and medium to great artifact abrasion.

Greater evidence of fauna, hominid remains, fire, worked organic material, cutmarked bone, and numbers and kinds of artifacts and Levallois products were found to be better represented when the amount of assemblage disturbance was little. Similarly, greater resolution in specific episodes of hominid behaviour such as curation and site function were also found. All of these patterns could be expected and do not warrant figures.

There is more evidence for hominid remains when faunal remains are also present, a pattern that can be explained in several ways. Perhaps taphonomic factors worked equally on both hominid and non-hominid bones so that in instances where fauna was preserved, there would be more chance of hominid preservation. Due to natural taphonomic processes, skeletal evidence of both hominids and fauna can become mixed at areas frequented by both groups, such as at water localities that were usually intensively scavenged by other animals. At places where hominids procured fauna, they might have stayed in the general locality longer while processing meat. Thus, at these localities, there is the possibility that hominids could have died at the spot by natural causes or by carnivores, which would have been attracted by the meat. Hominids may have made little distinction between faunal foodstuffs and other hominids as early cannibalism has been suggested (Fernandez-Jalvo *et al.* 1999; White 2001) (see Section 2.3).

Evidence of fauna and fire show a pattern very similar to that between fauna and hominid remains (Figure 4.38). In assemblages where fauna was present, there appears to be more evidence for fire usage. This pattern could indicate that hominids understood the principles of fire and its advantages to enhance their quality of life, such as the cooking of meat.

Levallois material tends to only be found in forested/woodland environments and not in savanna/grassland ones (Figure 4.39). While this pattern may be due to small sample size, perhaps Levallois technology could have been a behavioural consequence of hominids adapting to more heavily forested/woodland environments.

Since there appears to be no significant difference between site environment and artifact curation activities, Acheulean hominids throughout Africa, the Middle East and Europe could have been practicing similar lithic extraction and production behaviours in both forested/woodland and savanna/grassland habitats (Figure 4.40).

Hominid remains are absent at lithic exploitation areas and rare elsewhere (Figure 4.41). There appears to be more chance of hominid fossils becoming preserved in areas believed to have been used as living sites, perhaps because of longer terms of residency than in single activity sites.

More hominid remains should be expected where fire was used as fire usage probably points to a more prolonged stay, and thus there would be more chance of hominids dying in the general area. The relationship between hominid remains and fire was difficult to observe, probably due to small sample size (Figure 4.42).

Assemblages *without* cutmarked bone more often tend to produce evidence for Levallois manufacture (Figure 4.43), although it should be noted that the amount of Levallois material in assemblages is very low (Table 4.2). Perhaps Levallois material was not necessarily involved in defleshing operations but only used in initial hunting stages (*cf.* Kuhn 1993; Shea 1993). If Levallois material was a necessary part of butchering/ defleshing behaviours, one would expect more Levallois products to be uncovered where cutmarked bone was found. Experiments with hafted Levallois points and the kinds of microscopic damage they inflict on animal bones could lead to some interesting observations if they were used as hunting tools. It is possible that with a larger sample size, cutmarked bone would more often be found in assemblages with Levallois material.

Evidence for hominid intentional cutmarked bone assumes that animal exploitation was carried out. This predictable pattern has been observed in this research (Figure 4.44). Assemblages that were identified as lithic exploitation areas do not seem to contain any evidence for cutmarked bone since fauna is not equated with that kind of site function.

With more artifacts, there seems to be more evidence for expedient/curated behaviour (Figure 4.45). When hominids transported objects to and from sites, an observable consequence of such actions would be a larger number of artifacts in all stages of production.

There seems to be better identification of site function when fewer bifaces are found, perhaps indicative that bifaces served particular functions or were used for particular behavioural activities. However, when the number of bifaces was between one to 49, there was little difference between lithic and animal exploitation site types. Inferring function based on the number of bifaces (and other lithic material) could be misleading especially when low sample sizes and an unequal number of assemblages are used.

When numbers of utilized material and artifact curation are compared, there seems to be a pattern in that with fewer utilized lithic pieces, expedient behaviour was more common (Figure 4.47). This pattern is not surprising since one of the ways to test for expedient behaviour is to observe a range of lithic materials, especially utilized pieces and debitage.

An interesting question is what manufacturing procedure (either hard hammer or soft hammer percussion) produces more debitage? It seems that assemblages with less debitage (between 1 to 499 pieces) had greater chances of being produced by both hard and soft manufacturing techniques, while with a larger number of debitage (2,000 pieces and over), hard hammer percussion predominates (Figure 4.48). More experimental work is needed before any definite conclusions can be reached concerning the amount of debitage and the kinds of manufacturing techniques, although it may be tentatively concluded that hard hammer percussion produces more debitage than soft hammer.

There was more likelihood of assemblages believed to be lithic exploitation areas when less debitage was uncovered perhaps because episodes of tool making including discrete lithic reduction sequences through refitting, can be identified (Figure 4.49).

Levallois technology appears to most often be a feature of expedient behaviour (Figure 4.50). Perhaps hominids produced Levallois materials only when needed for immediate use or when they came across favourable raw material. When the variables of Levallois material and site function were compared (Figure 4.51), no Levallois products were found in assemblages for the purpose of animal exploitation, whereas the majority of assemblages with Levallois materials were found in living sites/home bases. Levallois technology leads to a greater degree of lithic standardization that Isaac (1986) attributes to a significant shift in hunting ability. If Levallois material was used for the purpose of hunting, then it would be expected that more Levallois evidence should be found in areas where animal exploitation was conducted. If Levallois points were hafted and used as projectiles, it is feasible some pieces would be discovered in direct association with faunal remains. It might be that Levallois points were removed from a carcass to be re-used at a later time. However, if carcasses were transported back to a living site for processing, then the Levallois points imbedded in the carcass would necessarily be discovered in those locations, although might not be a consequence (or even indicative) of butchering practices.

It was found that living sites have the largest amount of expedient technology (Figure 4.52). This is to be expected since hominids could have either manufactured tools at the location (a reason for such sites is the easily accessible range of materials), or that hominids brought materials with them from other areas to be used. Living sites can be considered to have been a general hub of activities where hominids engaged in a variety of behaviours, some of which were undoubtedly for lithic reduction processes. Sites believed to be indicative of animal exploitation areas appear more often as a feature of expedient behaviours. This could be explained by hominids processing animals at the

places where they were found or hunted, rather than the transportation of them to other areas.

4.2.3 Statistically Related Variables

To see what kinds of patterns exist within the Acheulean, some variables were subjected to a statistical analysis using Pearson's Chi-square. Chi-square results lead to a certain measure of association or level of confidence that a relationship exists between two variables that have finite numerical values. However, Chi-square results do not provide possible reasons on how or why two variable are associated. A major issue of Chi-square analysis is the problem of sample size (McClave and Sincich 2000:735; Shennan 1997:121). A larger sample size would have enhanced some of the patterns observed and might have led to other significant relationships and possibly greater associations between variables (Shennan 1997:115). Other than including more assemblages for study, small sample size was almost impossible to overcome. Some variables were recoded three times in order to reduce value categories. Upon reorganization, 23 pairs of variables were found to be statistically significant with a probability (p-value) of .05 or less. Any two variables that had a p-value of .05 or less were used to show that a statistical relationship exists. In other words, if the Chi-square result is significant, it would only be obtained by chance five percent of the time or under (as represented by p-values .05 and under). If significant, then the null hypothesis of both variables being independent would have to be rejected such that one variable is dependent on another (Christensen and Stoup 1986:444-446; Johnson 1988:341-349; S.P.S.S. 1993:206-209). The null hypothesis could be accepted if two variables are not statistically significantly through Chi-square and therefore both are independent so that one does not influence the other.

The location of a site and whether or not it was in primary or secondary context was statistically related with a Chi-square (X^2) of 16.746, two degrees of freedom and a p-value of <.001 (Table 4.5). Most of the 14 assemblages from the Middle East were in primary context (Figure 4.53). This could possibly be explained by archaeological research in the Middle East beginning after World War I, while only gaining momentum after World War II when more international and internal expeditions were permitted (Bar-Yosef 1994a). European assemblages seem to be split almost evenly between primary and secondary context, while African assemblages show approximately one third in primary context. The number of sites discovered increased dramatically after World War II (see Section 2.2) so a larger number of primary context assemblages have been uncovered.

After the 1960s, archaeological techniques and methods were also better equipped to deal with and analyze assemblages in primary context as it was only around this time that archaeologists were starting to ask broader behavioural questions and therefore to more closely examine site contents. Inquiring about behavioural issues brought about the realization that primary context assemblages would provide better behavioural resolution than secondary context assemblages.

Assemblage formational processes and amount of artifact abrasion were statistically related with a X^2 of 4.652, one degree of freedom and a p-value of <0.5 (Table 4.6). This relationship is expected since when fluvial/alluvial processes act on assemblages, there is a great probability that water action would wear down artifact edges and thus higher amounts of artifact abrasion will occur. It is likely that assemblages with fresh to light abrasion were subjected to slight fluvial disturbance while assemblages that showed medium to great abrasion were more effected (Figure 4.54). With high-energy fluvial environments (such as streams, currents and fast running tributaries), artifacts would more likely be displaced from their original context and undergo more extreme abrasion that causes flake removals and rounding of edges (Potts 1988:57-80; Sahnouni 1998:37; Schick 1986, 1987; Schiffer 1987:155; Shackley 1974, 1978; Sheppard and Kleindienst 1996:175). Assemblage context and degree of assemblage disturbance are related to the amount of artifact abrasion since with fresh to light abrasion and little to none assemblage disturbance, assemblages are likely to be found in primary context.

Assemblage context and evidence of fauna are related with a X^2 of 2.772, one degree of freedom and a p-value of <0.5 (Table 4.7). It would be easy to assume that assemblages in primary context would more often preserve faunal remains than sites in secondary context, but this appears not to be the case (Figure 4.55). Fauna is found in most assemblages, regardless of whether they are in primary or secondary context.

Assemblage context and number of tools are statistically related with a X^2 of 5.124, one degree of freedom and a p-value of <.05 (Table 4.8). Assemblages in primary context seem more likely to contain over 200 tools than assemblages in secondary context perhaps because artifactual material was not winnowed away in the distribution. Accumulations of tools in primary context assemblages could represent hominids who manufactured or transported lithics in close proximity to where they were discarded or lost (Figure 4.56).

More disturbance normally causes winnowing of smaller artifacts. With less disturbance, the chances of uncovering assemblages with more tools and debitage increases (Harris 1978:424-435). Greater assemblage disturbance does not normally

create discrete artifact clusters unless fluvial action washes material into a *cul de sac* (Schick 1986, 1987). A pattern similar to that observed between assemblage context and number of tools was found between degree of assemblage disturbance and number of tools and amount of debitage. With no to little disturbance, assemblages were more likely to preserve many tools and debitage.

Amount of artifact abrasion and number of tools are related with a X^2 of 4.642, one degree of freedom and a p-value of <.05 (Table 4.9). As suggested above, less abrasion normally means assemblages will more likely be in primary context and a larger number of artifacts may be preserved, an observation that can be tentatively concluded (Figure 4.57).

Site environment and evidence of fire are related with a X^2 of 4.947, one degree of freedom and a p-value of <.05 (Table 4.10). Evidence for possible or confirmed fire usage appears to be almost three time more likely in forested/woodland regions (12 of 34 assemblages or 35.3%) as opposed to savanna/grassland regions (four of 33 assemblages or 12.1%) (Figure 4.58) where Acheulean hominids are conclusively known to have lived in Africa (Isaac 1975). Since savanna/grassland regions are generally warmer then in forested or woodland regions, fire might not have been required for hominids to occupy the African savanna but could have been a precursor for hominids to colonize northern forested/woodland regions.

Site environment and worked organic material are related with a X^2 of 5.583, one degree of freedom and a p-value of <.02 (Table 4.11). Some assumptions of why these two variables appear to be related may be made (Figure 4.59). While 14 of 34 assemblages (41.2%) have possible or definitive evidence for worked organic material in a forested/woodland environment, only five of the 33 assemblages (15.2%) found within savanna/grassland environments do. Assemblages in forested/woodland environments seem to be almost three times as likely to contain evidence of worked material than in savanna/grassland assemblages. This difference may perhaps be that hominids in forested/woodland regions had a much broader range of perishable materials besides stone and bone to work with (such as wood). Wood may have been a much more common material in forested/woodland environments than in savanna/grasslands. It is also possible that organic preservation is simply better in non-savanna environments.

Evidence of hominid remains and cutmarked bone are related with a X^2 of 3.571, one degree of freedom and a p-value of <.05 (Table 4.12). Cutmarked bone more often appears in assemblages without hominid remains (Figure 4.60). It could be that hominids butchering and processed fauna in different parts of the landscape from where they died.

Evidence of fire and worked organic material are related with a X^2 of 9.638, one degree of freedom and a p-value of <.01 (Table 4.13). Most assemblages do not have any evidence of worked organic material. Those that do are spread almost equally between positive and negative fire usage so it appears that no relationship seems to exist between these variables (Figure 4.61).

Evidence of fire and cutmarked bone are related with a X^2 of 10.513, one degree of freedom and a p-value of <.001 (Table 4.14). Assemblages where cutmarked bones are absent predominate, likely due to their perishable nature (Figure 4.62). It was expected that cutmarked bone would more often be found in areas where fire is believed to have been used since both variables can be thought to be indicative of faunal consumption. Bones showing characteristic cutmarks can generally be thought of as the remains of butchery. In assemblages with both cutmarked bone and fire, it is very feasible that hominids both processed and cooked the meat. However, where present, assemblages with cutmarked bone are almost equally divided on the presence and absence of fire, so that fire was not necessarily needed for butchering and eating of meat. As fire is generally thought to only have become common during the middle part of the Middle Pleistocene (James 1989), hominids have been butchering meat without fire long before this time.

Evidence of fire and total numbers of tools are related with a X^2 of 7.313, one degree of freedom and a p-value of <.01 (Table 4.15). A seemingly negative correlation was observed because when fire was absent, many more assemblages with between 1 to 199 tools were found (Figure 4.63). When assemblages had over 200 tools, there was little distinction between the presence or absence of fire.

Evidence of fire and amount of debitage are related with a X^2 of 12.973, two degrees of freedom and a p-value of <.01 (Table 4.16). There seemed to be more debitage when fire was absent although there was no distinction when assemblages had over 2,000 debitage pieces of debitage (Figure 4.64). Without a larger sample size, it is difficult to conclude why the variables of fire and number of debitage appear to be associated. It is possible that if fire was used at a site where much debitage was produced, the evidence in the form of hearths might not survive.

Evidence of worked organic material and cutmarked bone are related with a X^2 of 15.880, one degree of freedom and a p-value of <.001 (Table 4.17). From microscopic cutmarked evidence, it is known that the defleshing of animals began in the Early Acheulean such as at Koobi Fora, Kenya, dated to around 1.7 mya (Keeley and Toth 1981). While hominids probably have always used perishable materials, the evidence in association with cutmarked bone is incredibly rare (Figure 4.65). The majority of

assemblages do not contain any evidence of cutmarked bone, but when present, are spread almost equally between assemblages with and without worked organic material. When evidence exists for either worked organic material or cutmarked bone, there appears to be a greater likelihood that the other would also be found perhaps due to preservational issues.

Evidence of cutmarked bone and amount of debitage are related with a X^2 of 6.783, two degrees of freedom and a p-value of <.05 (Table 4.18). There appears to be a correlation between the amount of debitage and the presence/absence of cutmarked bone (Figure 4.66). With more debitage, assemblages with cutmarked bone become slightly more numerous. Assemblages that contain traces of cutmarked bone may have been places where hominids processed larger numbers of animals or rather engaged in a variety of behavioural activities, including lithic manufacture. If hominids manufactured lithics in close proximity to where they butchered animals, this could explain why more assemblages with cutmarked bone have over 2000 pieces of debitage than assemblages when cutmarked bone was absent.

Total number of artifacts and tools are related with a X^2 of 25.348, two degrees of freedom and a p-value of <.001 (Table 4.19). This pattern is very easy to explain. With more artifacts in an assemblage, it can be expected that artifact kinds such as tools, bifaces, utilized material and debitage should increase (Jones 1994). With less artifacts, the amount of tools will not be as high (Figure 4.67). Likewise, numbers of artifacts and amount of debitage are also related with a X^2 of 75.327, four degrees of freedom and a p-value of <.001 (Table 4.20). In most cases, debitage in assemblages accounted for almost all artifacts, thus there is an obvious relationship (Figure 4.68). One of the consequences of producing utilized material is a proliferation of waste pieces. Thus, with more utilized material, it is expected that debitage pieces would increase. At sites where both bifaces and utilized material are present, perhaps flakes removed from a biface edge are classified as utilized pieces since they almost always seem to be part of a stage in the sequence of biface retouching. Perhaps this pattern is due more to the ways in which lithic assemblages are classified rather than hominid behavioural patterns; an issue previously raised by Isaac (1986:225).

A frequent explanation for many of the observable patterns outlined above could be due to longer periods of occupation producing more extensive behavioural actions and subsequently more archaeological residue. In other words, a prolonged stay at a certain locality could be the result of several factors such as proximity to water, lithic outcrops, shelter, animals and other foodstuffs. It is possible that hominid populations became

larger over time as hominids were able to successfully compete with other carnivores and scavengers and adapt to environmental stimuli thus accounting for more extensive land-use patterns. It will be argued in the next chapter that the patterns outlined from this analysis can be evidence of behavioural changes within the Acheulean.

Table 4.1 Sites and assemblages

Site Name / Location	Date in Years B.P.	Total Assemblages **Bold** = assemblages examined in this study	References
Olorgesailie - Kenya	990,000 - 450,000	- Many throughout Members 1 to 14 - **Isaac Site 3 (I 3)** - **DE / 89 Main; Horizon B**	Baker and Mitchell 1976; Bye *et al.* 1987; Isaac 1978d; Potts 1989; Potts *et al.* 1999; Shipman *et al.* 1981; Sikes *et al.* 1999.
Kapthurin - Kenya	700,000 - 240,000	28 assemblages - **Middle Silts - GnJj19**	Cornelissen *et al.* 1990; Leakey *et al.* 1969; McBrearty 2000; McBrearty *et al.* 1996, 2000; Tallon 1978.
Kilombe - Kenya	1.7 mya - 700,000	Many assemblages throughout AC, AH, EH and FH areas - **Gq Jh EH 1 Main**	Bishop 1978b; Gowlett 1978, 1986.
Olduvai Gorge - Tanzania	1.6 mya - 400,000	- **Upper Middle Bed II; EF-HR** - **Bed III; JK West A** - **Bed III; JK West B** - Bed III; Pink siltstone - Bed III; Clay above siltstone - **Base Bed IV; WK Hippo Cliff** - **Base Bed IV; PDK Trench IV** - **Base Bed IV; WK Lower Channel** - **Lower Bed IV; HEB East** - **Lower Bed IV; HEB Level 4; The Channel** - **Lower Bed IV; HEB Level 3** - Lower Bed IV; HEB - **Lower Bed IV; HEB West; Level 2B** - **Lower Bed IV; HEB West; Level 2A** - **Lower Bed IV; WK Intermediate Channel** - **Upper Bed IV; WK Upper Channel** - **Upper Bed IV; WK East A** - **Upper Bed IV; WK East C** - **Upper Bed IV; PDK Trenches I -III** - **Masek Bed; FLK** - **Masek Bed; HK** - **Masek Bed; TK Fish Gully**	Hay 1994; M. D. Leakey 1971, 1975, 1978, 1994; Plummer and Bishop 1994; Potts 1988; Roe 1994b.
Isimila - Tanzania	400,000 - 200,000	Many assemblages throughout Sands 1 to 5 - **Sands 3; K 19** - **Sands 1 - 1b; K 6** - **Sands 1 - 1a; K 14**	Cole and Kleindienst 1974; Hansen and Keller 1971; Howell *et al.* 1962, 1972.
Gadeb - Ethiopia	1.2 mya - 1.0 mya	More than 20 localities - **8 E**	J.D. Clark 1987; Clark and Kurashina 1979a, 1979b.
Bodo - Ethiopia	1.0 mya - 600,000	Many assemblages - **BOD A 1** - **HAR A 2** - **BOD A 2** - **HAR A 4**	J. D. Clark 1987; Clark *et al.* 1984, 1994; Conroy *et al.* 1978:67; Rightmire 1996; White 1986.

Table 4.1 continued: Sites and assemblages

Melka-Kunture - Ethiopia	1.5 mya - 250,000	More than 50 archaeological levels - **Garba IV** - **Garba III** - **Garba I**	Chavaillon *et al.* 1979; J.D. Clark 1988; Piperno and Piperno 1974-1975.
Kalambo Falls - Zambia	400,000 - 200,000	Several assemblages within areas A and B - **B 5 Lower**	Badein 1981:131-136; J.D. Clark 1962, 1969, 1975; Schick 1992; Sheppard and Kleindienst 1996.
Mwanganda - Malawi	400,000 - 200,000	Areas 1 to 2 - **Area 1**	J.D. Clark 1970b; Clark and Haynes 1969; Haynes 1970; Kaufulu and Stern 1987.
Montagu Cave - South Africa	250,000 - 150,000	Layers 1 to 8 - **Layer 3** - **Layer 5**	Keller 1970, 1973.
Elandsfontein - South Africa	700,000 - 400,000	No individual assemblage - Site examined as a whole	Deacon 1998; Klein 1988; Klein and Cruz-Uribe 1991; Singer and Wymer 1968.
Duinefontein 2 - South Africa	400,000 - 150,000	Horizons 1 to 3. - **Horizon 2**	Klein *et al.* 1999.
Ain Hanech - Algeria	2.0 mya - 1.7 mya	Layers 1 to 5 - **Layer 3; Gray Clay**	Jaeger 1975; Sahnouni 1998; Sahnouni and Heinzelin 1998.
El Kherba - Algeria	Missing	No individual assemblage - Site examined as a whole	Sahnouni 1998; Sahnouni and Heinzelin 1998.
Tigenif - Algeria	700,000 - 600,000	11 stratigraphic levels - **Level 2**	Dauphin *et al.* 1994; Freeman 1975; Geraads *et al.* 1986; Jaeger 1975.
Cape Ashakar - Morocco	400,000 - 200,000	11 zones - **Zones B1, B2, B3 - Plateau Gravels**	Howe 1967.
Yiron Plateau - Israel	200,000 - 100,000	8 units - **Y 25**	Brosh and Ohel 1981; Ohel 1982, 1983a, 1983b,1986a, 1986b.
Avivim - Israel	250,000 - 150,000	2 units - **A 43 (Nahalit)** - **A 63 (Mul Ha'amud)**	Ohel 1986a, 1990.
Gesher Benot Ya'aqov - Israel	730,000 - 240,000	13 to 14 assemblages - **Layer II 6; Level 4** - **Layer II 6; Level 1; Elephant Skull**	Belitzky *et al.* 1991; Fiebel *et al.* 1998; Goren-Inbar 1998; Goren-Inbar and Belizsky 1989; Goren-Inbar and Saragusti 1996; Goren-Inbar *et al.* 1992a, 1992b, 1994, 2000; Saragusti and Goren-Inbar 2001; Stekelis 1960; Verosub *et al.* 1998.
Evron Quarry - Israel	500,000 - 100,000	12 layers - **Layer 4**	Prausnitz 1969; Ronen 1991; Ronen and Amiel 1974; Tchernov *et al.* 1994.
Holon - Israel	250,000 - 150,000	5 units labelled A to E - **Stratum C**	Porat *et al.* 1999; Yizraeli 1967.
Kissufim - Western Negev	250,000 - 150,000	5 units - **Unit 3**	Ronen *et al.* 1972.
Berekhat Ram - Israel	500,000 - 350,000	10 units - **Unit 7; Paleosol B**	Feraud *et al.* 1983; Goren 1982; Goren-Inbar 1985.
'Ubeidiya Israel	1.5 mya - 1.4 mya	Dozens of layers - **I - 15 A** - **I - 26 C**	Bar-Yosef 1998; Bar-Yosef and Tchernov 1972; Bar-Yosef and Goren-Inbar 1993; Tchernov 1987.
Wadi Qalkha - Jordon	250,000 - 150,000	No individual assemblage - Site examined as a whole	Henry 1995a.
Adlun - Lebanon	250,000 - 150,000	Many levels - **Level C**	Copeland 1983; Kirkbride 1983; Kirkbride *et al.* 1983; Roe 1983a, 1983b.

Table 4.1 continued: Sites and assemblages

Latamne - Syria	700,000 - 500,000	No individual assemblage - Site examined as a whole	Bar-Yosef 1994a; J.D. Clark 1966, 1967, 1968, 1975; Sanlaville *et al.* 1993.
Dmanisi - Republic of Georgia	1.8 mya	No individual assemblage - Site examined as a whole	Bar-Yosef and Belfer-Cohen 2001; Bosinski 1995; Brauer and Schultz 1996; Dean and Delson 1995; Gabunia and Vekua 1995; Gabunia *et al.* 2000; Liubin and Bosinski 1995.
Markkleeberg - Germany	250,000 - 150,000	No individual assemblage - Site examined as a whole	Grahmann 1955.
Bilzingsleben - Germany	450,000 - 280,000	9 layers **- Layer 3**	Harmon *et al.* 1980; Mania and Mania 1988, 1995; Mania and Vlcek 1981; Mania *et al.* 1994; Schwarcz *et al.* 1988b; Svoboda 1987; Vlcek 1978.
Ariendorf Quarry - Germany	600,000 - 400,000	Horizons 1 to 3 **- Horizon I**	Kolfschoten 1990; Roebroeks *et al.* 1992; Turner 1998.
Kärlich-Seeufer - Germany	400,000 - 250,000	10 levels labeled units A to J **-Unit D**	Bosinski 1995a; Gaudzinski *et al.* 1996.
Vértesszőllős - Hungary	500,000 - 200,000	No individual assemblage - Site examined as a whole	Henning *et al.* 1983; Kordos 1994; Kretzoi and Vertes 1965; Kretzoi and Dobosi 1990; Svoboda 1987; Thoma 1981; Valoch 1995.
Torralba - Spain	750,000 - 550,000	10 Horizons Site examined as a whole due to lack of detailed information on each horizon	Butzer 1965; Freeman 1975, 1994; Freeman and Butzer 1966; Howell 1966; Howell and Freeman 1983; Howell *et al.* 1995; Shipman and Rose 1983.
Ambrona - Spain	750,000 - 550,000	Units 1 to 5 **- Lower Unit 3** **- Upper Unit 5**	Butzer 1965; Freeman 1975, 1994; Freeman and Butzer 1966; Howell 1966; Howell and Freeman 1983; Howell *et al.* 1995; Shipman and Rose 1983.
El Castillo - Spain	200,000 - 100,000	Many levels spanning Acheulean to Upper Palaeolithic **- Level 24**	Bischoff *et al.* 1992; Santonja and Villa 1994; Straus 1982, 1992; Valdes *et al.* 1992.
Gran Dolina - Spain	990,000 - 780,000	11 Levels - TD1 to TD11 **- TD 6**	Aguirre and Carbonell 2001; Arsuaga *et al.* 1993, 1999; Bermudez de Castro *et al.* 1997, 1999a, 1999b; Carbonell *et al.* 1999a, 1999b, 1999c; Carretero *et al.* 1999; Cuenca-Bescoc *et al.* 1999; Diez *et al.* 1999; Falgueres *et al.* 1999; Fernandez-Jalvo *et al.* 1999; Garcia and Arsuaga 1999; Lorenzo *et al.* 1999; Mallol 1999, 2000; Pares and Pares-Gonzalez 1999; Pares *et al.* 2000; Rosas and Bermudez de Castro 1999.
Isernia la Pineta - Italy	850,000 - 730,000	Sectors 1 to 2 **- Sector 1** **- Sector 2**	Coltorti *et al.* 1981, 1982; Mussi 1995.
Pontnewydd Cave - Wales	300,000 - 200,000	9 Beds **- Lower Breccia Bed**	Aldhouse-Green 1995, 1998; Collcutt 1984; Currant 1984; Debenham *et al.* 1984; Green 1984a, 1984b, 1986; Green *et al.* 1989; Huxtable 1984; Ivanovich *et al.* 1984; Molleson 1984; Schwarcz 1984; Stringer 1986.

Table 4.1 continued: Sites and assemblages

Caddington - England	400,000 - 200,000	4 sections subdivided into 8 layers lettered A to H - **Section 3; Layer G**	Bradley and Sampson 1978, 1986; Campbell and Sampson 1978; Catt *et al.* 1978; Sampson 1978; Smith 1894.
Boxgrove - England	600,000 - 400,000	7 deposits - **Slindon Sands; Lower Brickearth** - **Lower Chalk; Lower Brickearth; Channel Deposits**	Bergman *et al.* 1990; Calkin 1934; Curwen 1925; Roberts 1986a, 1986b; Roberts *et al.* 1994, 1995; Woodcock 1981.
Lavant - England	600,000 - 400,000	No individual assemblage - Site examined as a whole	Calkin 1934; Curwen 1925; Woodcock 1981.
Slindon - England	600,000 - 400,000	No individual assemblage - Site examined as a whole	Calkin 1934; Curwen 1925; Woodcock 1981.
Hoxne - England	400,000 - 200,000	Beds 1 to 9 subdivided into many units - **Bed 4; Upper** - **Bed 4; Stratum C; Lower Industry** - **Bed 5; Stratum C; Upper Industry** - **Bed 6**	Gladfelter 1993, 1998; Gladfelter *et al.* 1993; Singer *et al.* 1973; Wymer and Singer 1993; Wymer *et al.* 1993a.
High Lodge - England	500,000 - 400,000	6 units subdivided into beds A to L - **Old Collections** - **Bed C2** - **Bed D** - **Bed E**	Ashton *et al.* 1992; Bridgland 1994; Lewis 1998.
Swanscombe - England	400,000 - 300,000	10 levels - **Lower Middle Gravel** - **Lower Gravel Unit 4**	Barton and Stringer 1997; Conway 1996a, 1996b, 1996c, 1996d; Conway *et al.* 1996; Currant 1996; Gibbard 1994; McNabb 1996b; Stringer and Hublin 1999.
La Cotte de St. Brelade - Jersey	300,000 - 200,000	7 stages subdivided into layers A to H - **Stage III; Layer A**	Callow 1986c, 1986d; Callow and Cornford 1986; Scott 1980.
Nantet - France	Missing	Layers 1 to 4 - **Layer 4**	Thibault 1968; Villa 1983.
Terra Amata - France	250,000 - 200,000	7 occupation floors - **Dune** - **Beach** - **Lower Cycle**	de Lumley 1969, 1975; Villa 1983; Wintle and Aitken 1977.
Le Vallonnet - France	1.3 mya - 700,000	No individual assemblage - Site examined as a whole	Eschassoux 1995; de Lumley 1975; de Lumley *et al.* 1963, 1988; White 1995.

Table 4.2 Variables and values

Variable name	*Values*	*n*	%
Date of site discovery	< 1900	13	14.1
	1900-1949	19	20.7
	≥ 1950	41	46.7
	Missing	17	18.5
Site location	Africa	42	45.7
	Middle East	15	16.3
	Europe	35	38.0
	Missing	0	0
Age of assemblage	< 400,000	34	37.0
	400,000-800,000	43	46.7
	≥ 800,000	13	14.1
	Missing	2	2.2
Site elevation	0-499 m	20	21.7
	500-1,499 m	11	12.0
	≥1,500 m	5	5.4
	Missing	56	60.9
Site layout	Open air	84	91.3
	Cave	8	8.7
	Missing	0	0
Assemblage formational processes	Fluvial/alluvial	62	67.4
	Other	17	18.5
	Missing	13	14.1
Assemblage context	Primary	40	43.5
	Secondary	40	43.5
	Missing	12	13.0
Amount of artifact abrasion	Fresh-light	49	53.3
	Medium-great	21	22.8
	Missing	22	23.9
Degree of assemblage disturbance	None-little	58	63.0
	Medium-great	23	25.0
	Missing	11	12.0
Fauna	Present/possible	73	79.3
	Absent	17	18.5
	Missing	2	2.2
Site environment	Forested/woodland	34	37.0
	Savanna/grassland	33	35.9
	Missing	25	27.2
Hominid remains	Present/possible	20	21.7
	Absent	72	78.3
	Missing	0	0
Cutmarked bone	Present/possible	34	37.0
	Absent	58	63.0
	Missing	0	0
Worked organic material	Present/possible	22	23.9
	Absent	70	76.1
	Missing	0	0

Table 4.2 continued: Variables and values

Variable name	*Values*	*n*	*%*
Fire	Present/Possible	23	25.0
	Absent	69	75.0
	Missing	0	0
Number of artifacts	1-499	25	27.2
	500-2,499	35	38.0
	≥ 2,500	23	25.0
	Missing	9	9.8
Number of tools	1-199	49	53.3
	≥ 200	26	28.3
	Missing	17	18.5
Number of bifaces	1-49	40	43.5
	50-99	15	16.3
	≥100	13	14.1
	Missing	24	26.1
Amount of utilized material	1-49	25	27.2
	50-199	17	18.5
	≥ 200	14	15.2
	Missing	36	39.1
Amount of debitage	1-499	33	35.9
	500-1,999	22	23.9
	≥ 2000	24	26.1
	Missing	13	14.1
Amount of Levallois material	None	72	78.3
	Rare-some	10	10.9
	Medium-great	4	4.3
	Missing	6	6.5
Artifact manufacturing techniques	Hard	18	19.6
	Soft	4	4.3
	Hard-soft	30	32.6
	Missing	40	43.5
Artifact curation	Expedient	41	44.6
	Curated	10	10.9
	Expedient/curated	21	22.8
	Missing	20	21.7
Site function	Lithic	6	6.5
	Animal	14	15.2
	Lithic-animal	66	71.7
	Missing	6	6.5

Table 4.3 Abrasion categories

Fresh	Majority of artifacts did not appear to have any abraded characteristics. All edges were found to have remained generally sharp. Most often suggestive of primary context.
Light	Most artifacts experienced only slight abrasion with many object edges being relatively sharp. If the majority of artifacts appeared to be very lightly abraded, then it is possible to assume they have not traveled far from their original placement. Usually suggestive of primary context, although some sites could be in secondary context.
Medium	Some artifacts were very abraded, while an equal amount were only slightly so. Usually suggestive of secondary context.
Great	Most artifacts experienced a great amount of abrasion, such that their original surface could not be determined with any accuracy. Most often suggestive of secondary context.

Table 4.4 Site function

Lithic modification	- Quarry - Factory
Animal modification	- Single animal hunting/butchering - Multiple animal hunting/butchering
Lithic and animal modification	- Living site/home base

Table 4.5 Site location by assemblage context

		Assemblage context		Total
		Primary	Secondary	
Site location	Africa	11	25	36
	Middle East	14	1	15
	Europe	15	14	29
Total		40	40	80

X^2 = 16.746 Df = 2 P<.001 Missing = 12

(Degrees of freedom)

Table 4.6 Assemblage formational processes by amount of artifact abrasion

		Amount of artifact arasion		Total
		Fresh-Light	Medium-Great	
Assemblage formational processes	Fluvial/Alluvial	28	19	47
	Other	15	2	17
Total		43	21	64

X^2 = 4.652 Df = 1 P<.05 Missing = 28

Table 4.7 Assemblage context by fauna

		Fauna		Total
		Present/ Possible	Absent	
Assemblage context	Primary	30	10	40
	Secondary	34	4	38
Total		64	14	78

$X^2 = 2.772$ Df = 1 P<.05 Missing = 14

Table 4.8 Assemblage context by number of tools

		Number of tools		Total
		1-199	≥ 200	
Assemblage context	Primary	18	16	34
	Secondary	29	8	37
Total		47	24	71

$X^2 = 5.124$ Df = 1 P<.05 Missing = 21

Table 4.9 Amount of artfiact abrasion by number of tools

		Number of tools		Total
		1-199	≥ 200	
Amount of Artifact abrasion	Fresh-Light	24	19	43
	Medium-Great	16	3	19
Total		40	22	62

$X^2 = 4.642$ Df = 1 P<.05 Missing = 30

Table 4.10 Site environment by fire

		Fire		Total
		Present/ Possible	Absent	
Site environment	Forested/ Woodland	12	22	34
	Savanna/ Grassland	4	29	33
Total		16	51	67

$X^2 = 4.947$ Df = 1 P<.05 Missing = 25

Table 4.11 Site environment by worked organic material

		Worked organic material		Total
		Present / Possible	Absent	
Site environment	Forested/ Woodland	14	20	34
	Savanna/ Grassland	5	28	33
Total		19	48	67

$X^2 = 5.583$ Df = 1 P<.02 Missing = 25

Table 4.12 Hominid remains by cutmarked bone

		Cutmarked bone		Total
		Present/ Possible	Absent	
Hominid remains	Present/ Possible	11	9	20
	Absent	23	49	72
Total		34	58	92

$X^2 = 3.571$ Df = 1 P<.05 Missing = 0

Table 4.13 Fire by worked organic material

		Worked organic material		Total
		Present/ Possible	Absent	
Fire	Present/ Possible	11	12	23
	Absent	11	58	69
Total		22	70	92

$X^2 = 9.638$ Df = 1 P<.01 Missing = 0

Table 4.14 Fire by cutmarked bone

		Cutmarked bone		Total
		Present/ Possible	Absent	
Fire	Present/ Possible	15	8	23
	Absent	19	50	69
Total		34	58	92

$X^2 = 10.513$ Df = 1 P<.001 Missing = 0

Table 4.15 Fire by number of tools

		Number of tools		Total
		1-199	≥ 200	
Fire	Present/ Possible	7	11	18
	Absent	42	15	57
Total		49	26	75

$X^2 = 7.313$ Df = 1 P<.01 Missing = 17

Table 4.16 Fire by amount of debitage

		Amount of debitage			Total
		1-499	500-1999	≥ 2000	
Fire	Present/ Possible	5	2	12	19
	Absent	28	20	12	60
Total		33	22	24	79

$X^2 = 12.973$ Df = 2 P<.01 Missing = 13

Table 4.17 Worked organic material by cutmarked bone

		Cutmarked bone		Total
		Present/ Possible	Absent	
Worked organic material	Present/ Possible	16	6	22
	Absent	18	52	70
Total		34	58	92

$X^2 = 15.880$ Df = 1 P<.001 Missing = 0

Table 4.18 Cutmarked bone by amount of debitage

		Amount of debitage			Total
		1-499	500-1999	≥ 2000	
Cutmarked bone	Present/ Possible	7	7	13	27
	Absent	26	15	11	52
Total		33	22	24	79

$X^2 = 6.783$ Df = 2 P<.05 Missing = 13

Table 4.19 Number of artifacts by number of tools

		Number of tools		Total
		1-199	≥ 200	
Number of artifacts	1-499	19	2	21
	500-2499	25	9	34
	≥ 2500	3	15	18
Total		47	26	73

X^2 = 25.348 Df = 2 P<.001 Missing = 19

Table 4.20 Number of artifacts by amount of debitage

		Amount of debitage			Total
		1-499	500-1999	≥ 2000	
Number of artifacts	1-499	20	0	3	23
	500-2499	11	20	2	33
	≥ 2500	1	2	19	22
Total		32	22	24	78

X^2 = 72.055 Df = 4 P<.001 Missing = 14

Figure 4.1 African sites

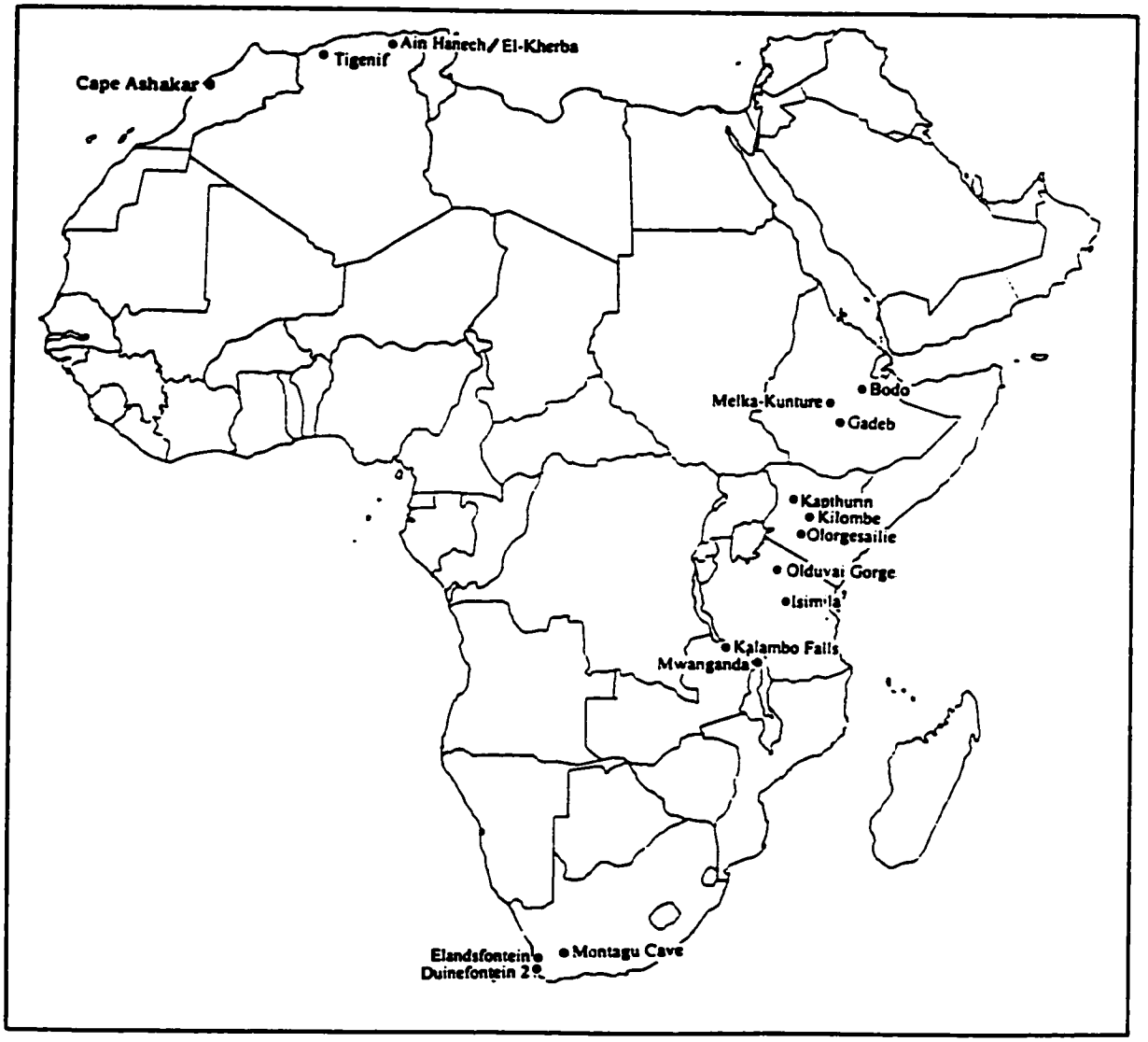
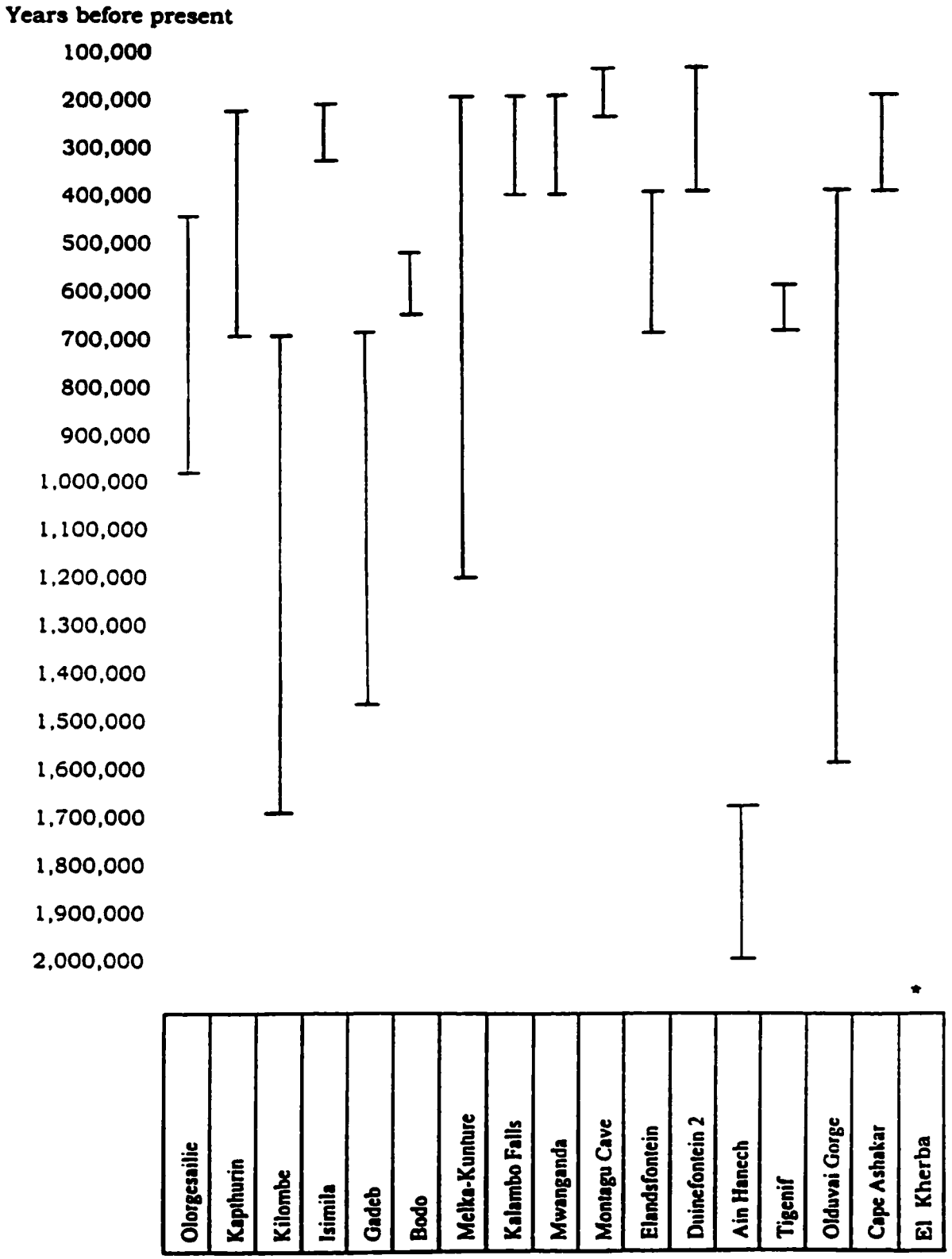


Figure 4.2 African site ages in years before present



* No data provided

Figure 4.3 Middle Eastern sites

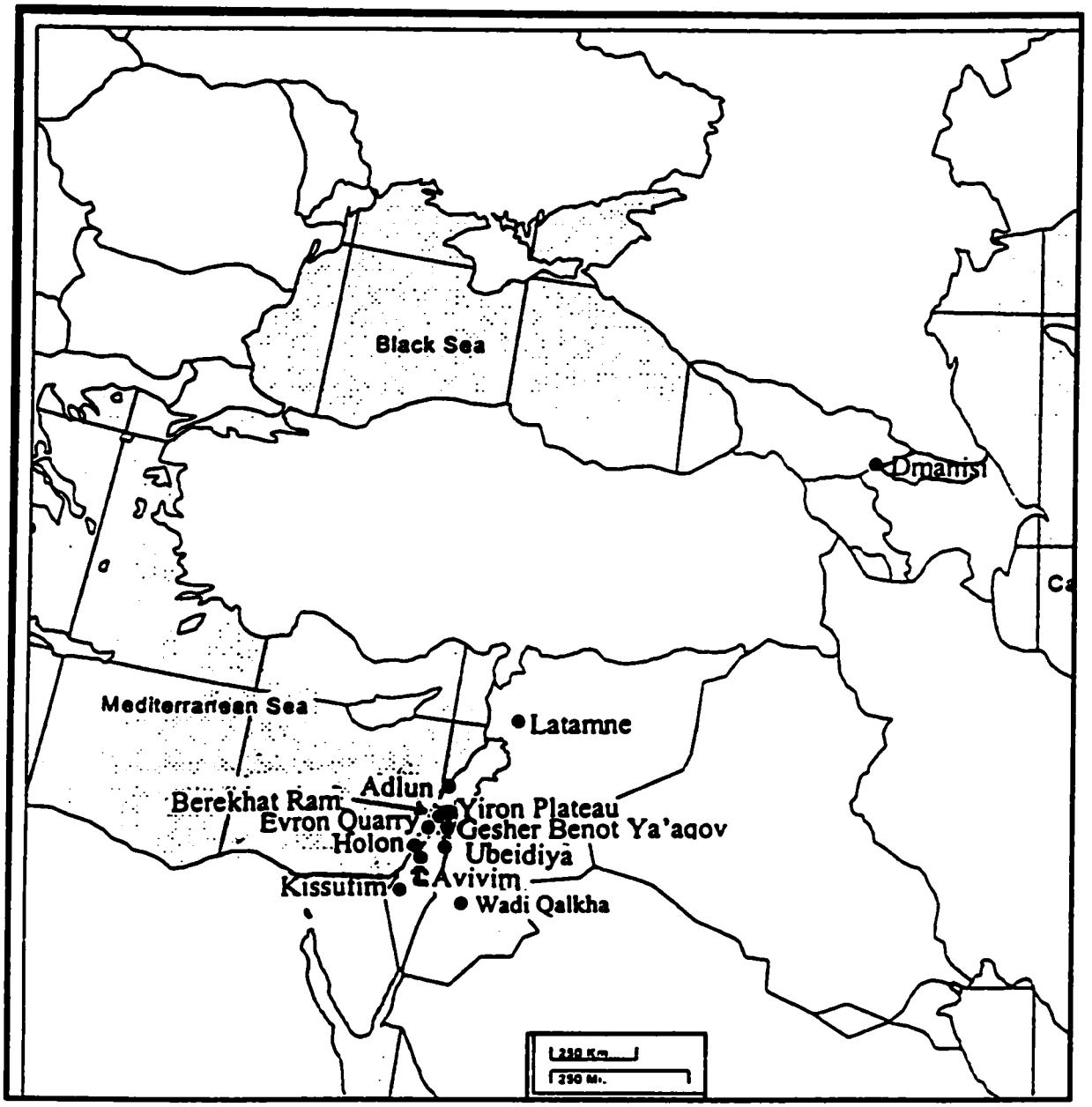


Figure 4.4 Middle Eastern site ages in years before present

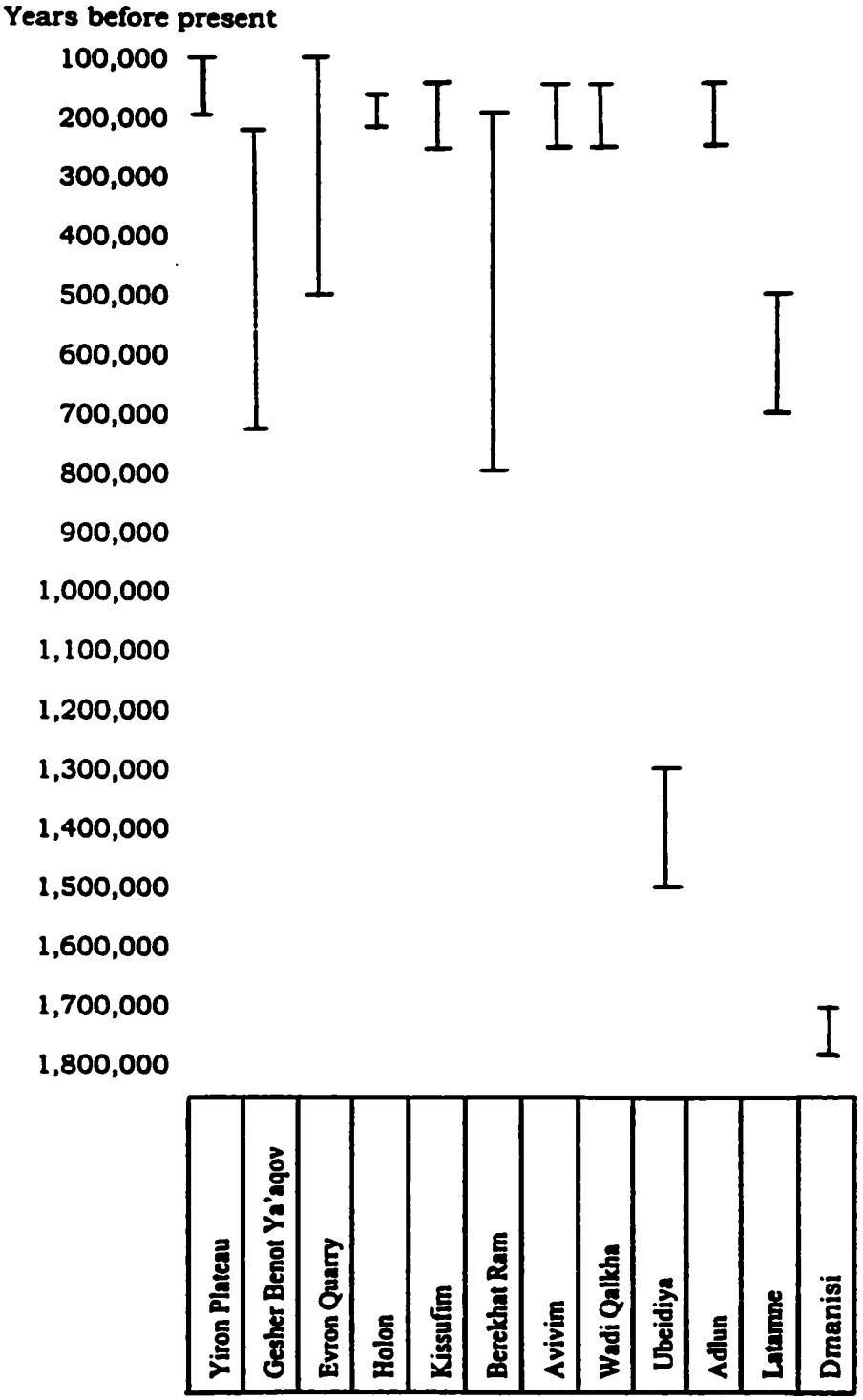


Figure 4.5 European sites

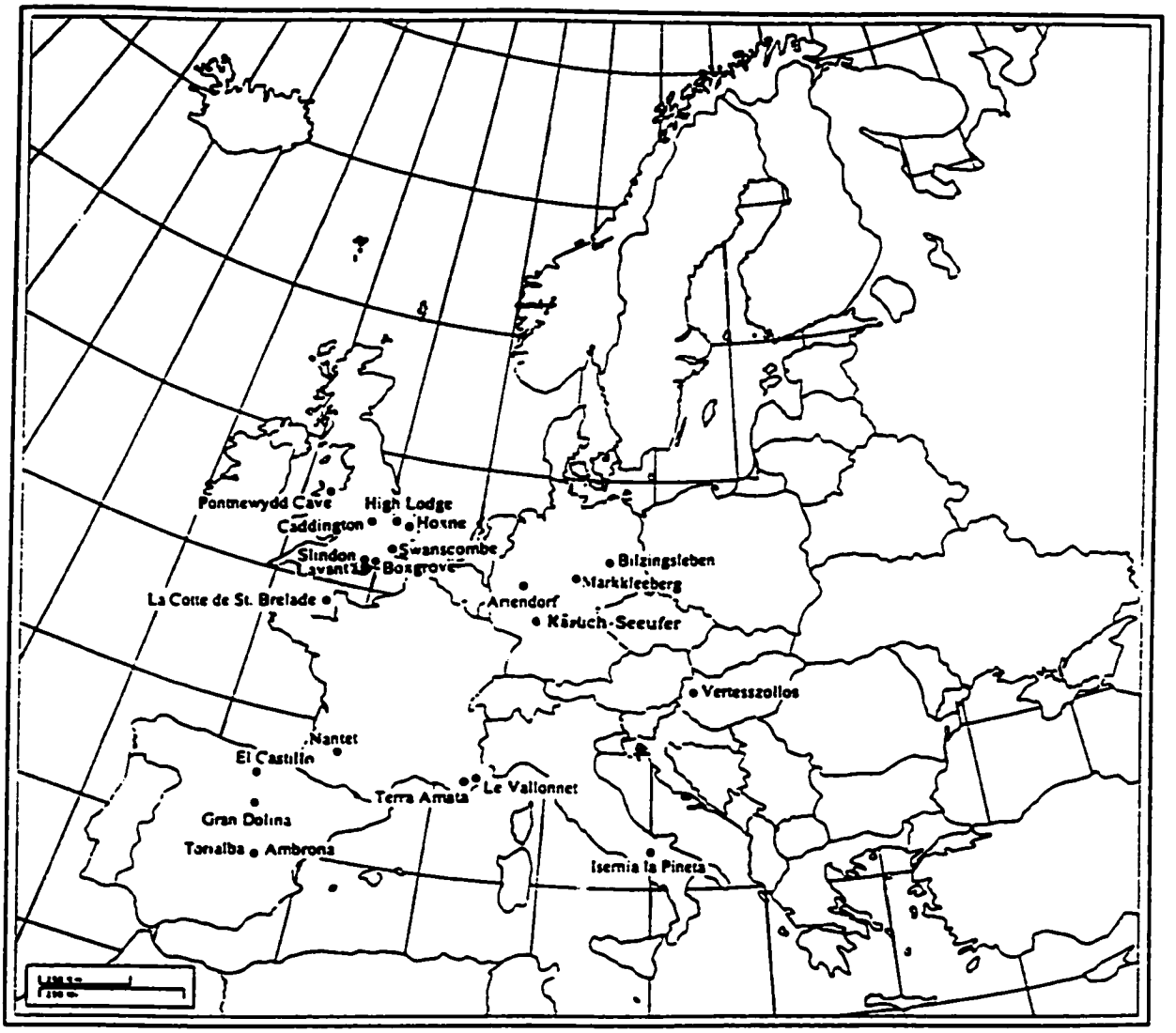
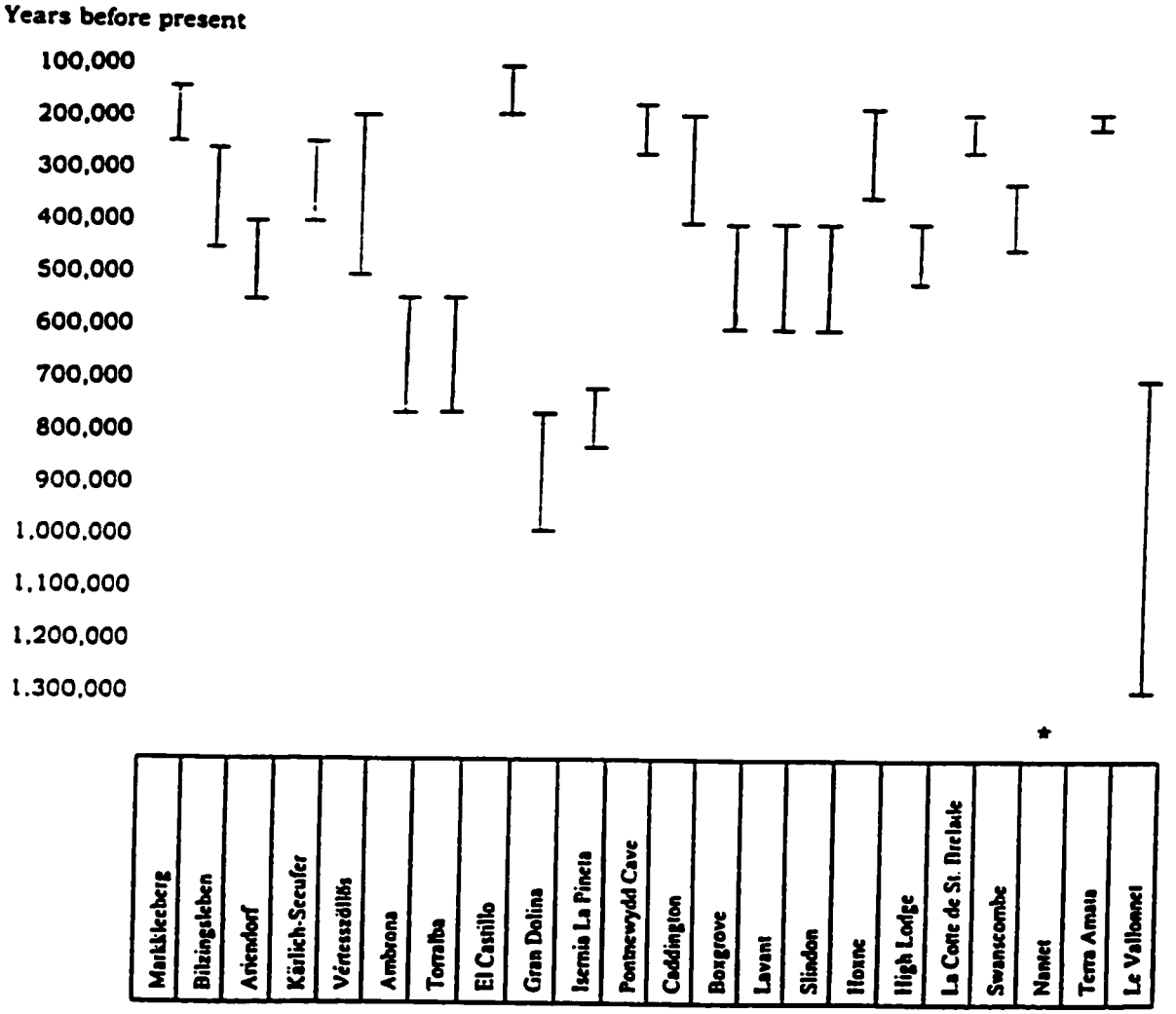


Figure 4.6 European site ages in years before present



* No data provided

Figure 4.7 Site location by age of assemblage

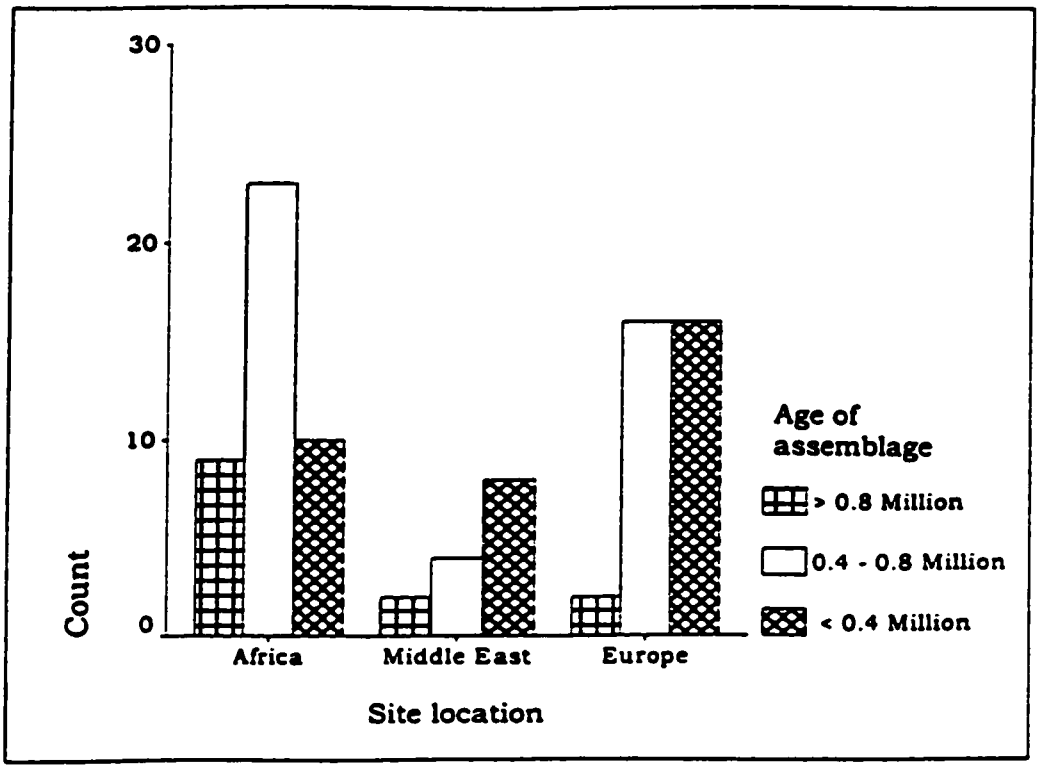


Figure 4.8 Age of assemblage by site elevation

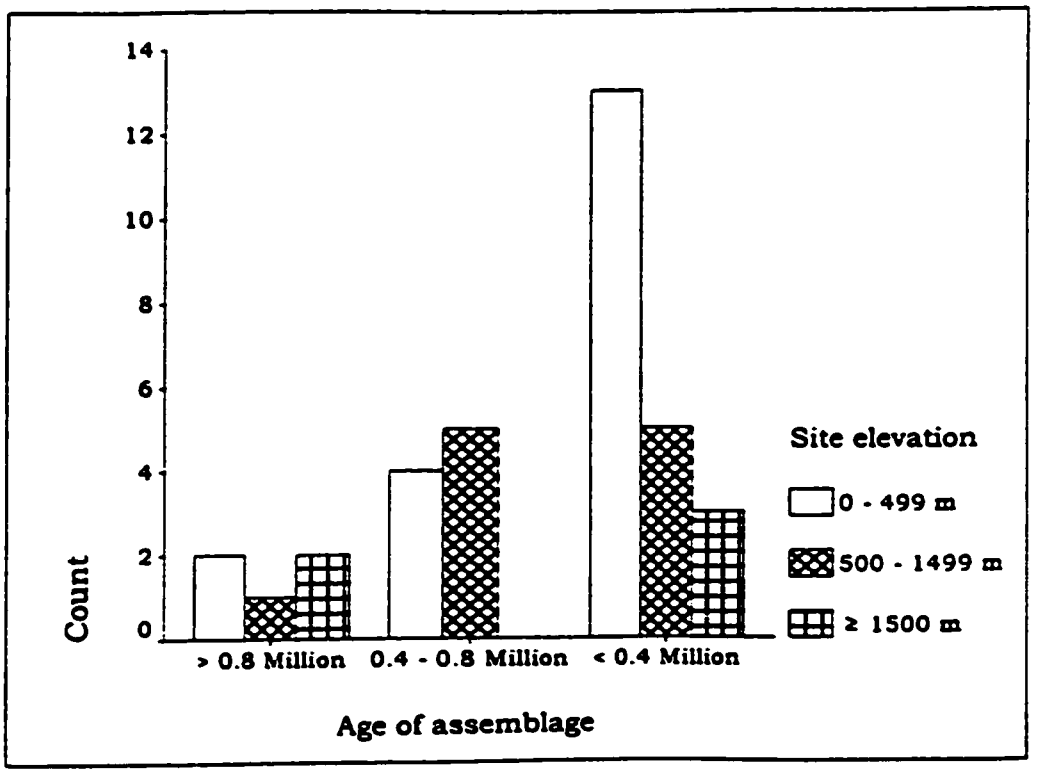


Figure 4.9 Age of assemblage by site layout

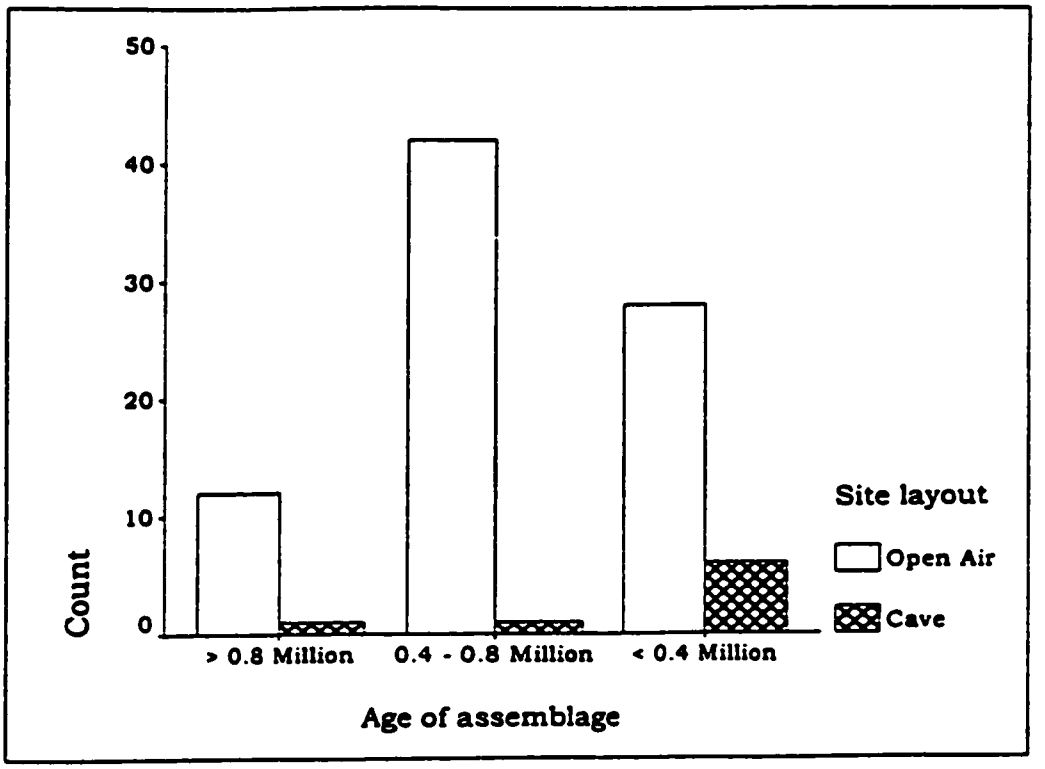


Figure 4.10 Age of assemblage by fauna

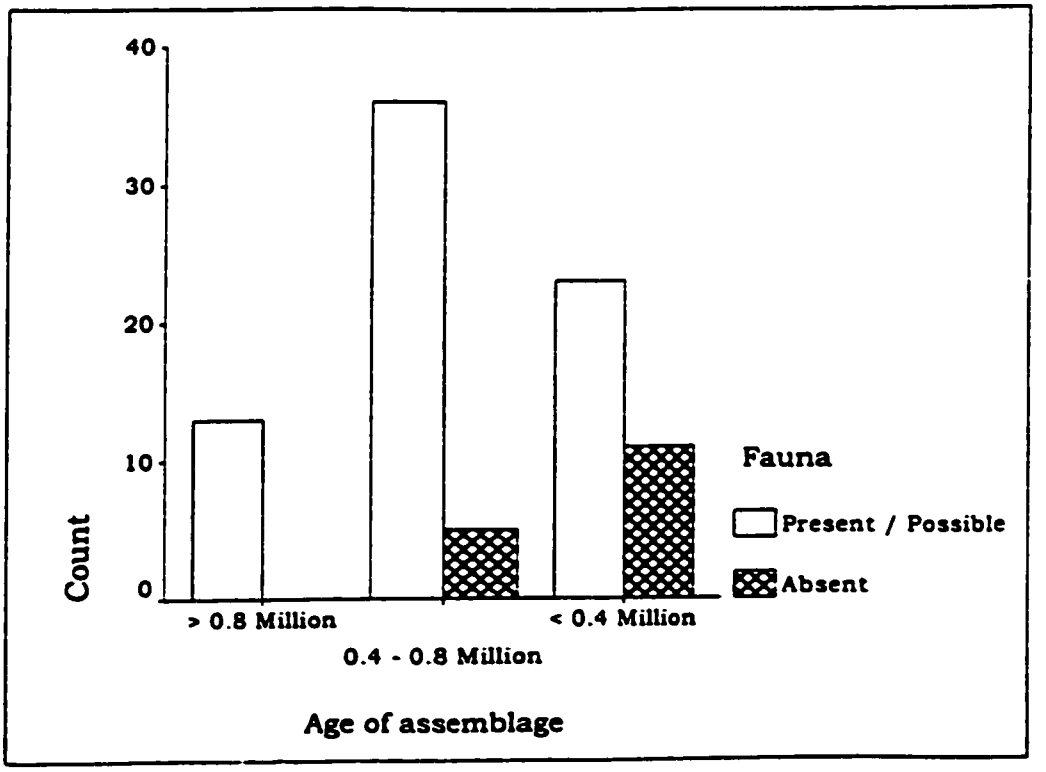


Figure 4.11 Age of assemblage by site environment

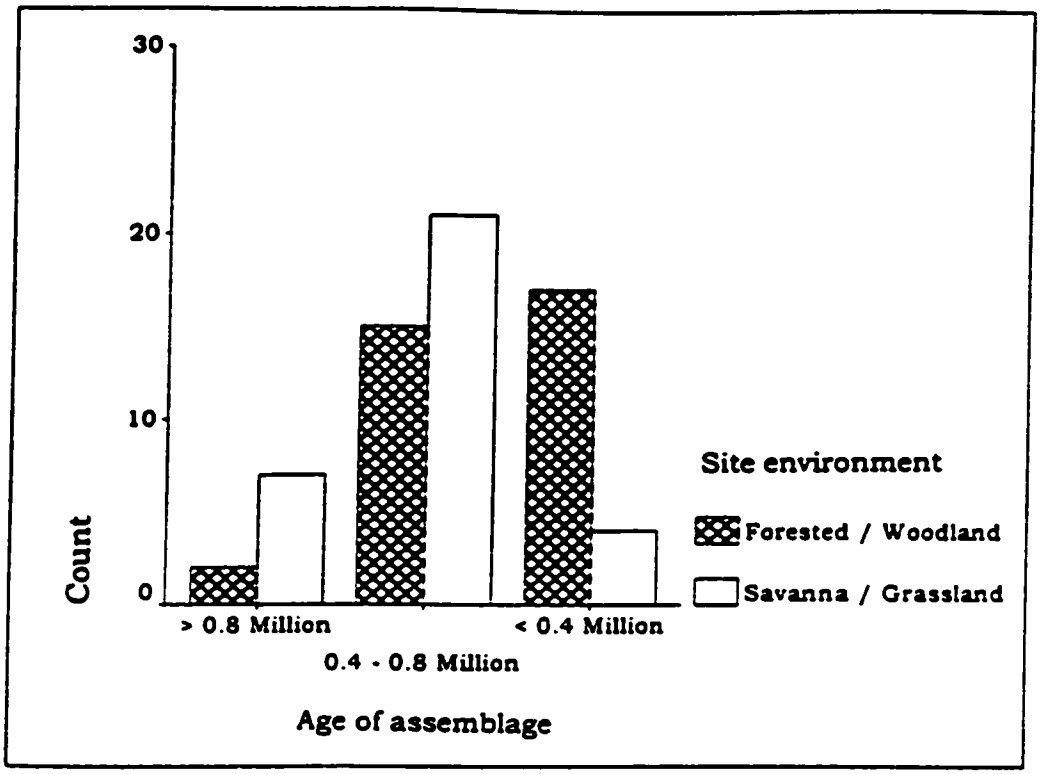


Figure 4.12 Age of assemblage by cutmarked bone

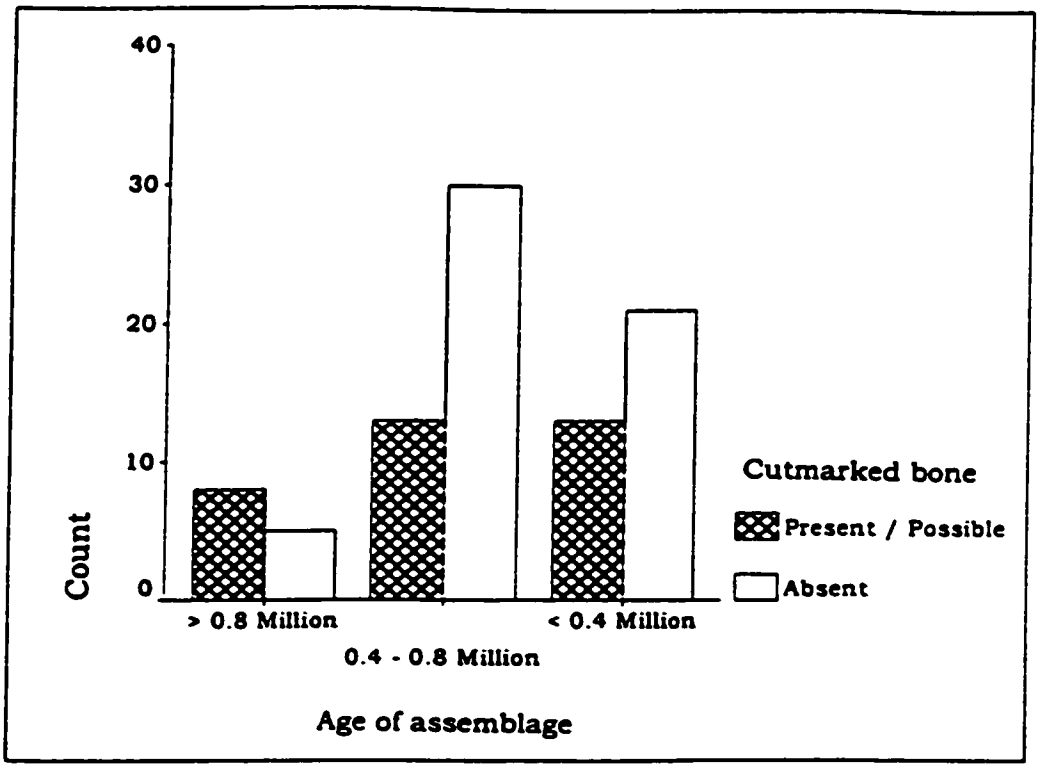


Figure 4.13 Age of assemblage by worked organic material

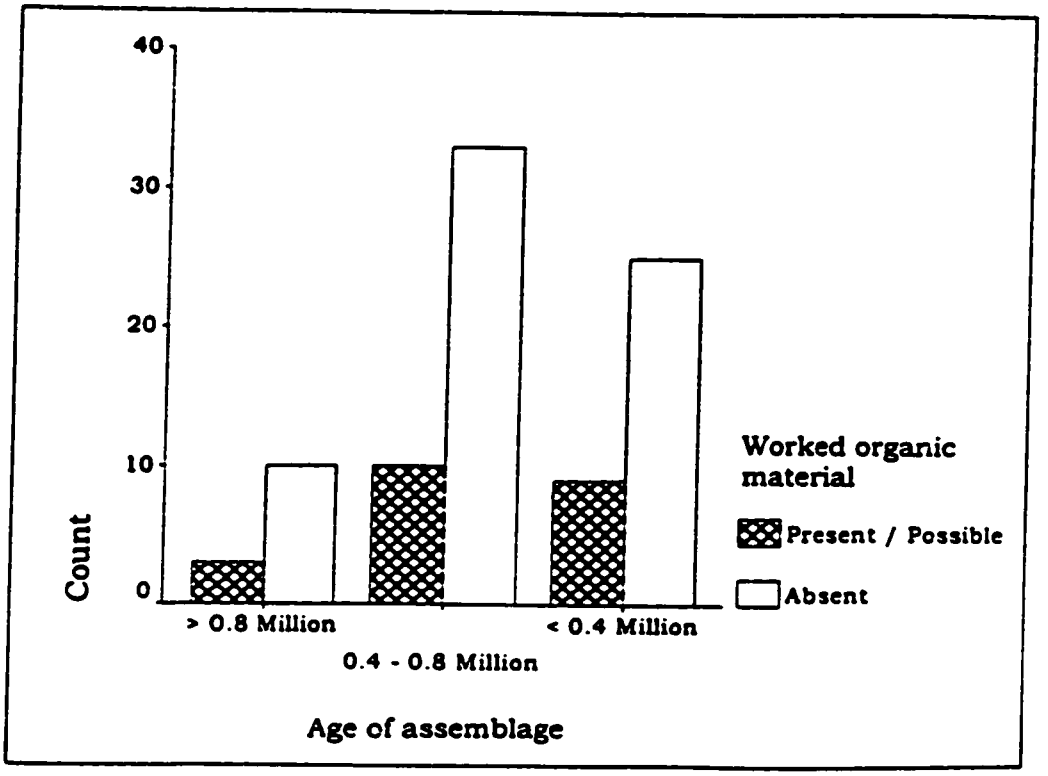


Figure 4.14 Age of assemblage by fire

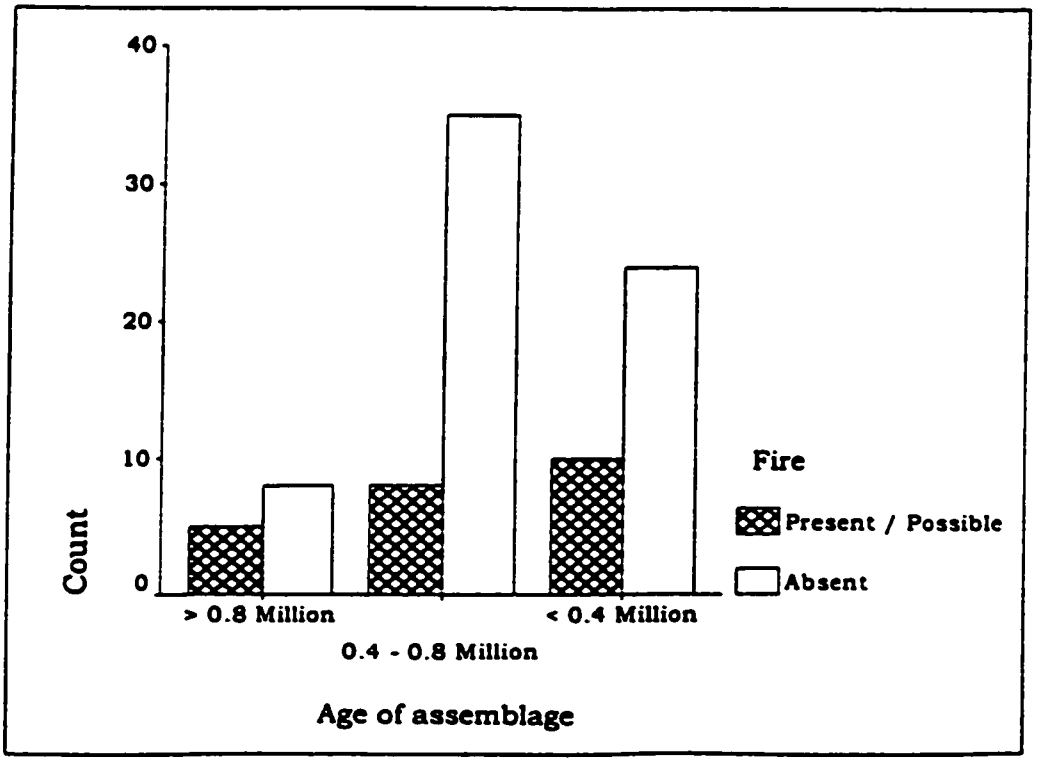


Figure 4.15 Age of assemblage by number of artifacts

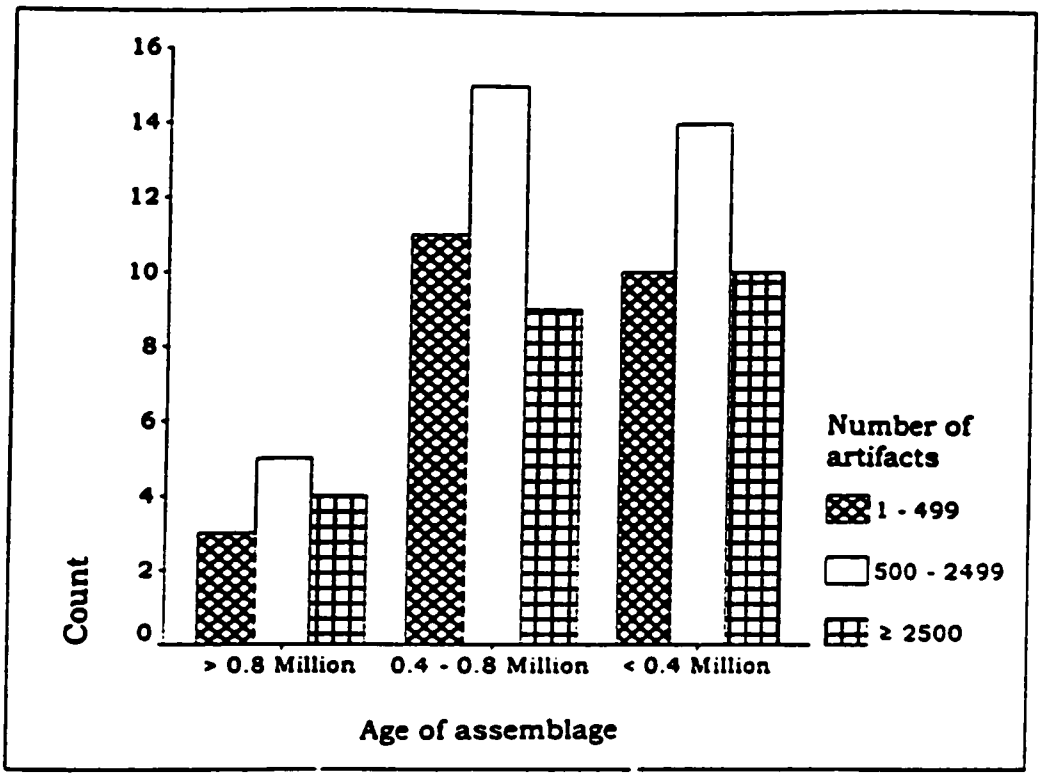


Figure 4.16 Age of assemblage by number of tools

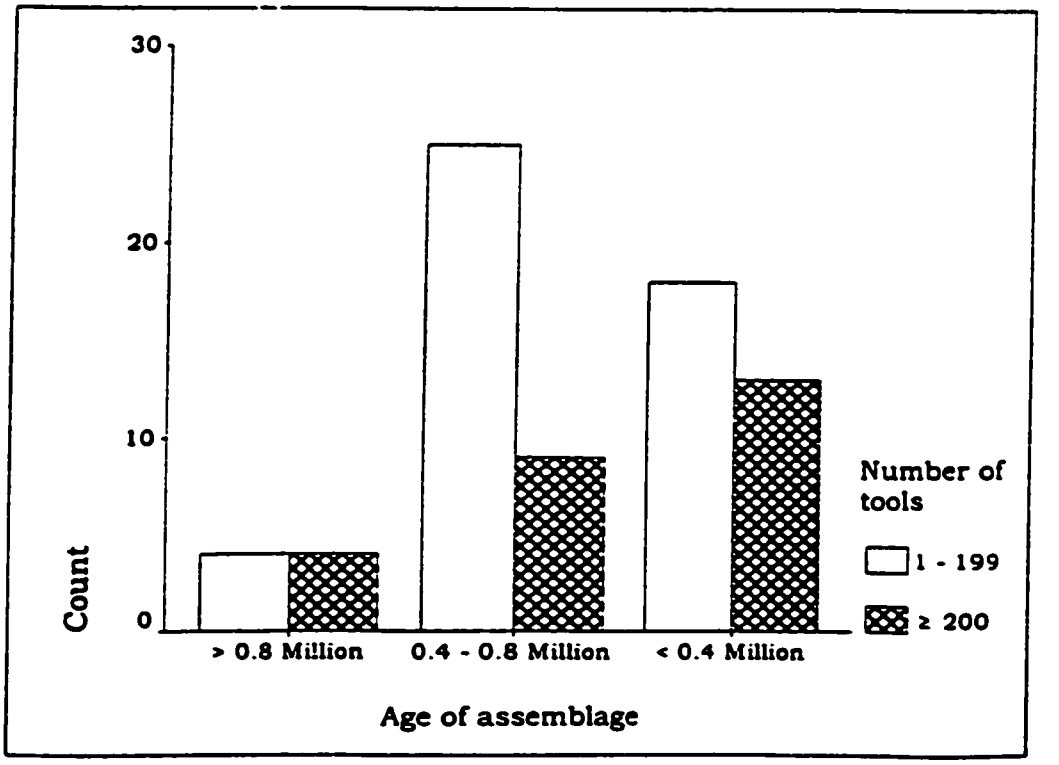


Figure 4.17 Age of assemblage by amount of Levallois material

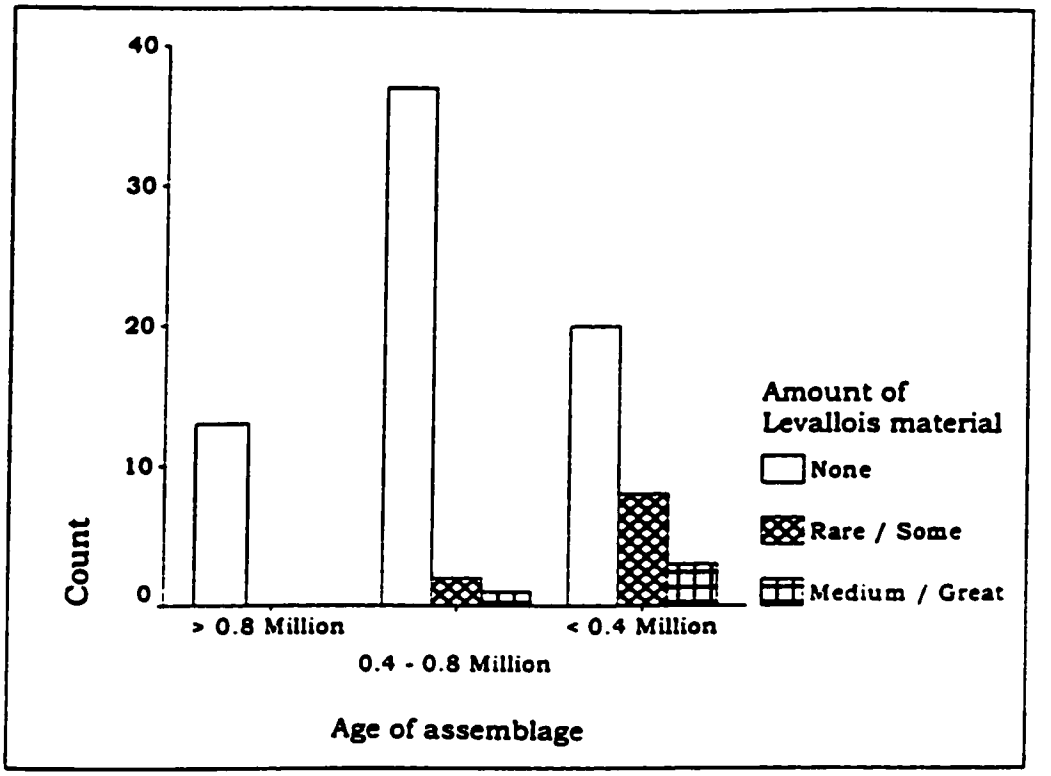


Figure 4.18 Age of assemblage by artifact manufacturing techniques

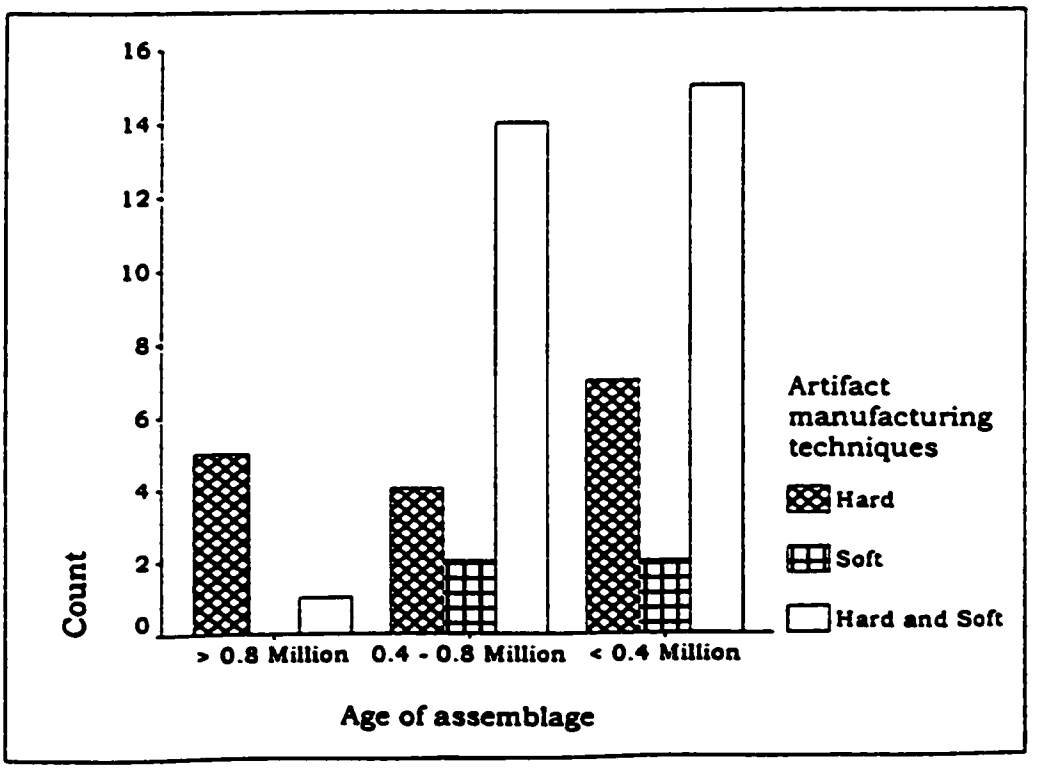


Figure 4.19 Age of assemblage by artifact curation

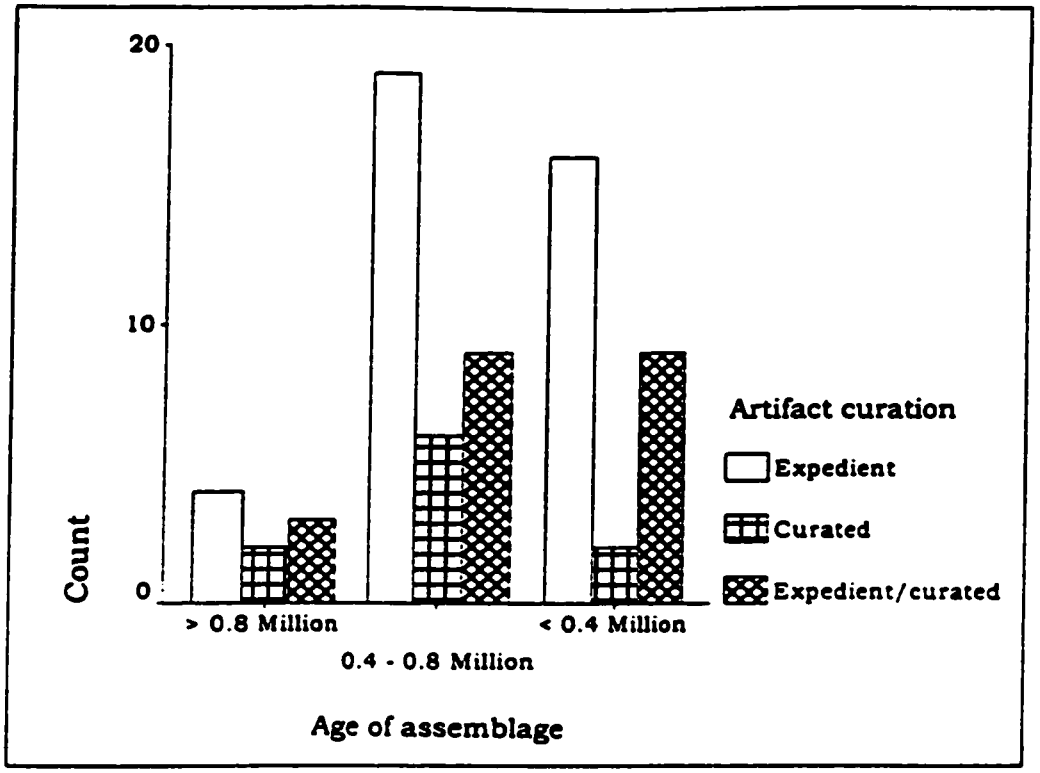


Figure 4.20 Age of assemblage by site function

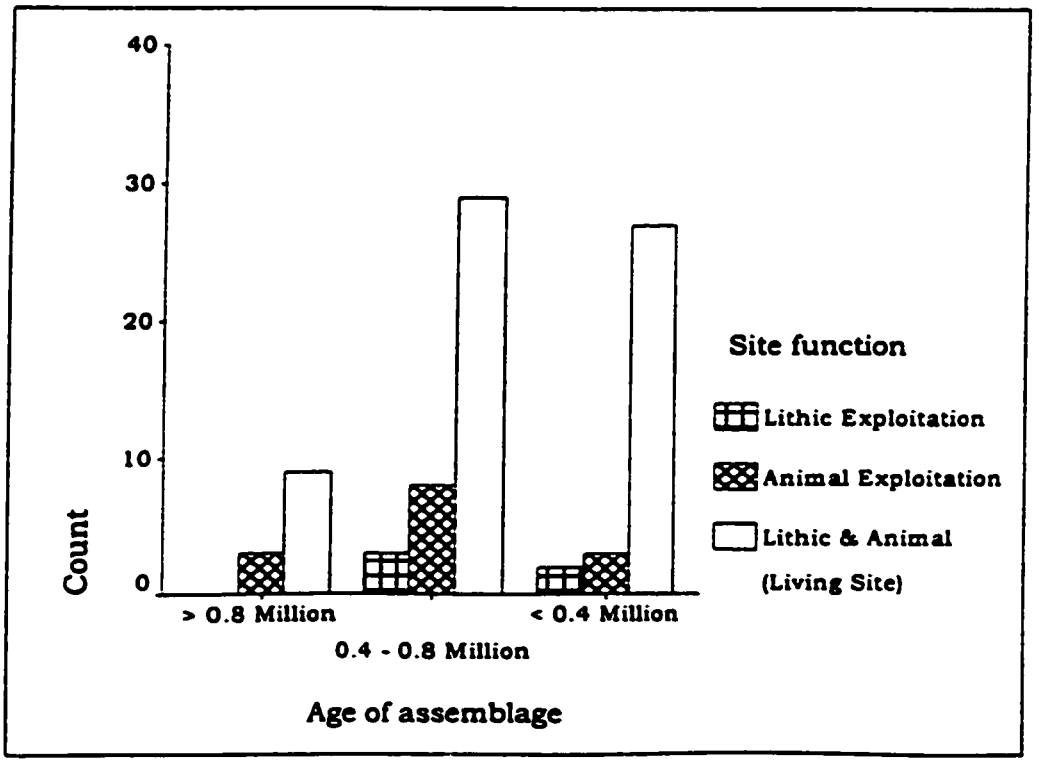


Figure 4.21 Date of site discovery by site location

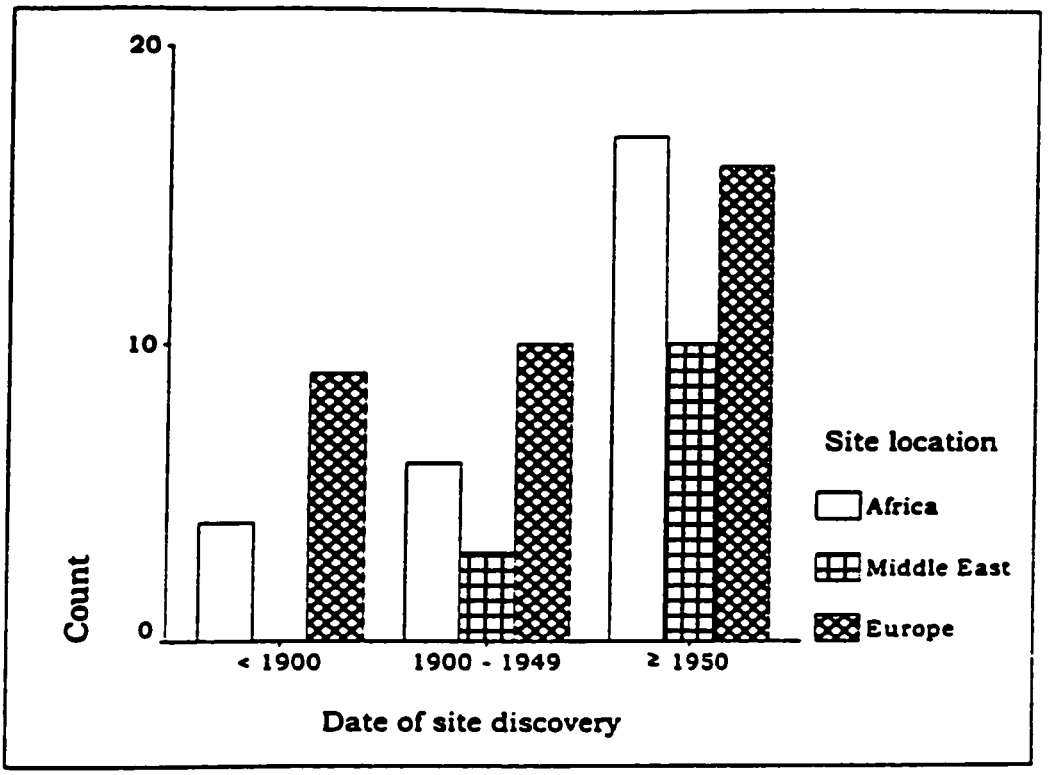


Figure 4.22 Date of site discovery by assemblage context

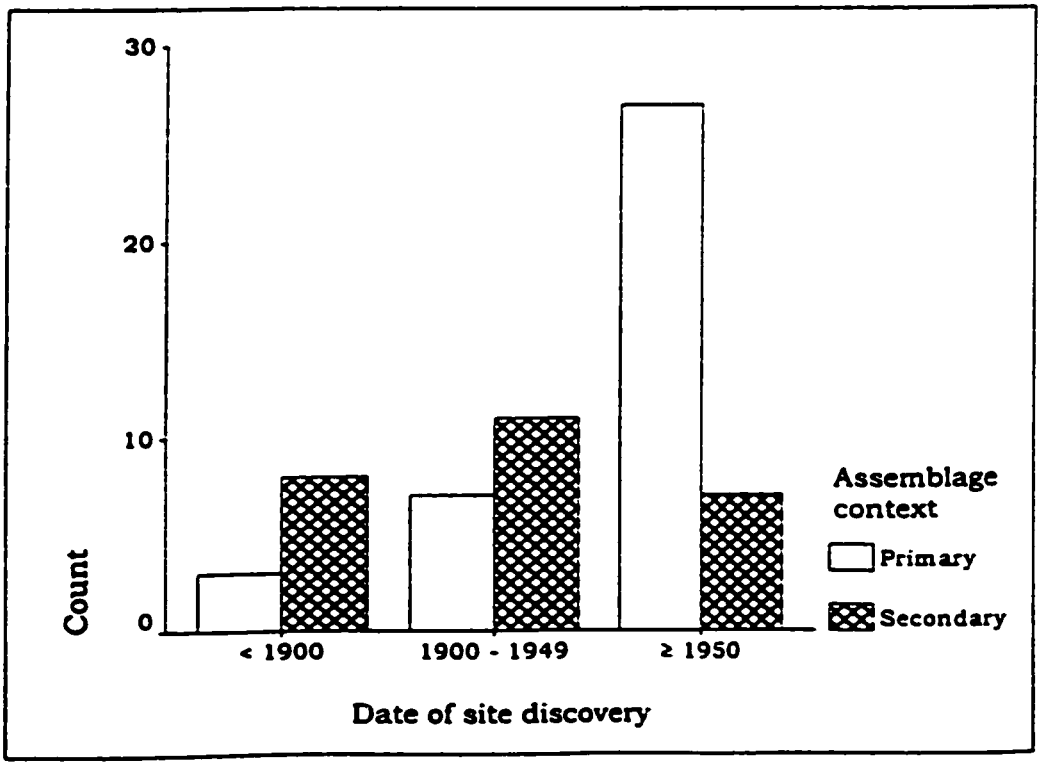


Figure 4.23 Date of site discovery by hominid remains

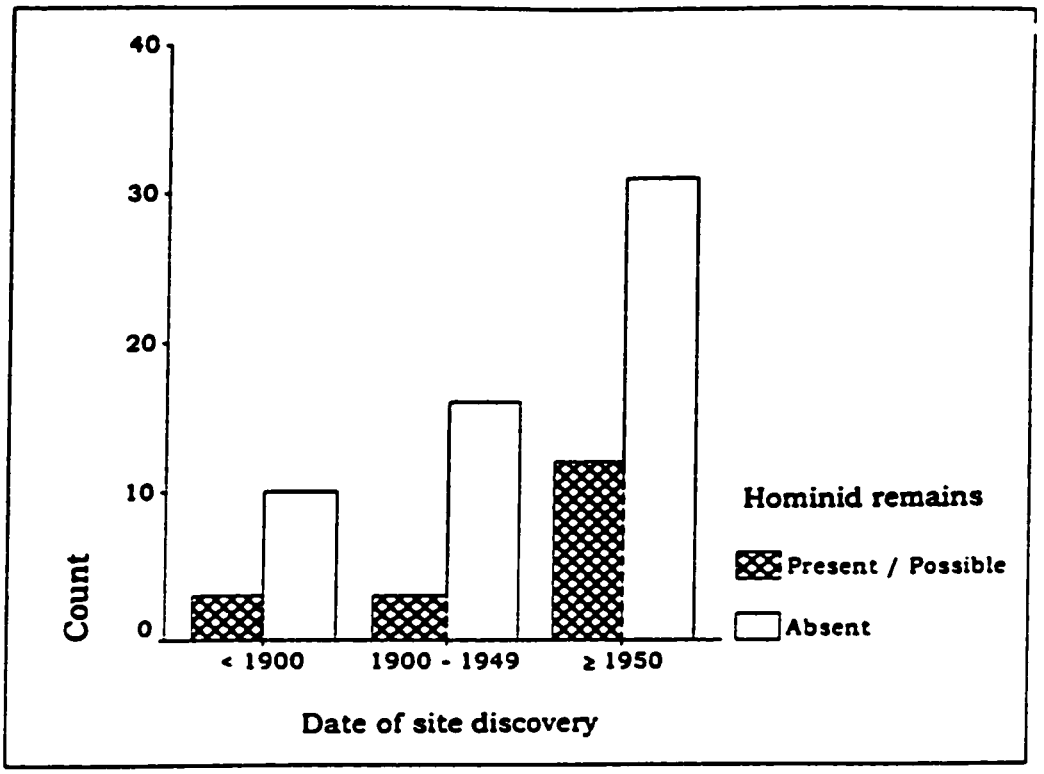


Figure 4.24 Date of site discovery by fire

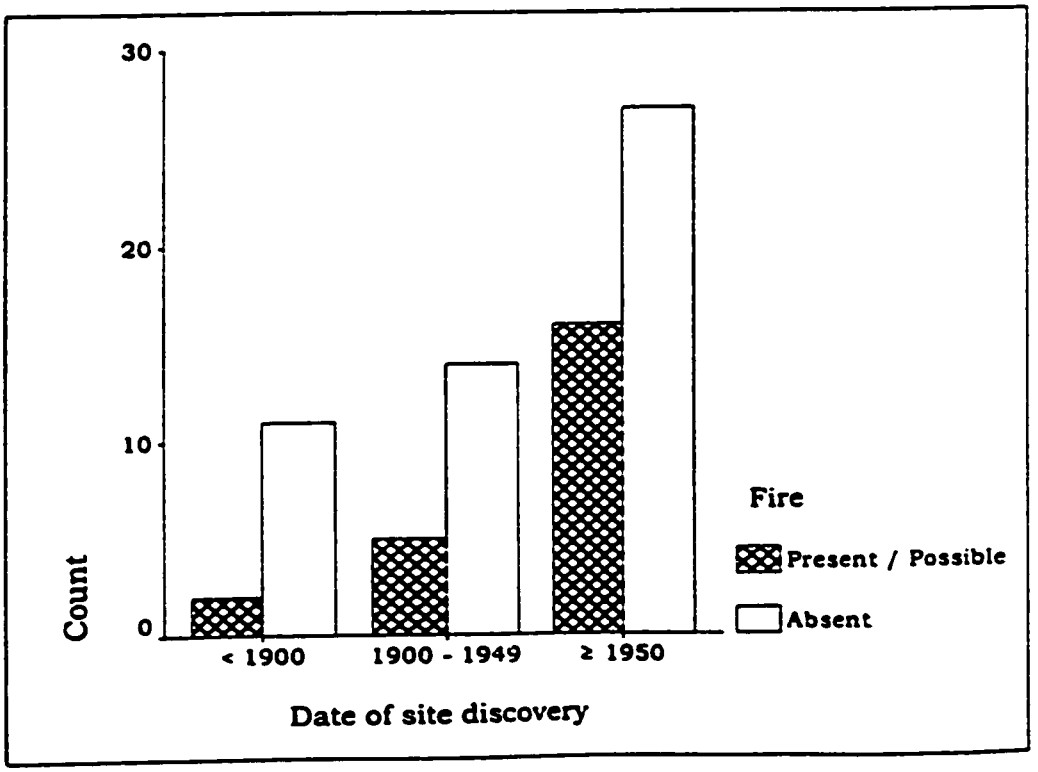


Figure 4.25 Date of site discovery by worked organic material

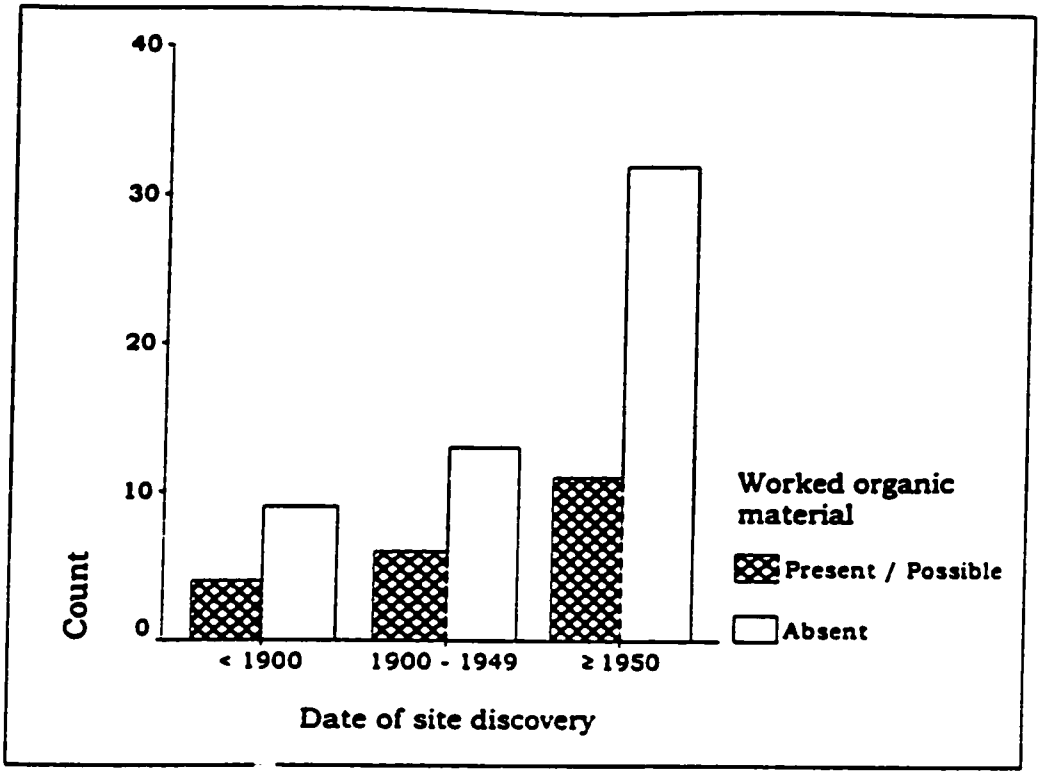


Figure 4.26 Date of site discovery by cutmarked bone

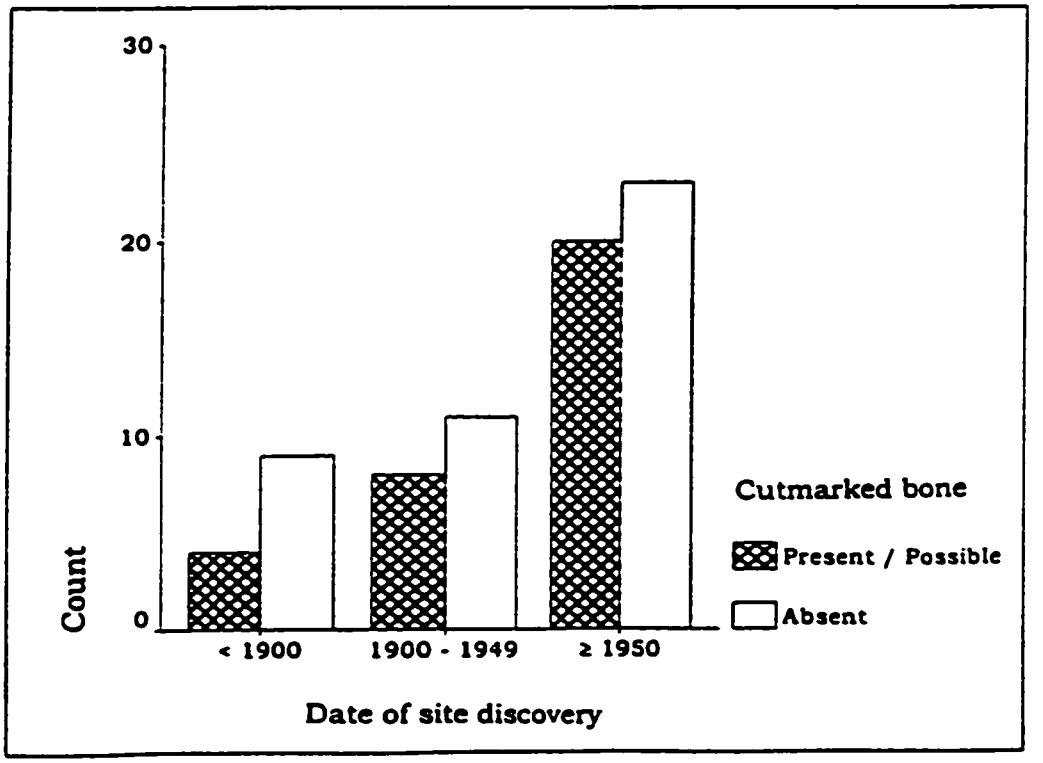


Figure 4.27 Date of site discovery by number of artifacts

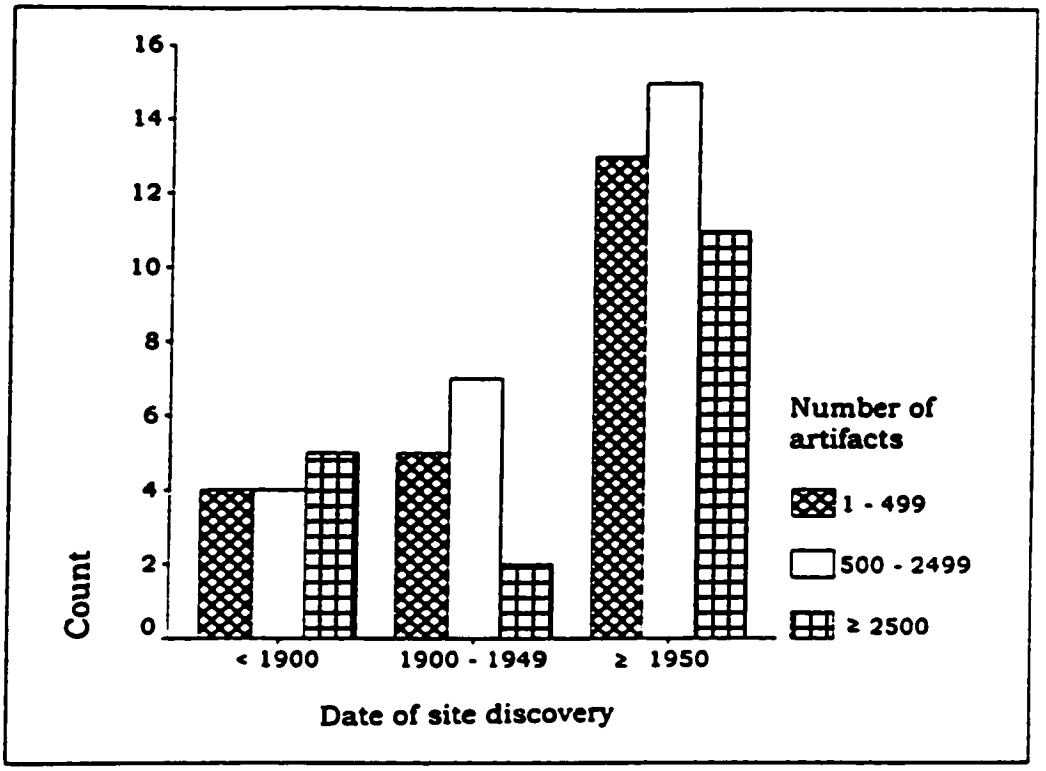


Figure 4.28 Site location by site environment

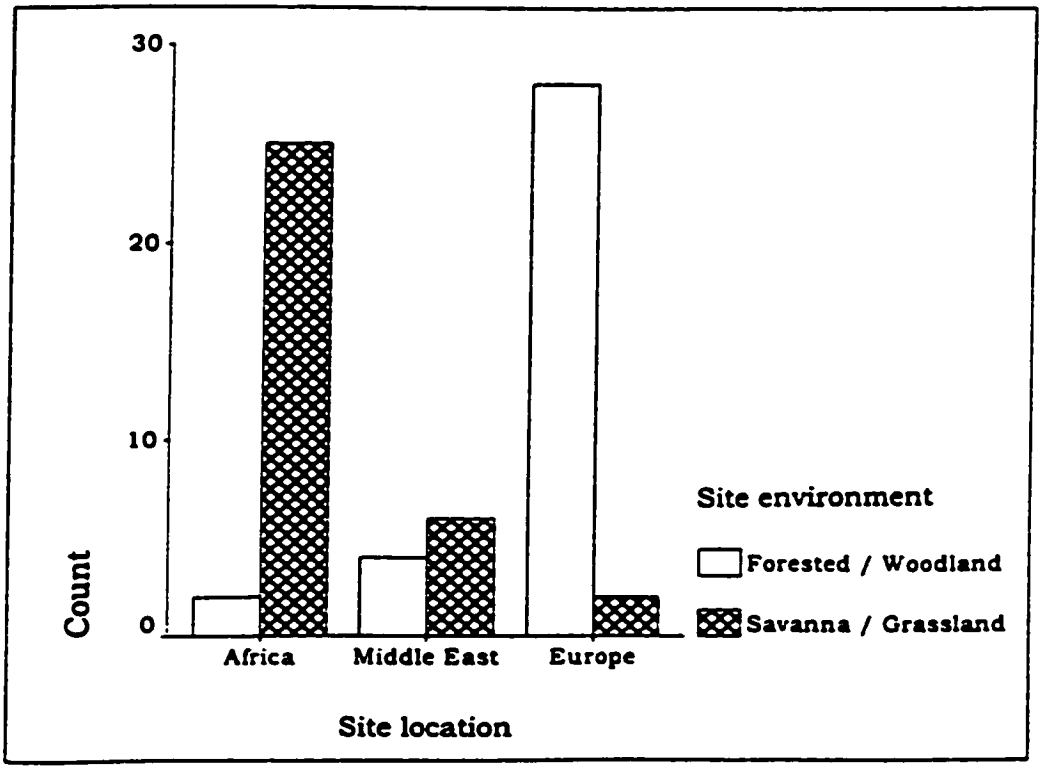


Figure 4.29 Site location by fire

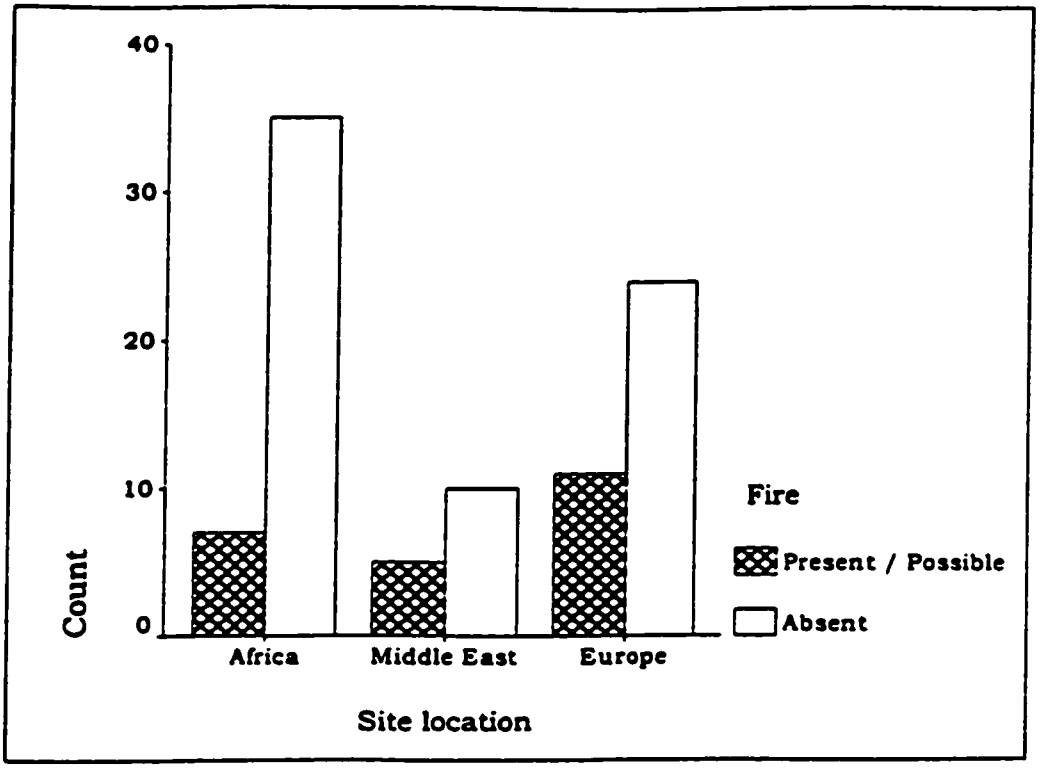


Figure 4.30 Site elevation by artifact curation

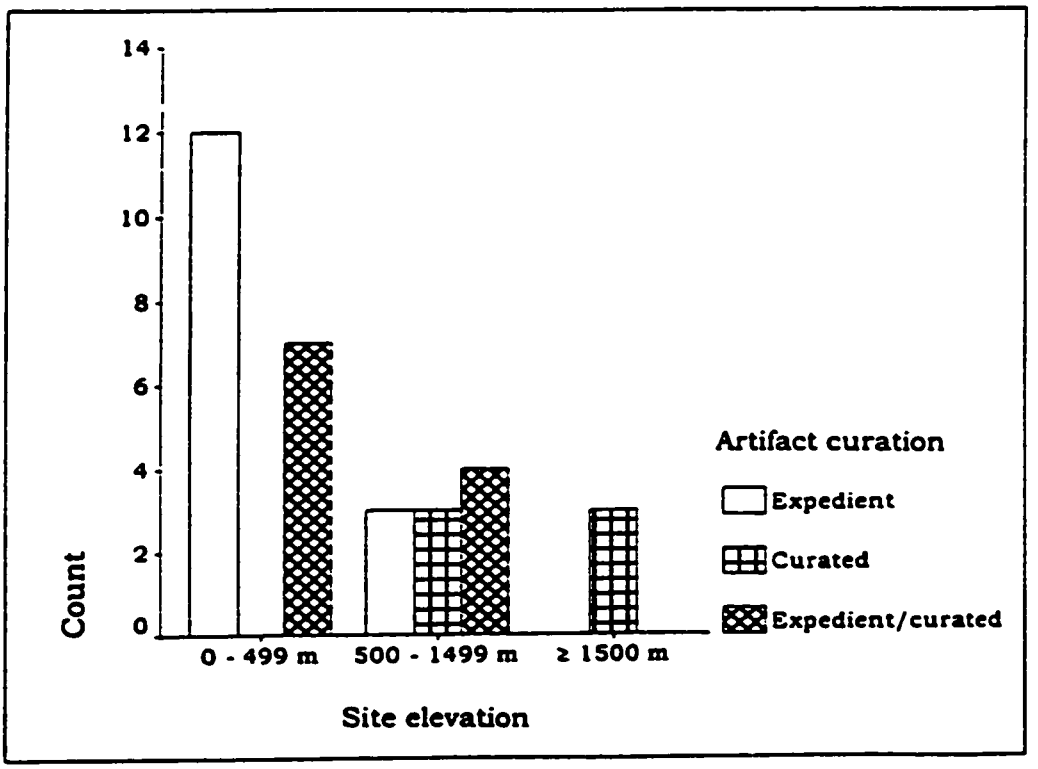


Figure 4.31 Site elevation by site function

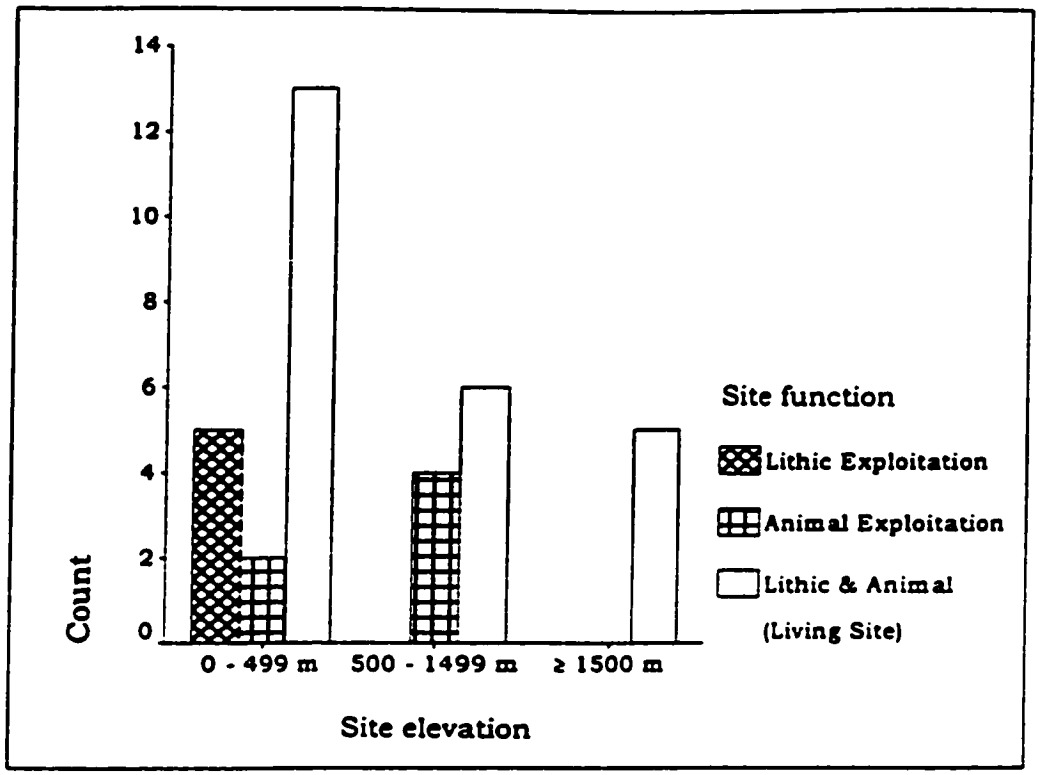


Figure 4.32 Site layout by number of bifaces

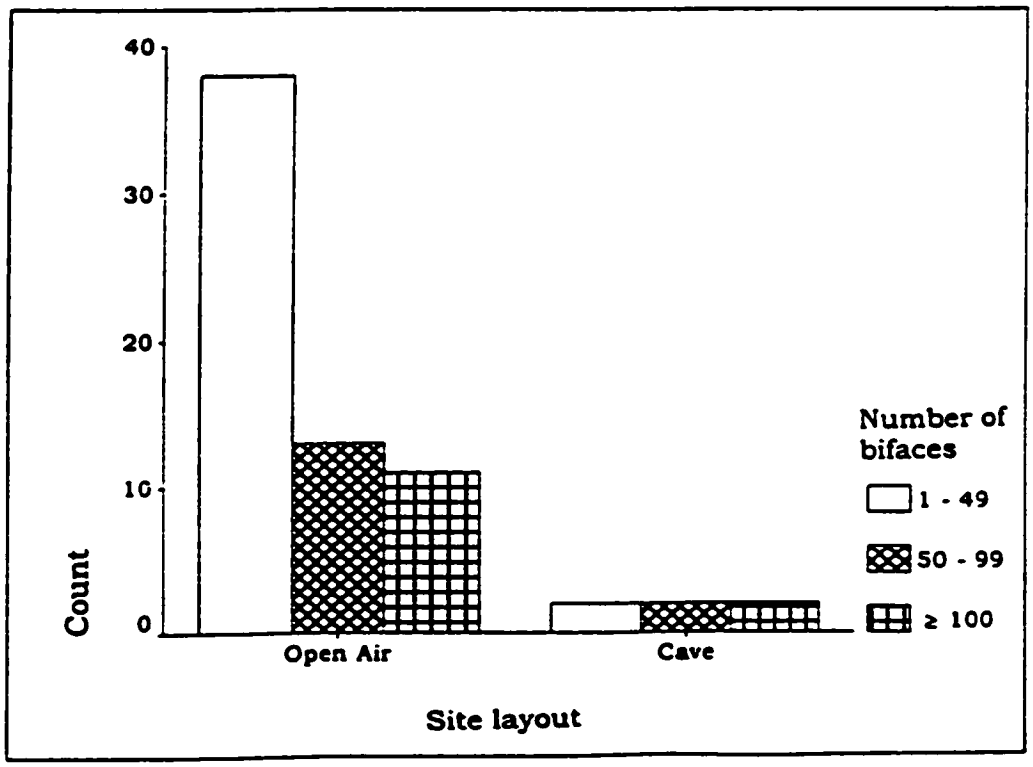


Figure 4.33 Site layout by artifact curation

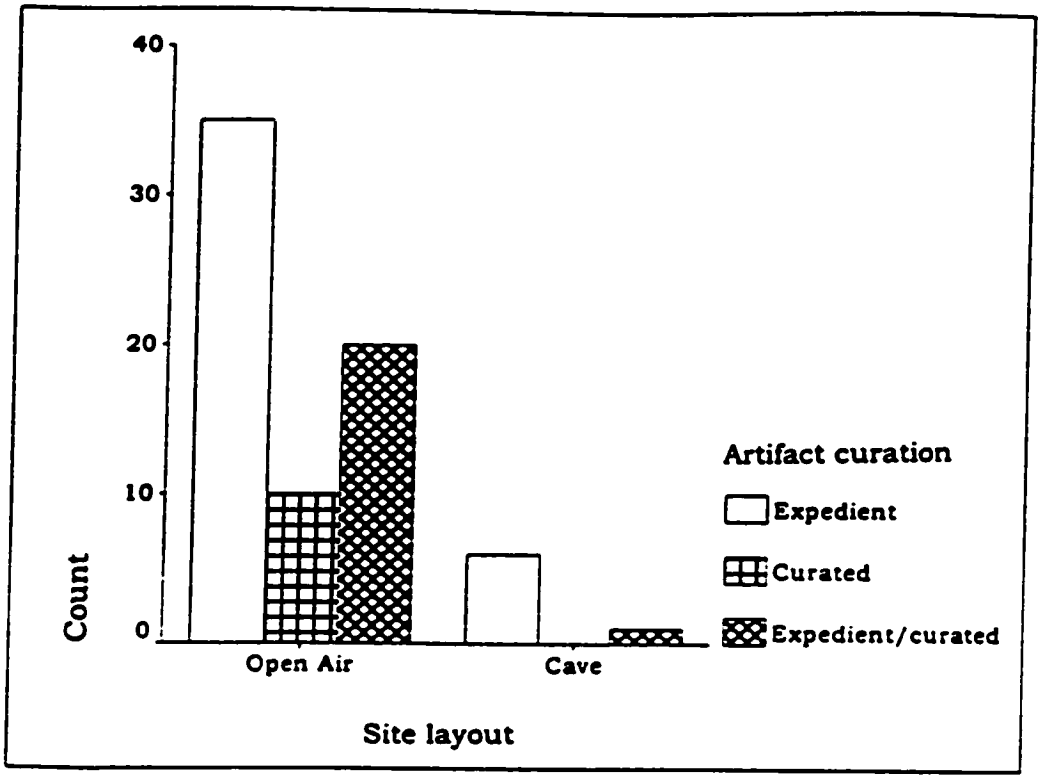


Figure 4.34 Site layout by site function

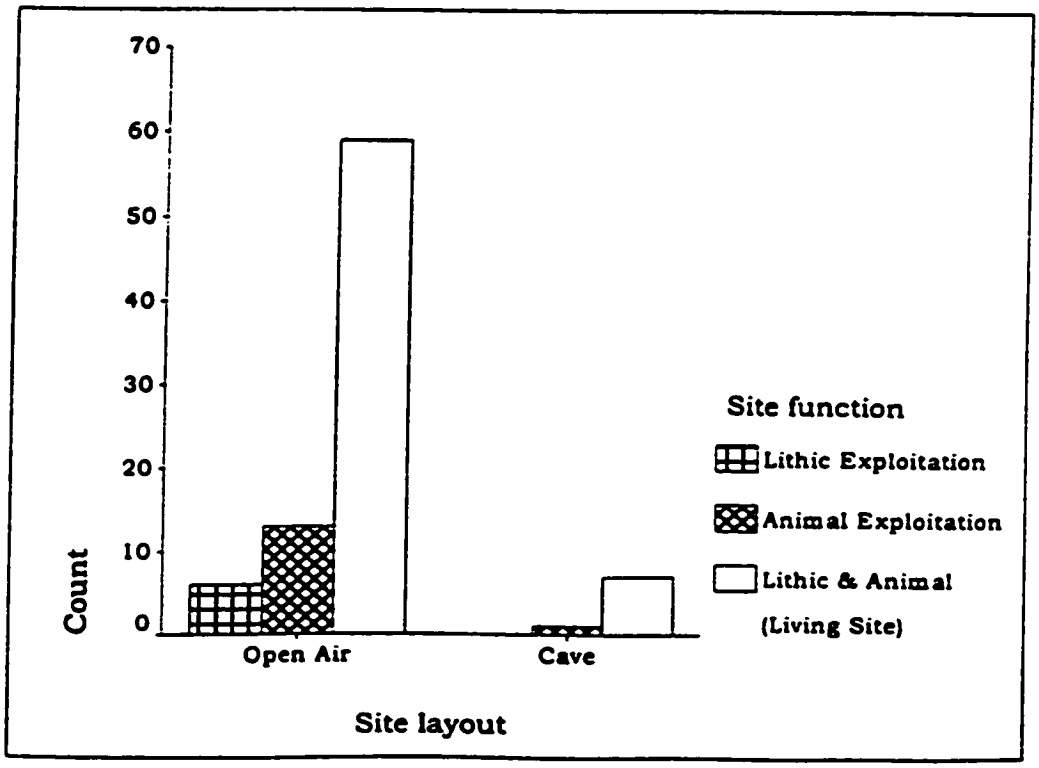


Figure 4.35 Assemblage context by fire

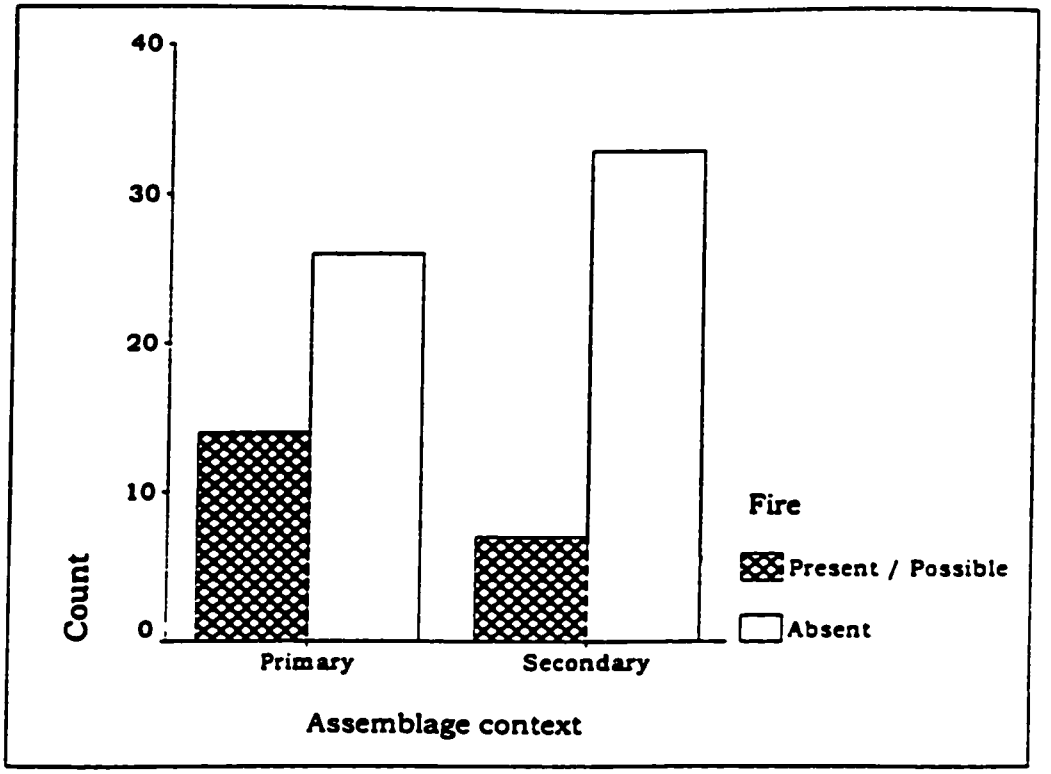


Figure 4.36 Assemblage context by site function

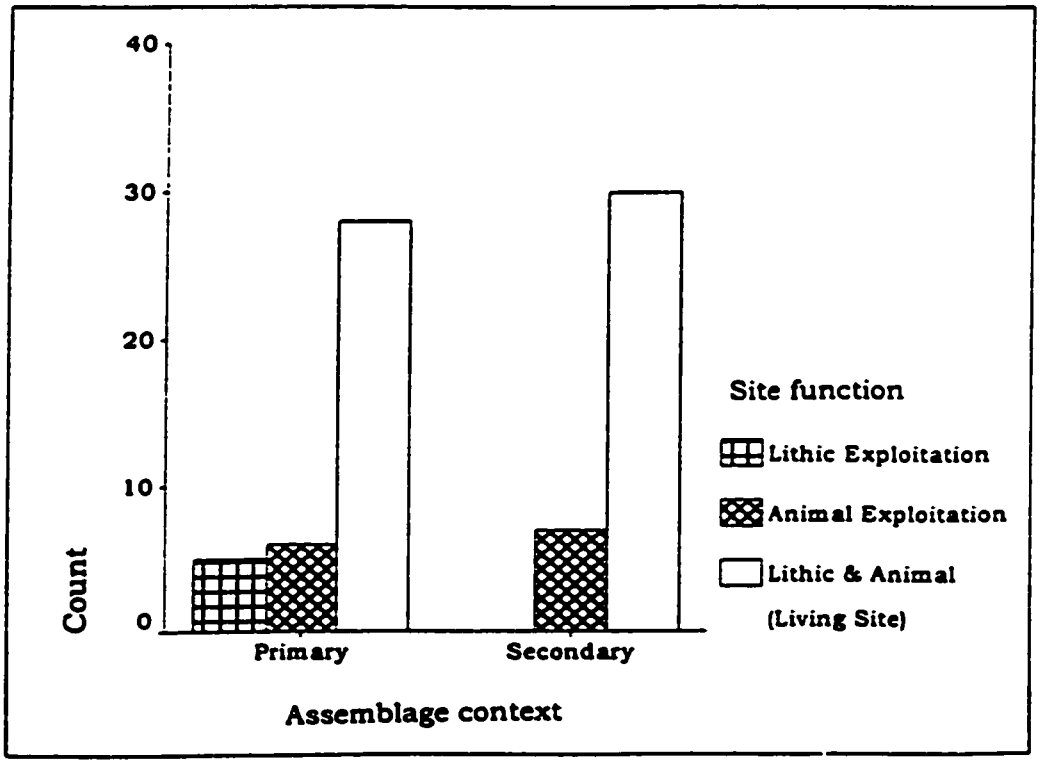


Figure 4.37 Fauna by hominind remains

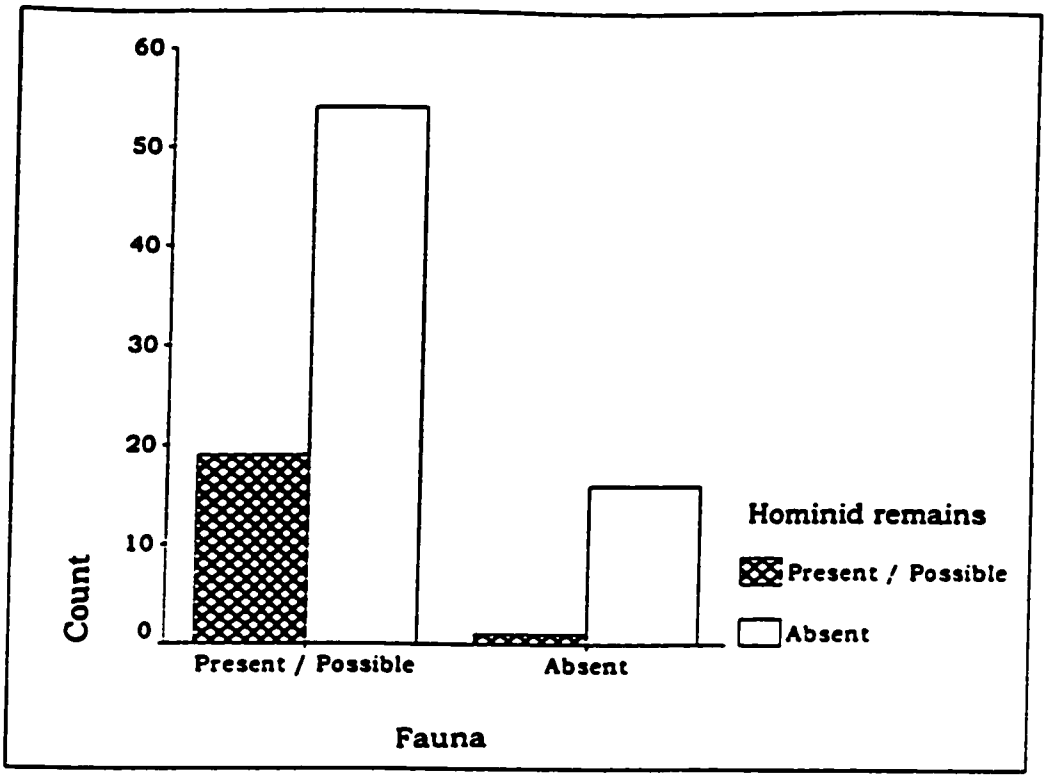


Figure 4.38 Fauna by fire

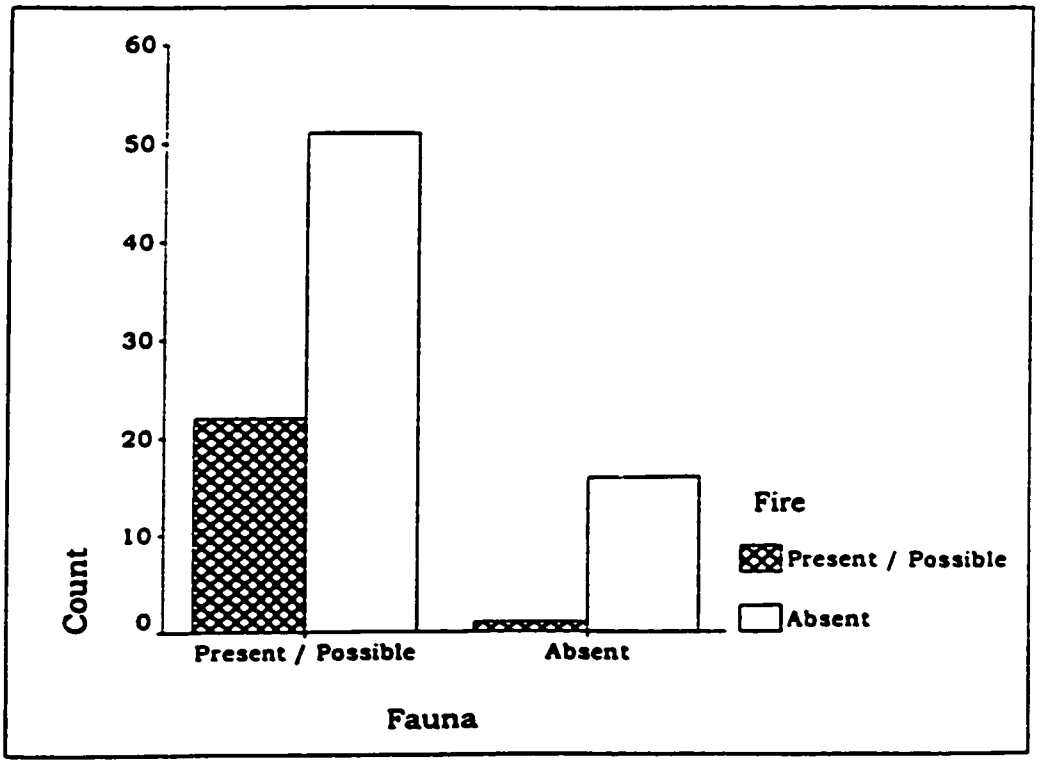


Figure 4.39 Site environment by amount of Levallois material

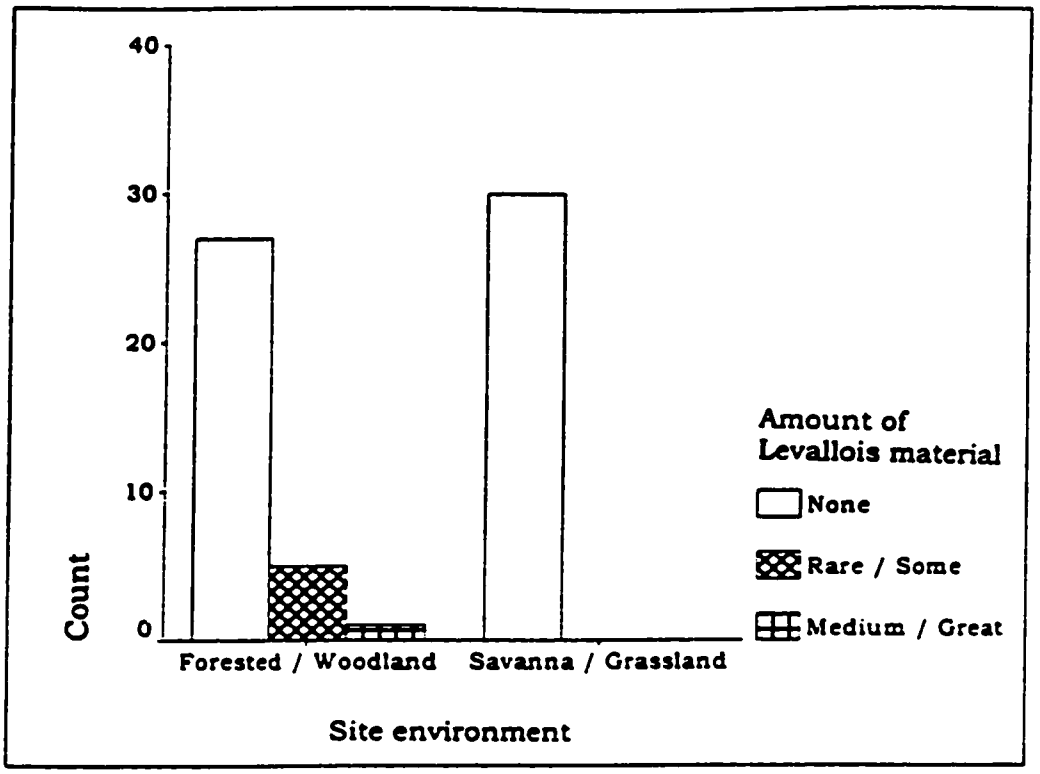


Figure 4.40 Site environment by artifact curation

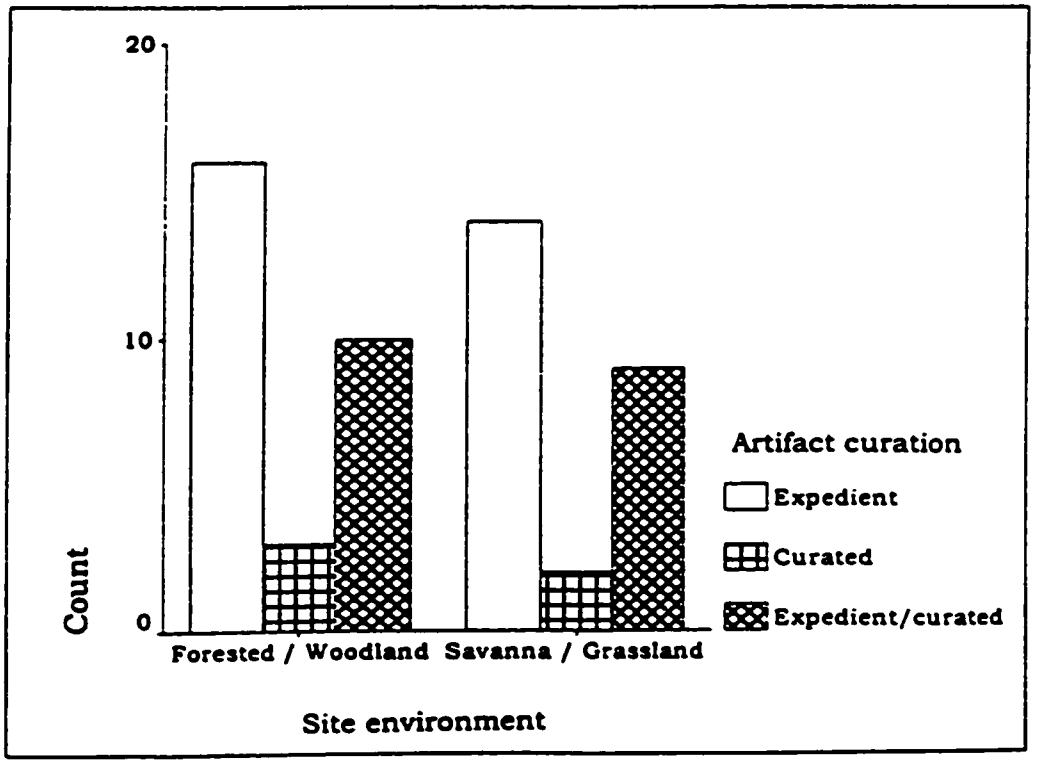


Figure 4.41 Hominid remains by site function

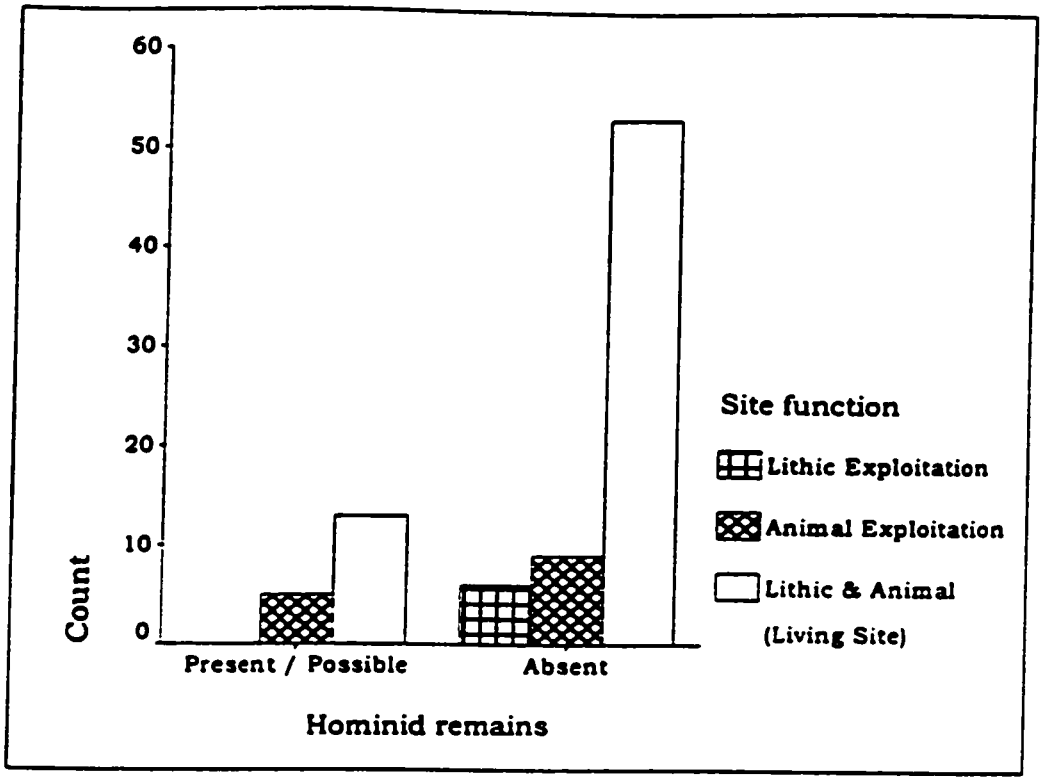


Figure 4.42 Hominid remains by fire

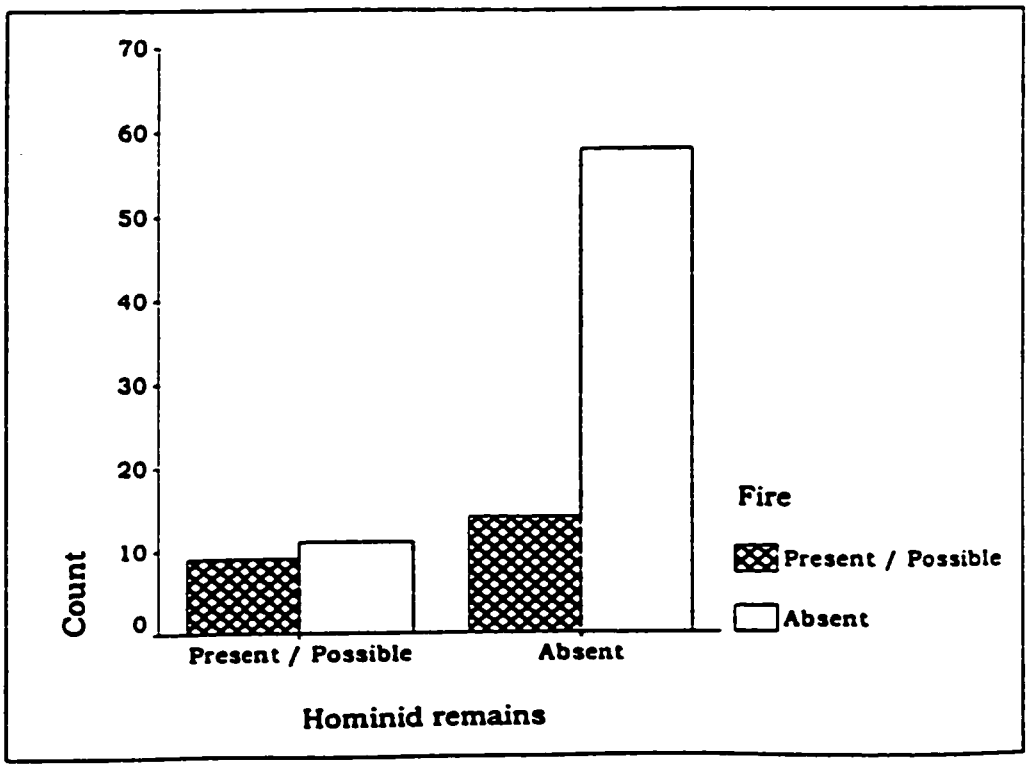


Figure 4.43 Cutmarked bone by amount of Levallois material

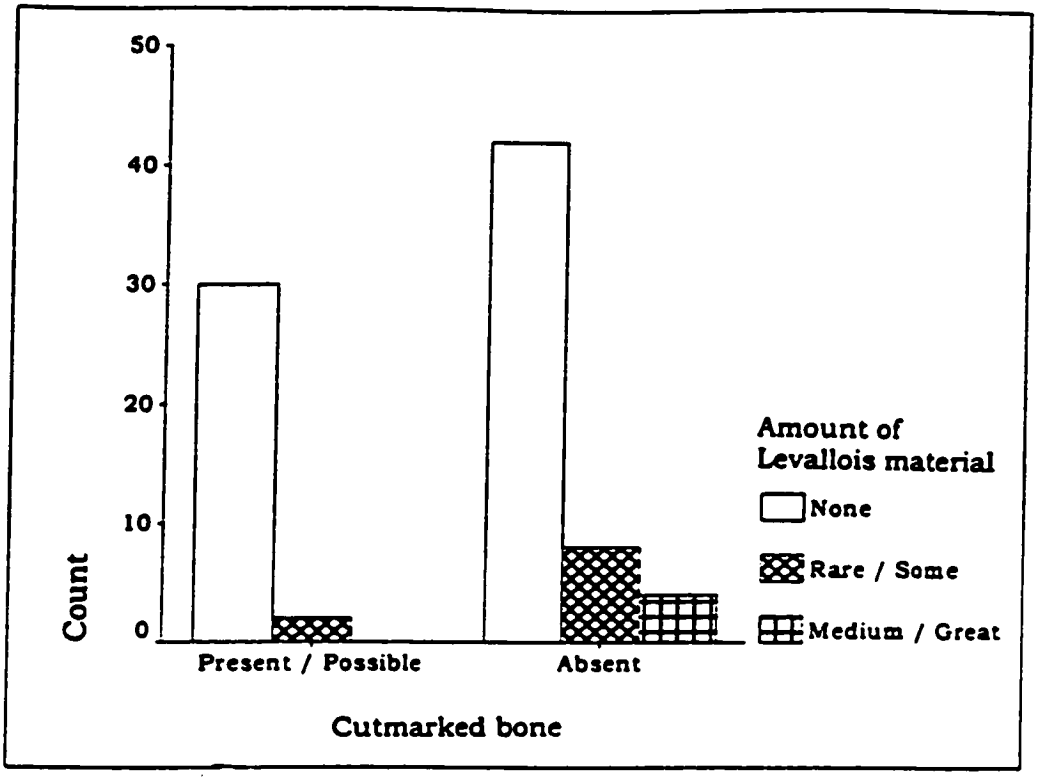


Figure 4.44 Cutmarked bone by site function

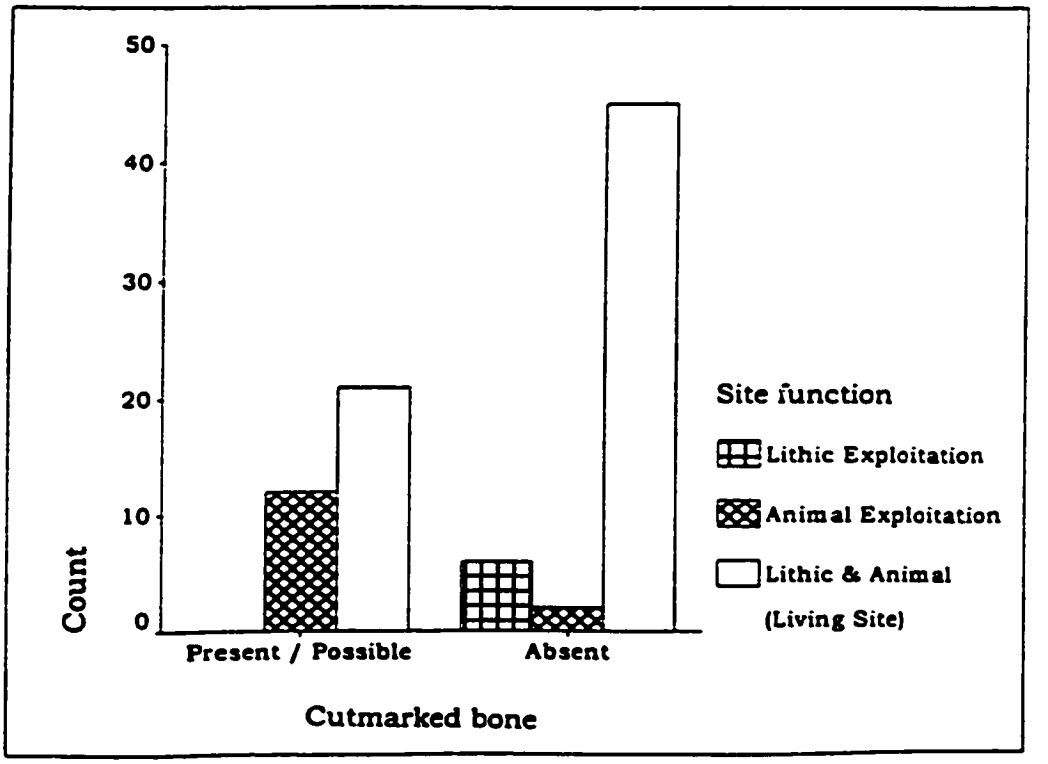


Figure 4.45 Number of artifacts by artifact curation

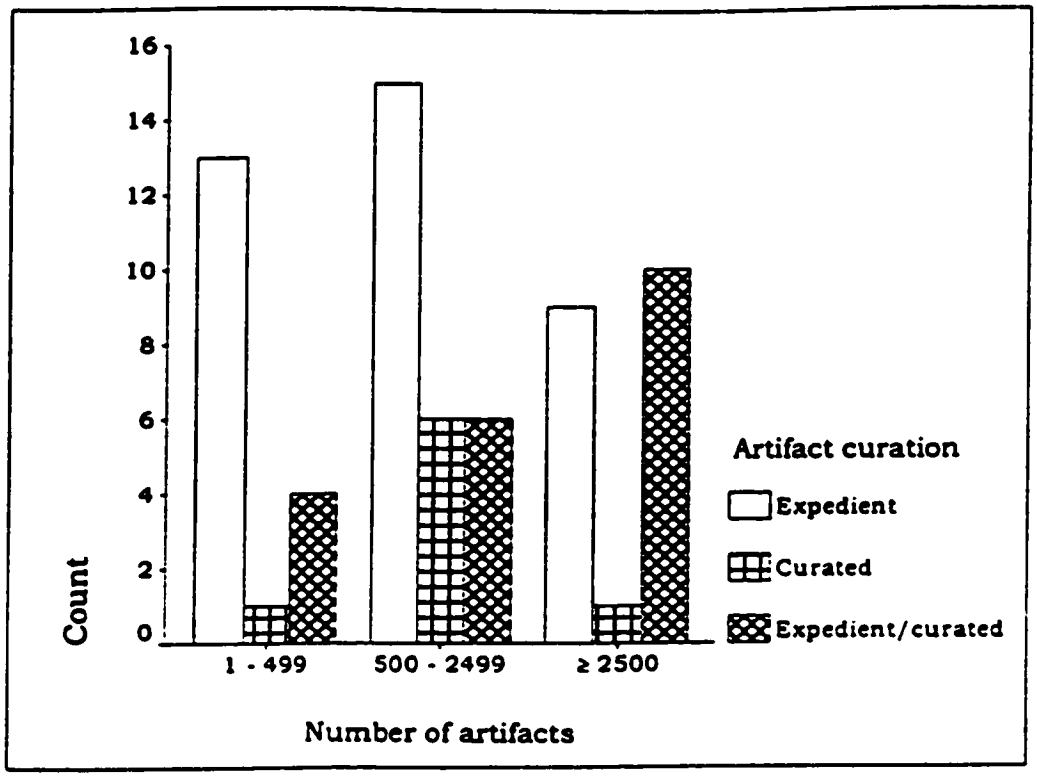


Figure 4.46 Number of bifaces by site function

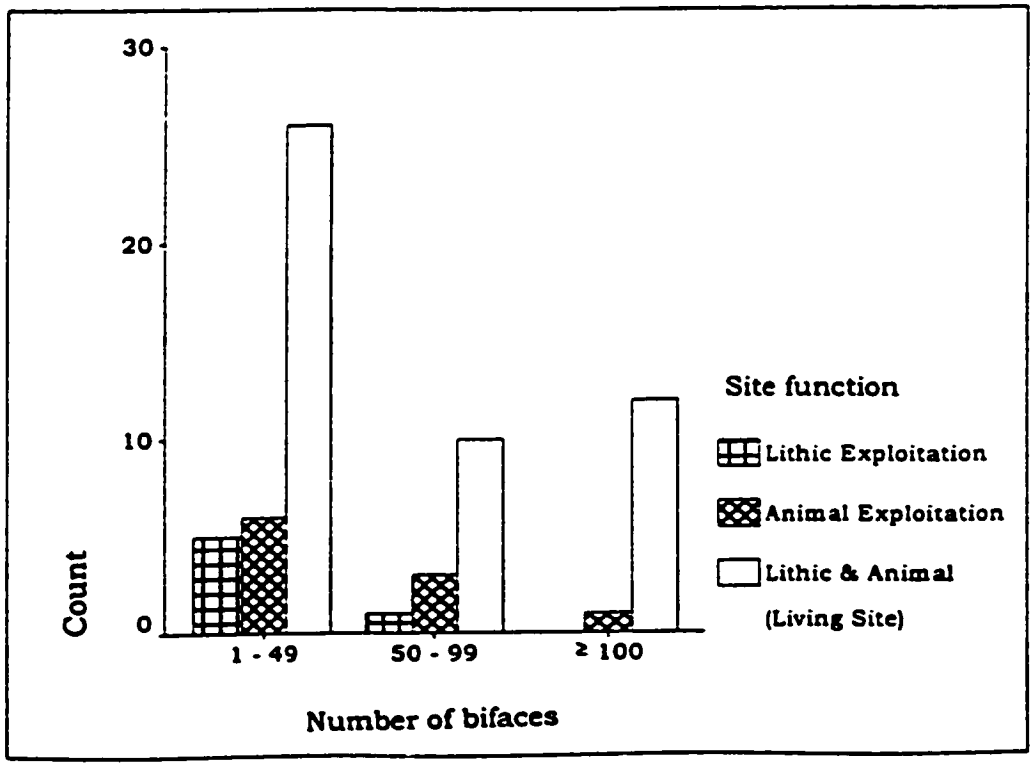


Figure 4.47 Amount of utilized material by artifact curation

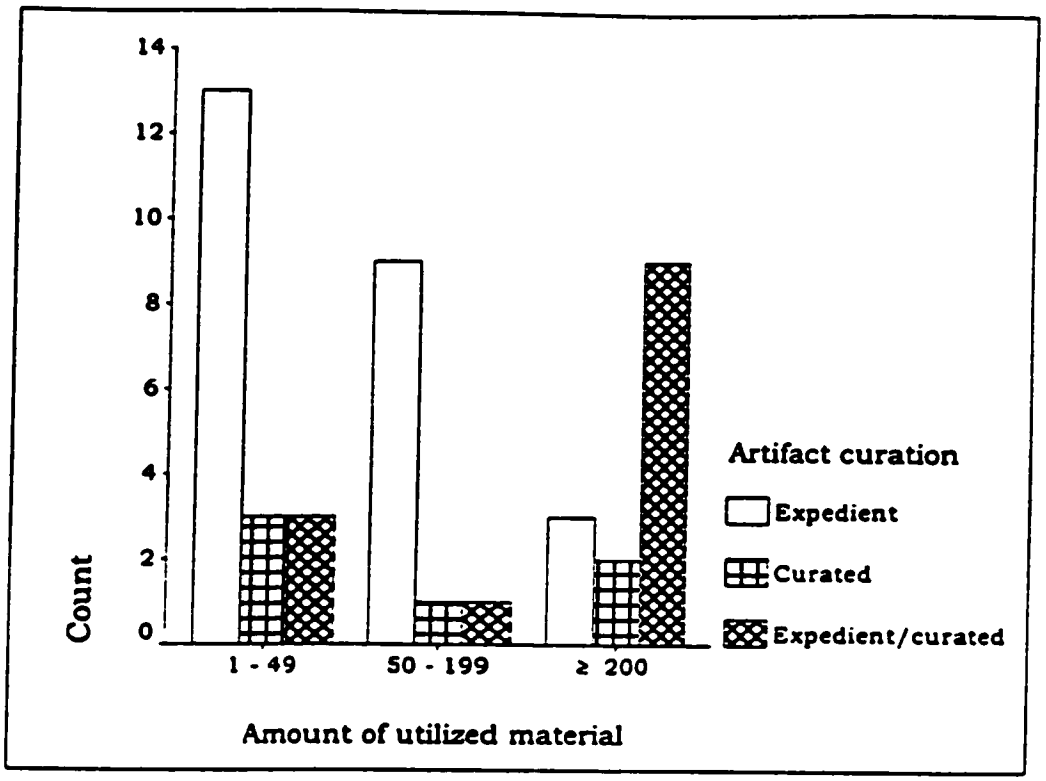


Figure 4.48 Amount of debitage by artifact manufacturing techniques

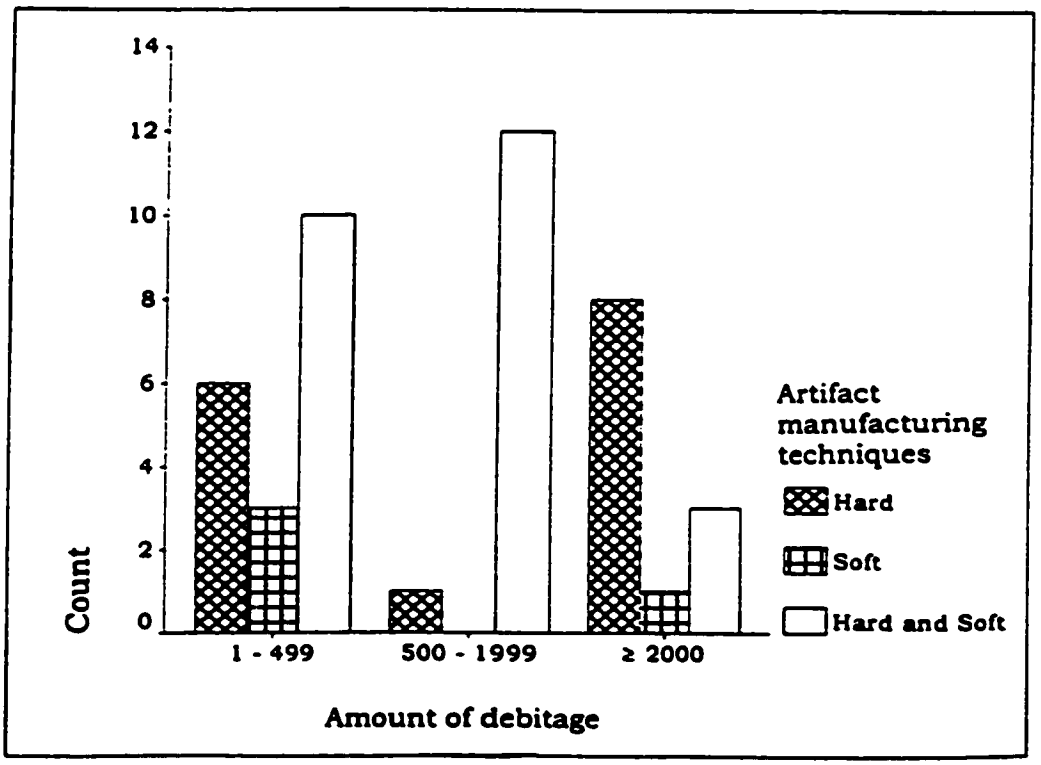


Figure 4.49 Amount of debitage by site function

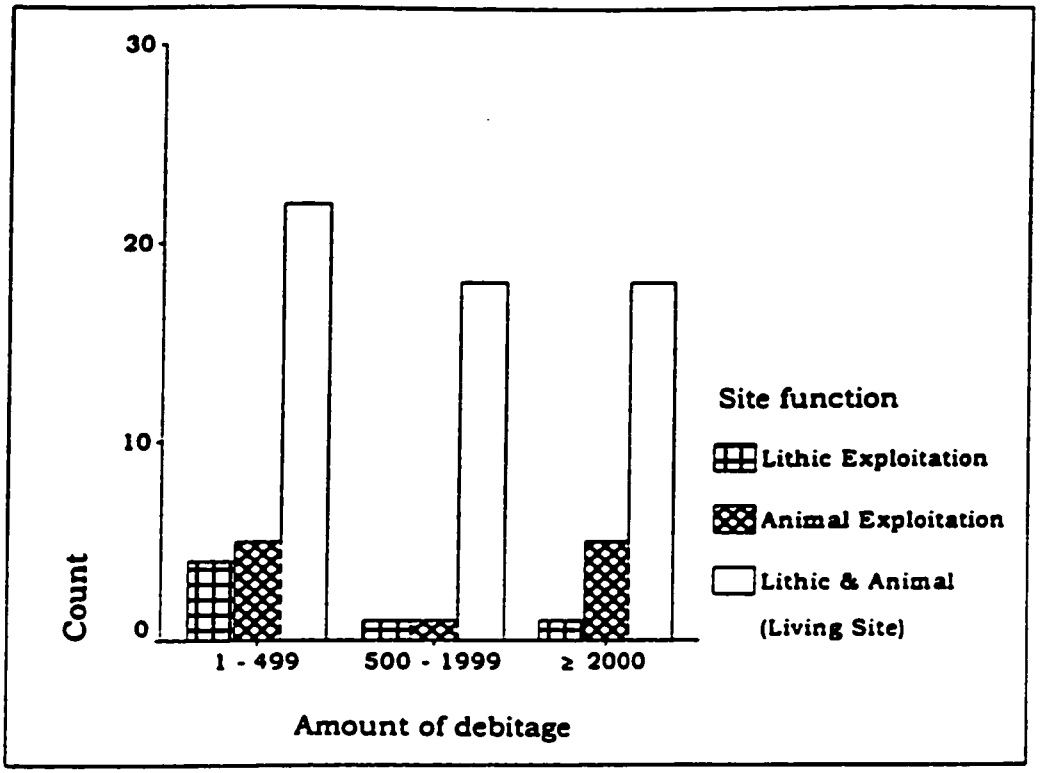


Figure 4.50 Amount of Levallois material by artifact curation

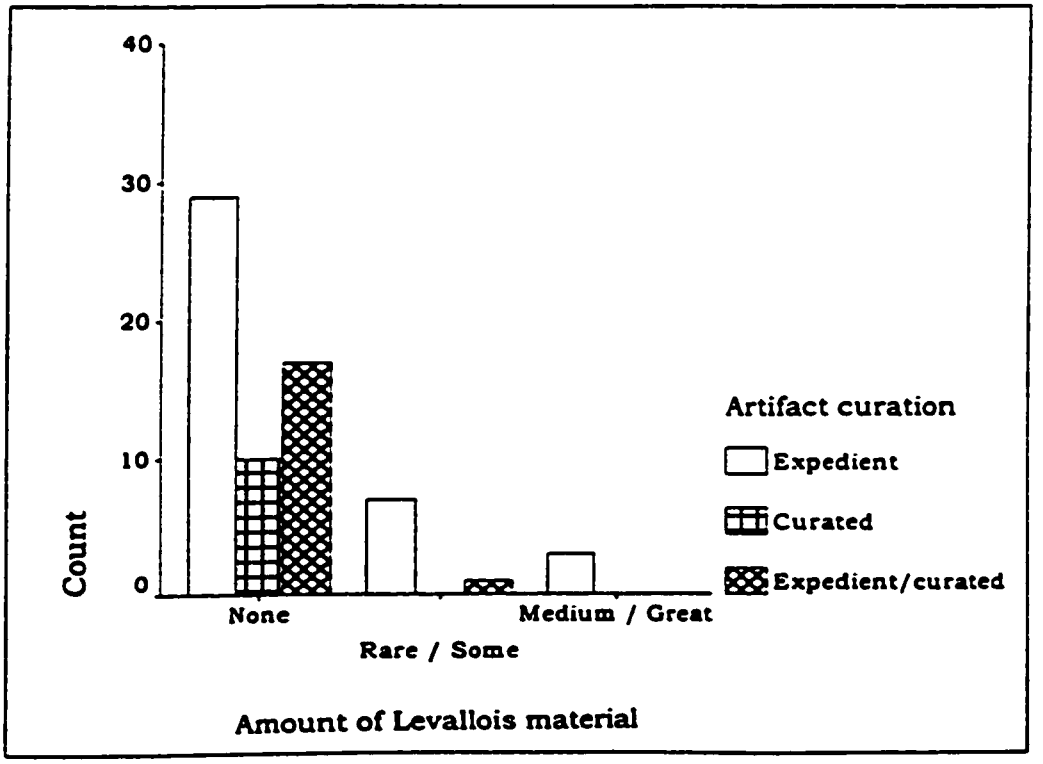


Figure 4.51 Amount of Levallois material by site function

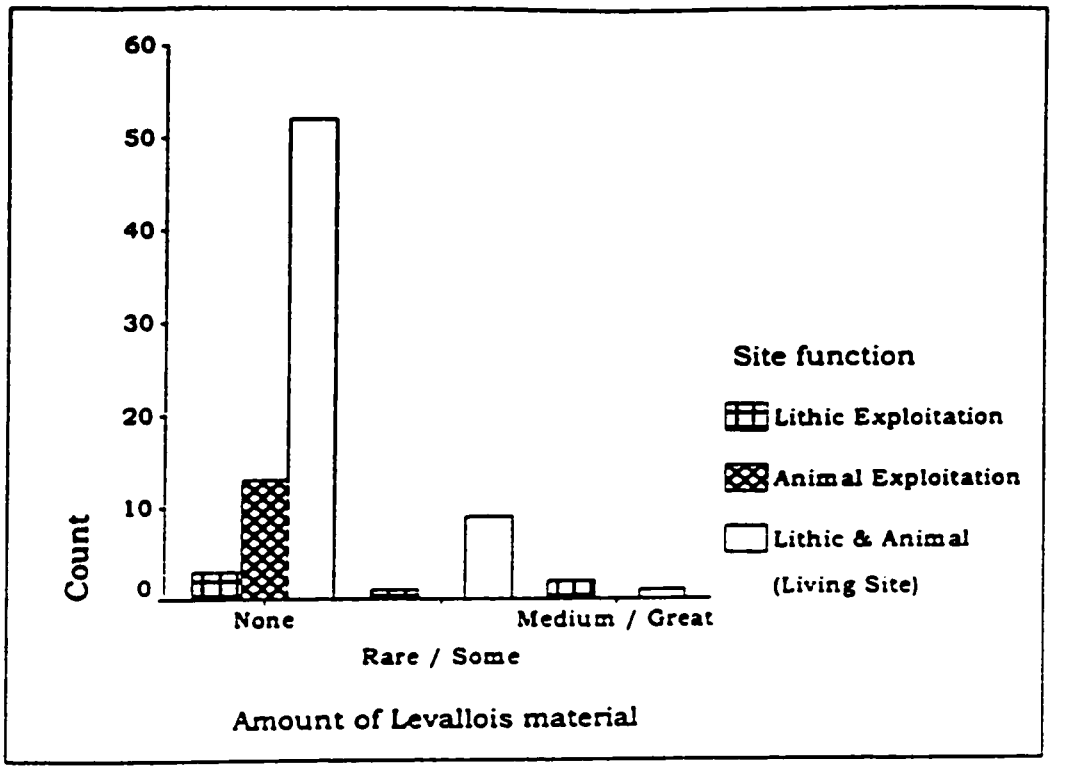


Figure 4.52 Artifact curation by site function

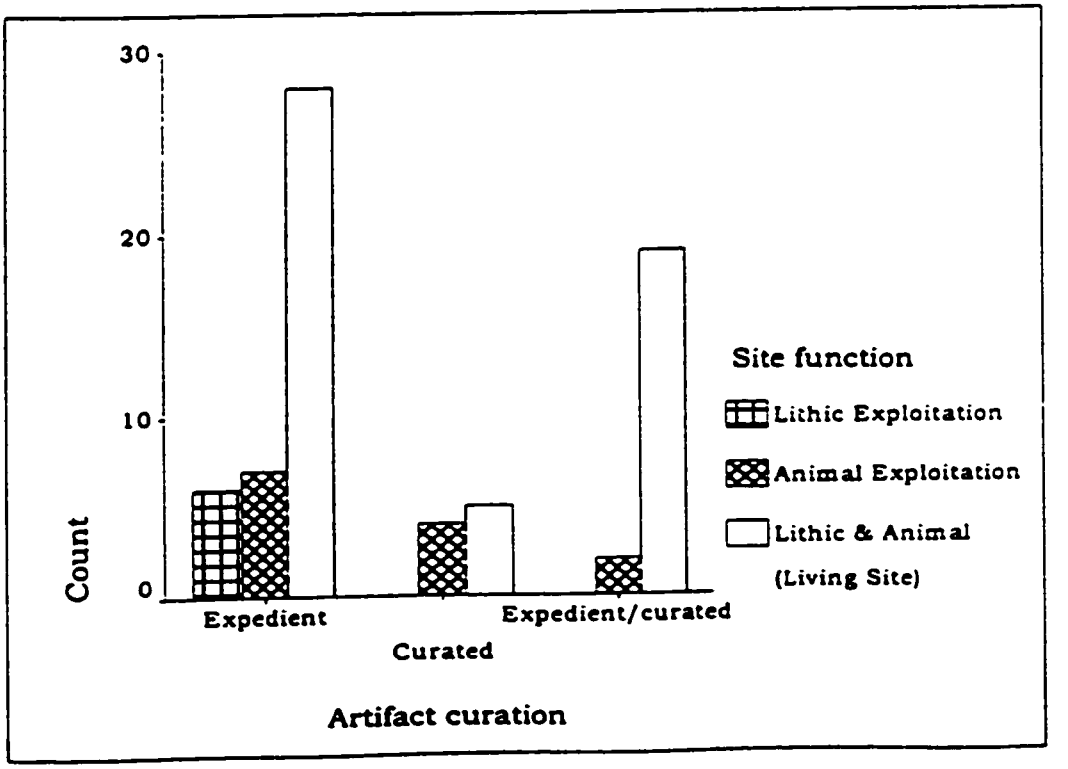


Figure 4.53 Site location by assemblage context

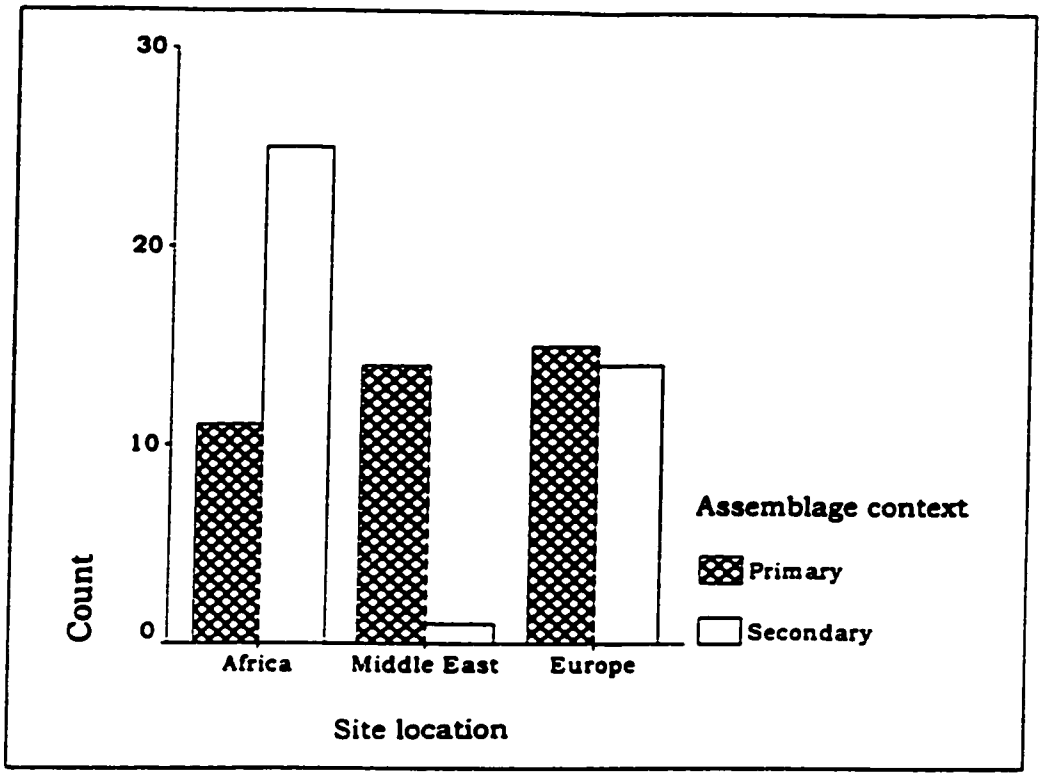


Figure 4.54 Assemblage formational processes by amount of artifact abrasion

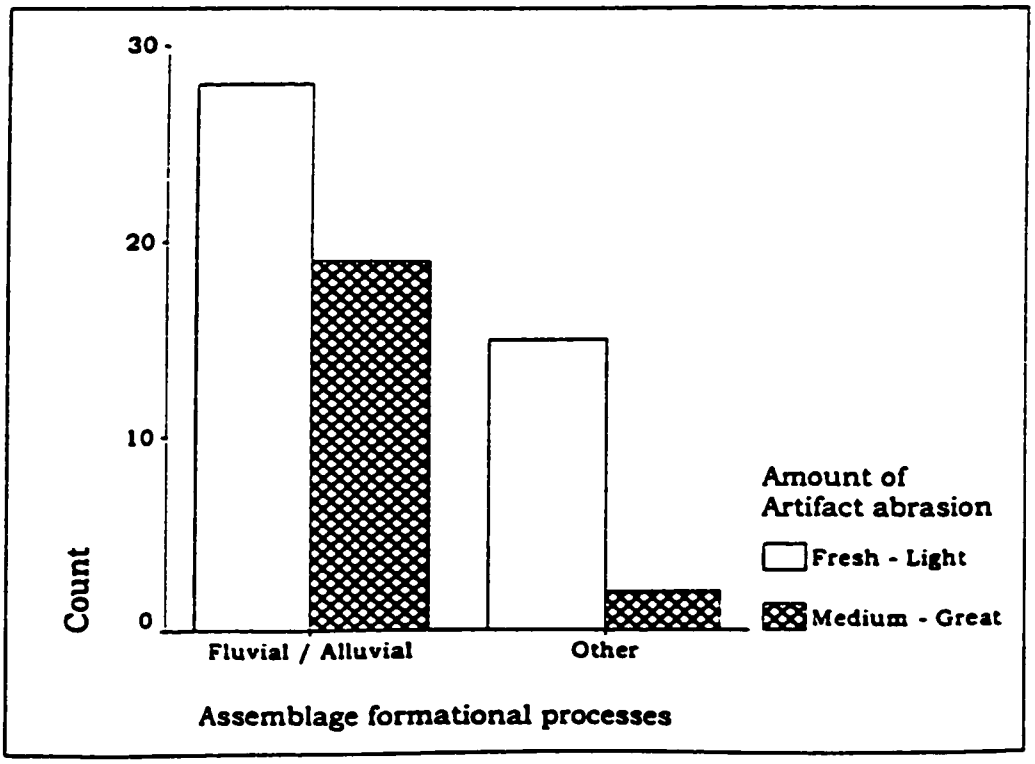


Figure 4.55 Assemblage context by fauna

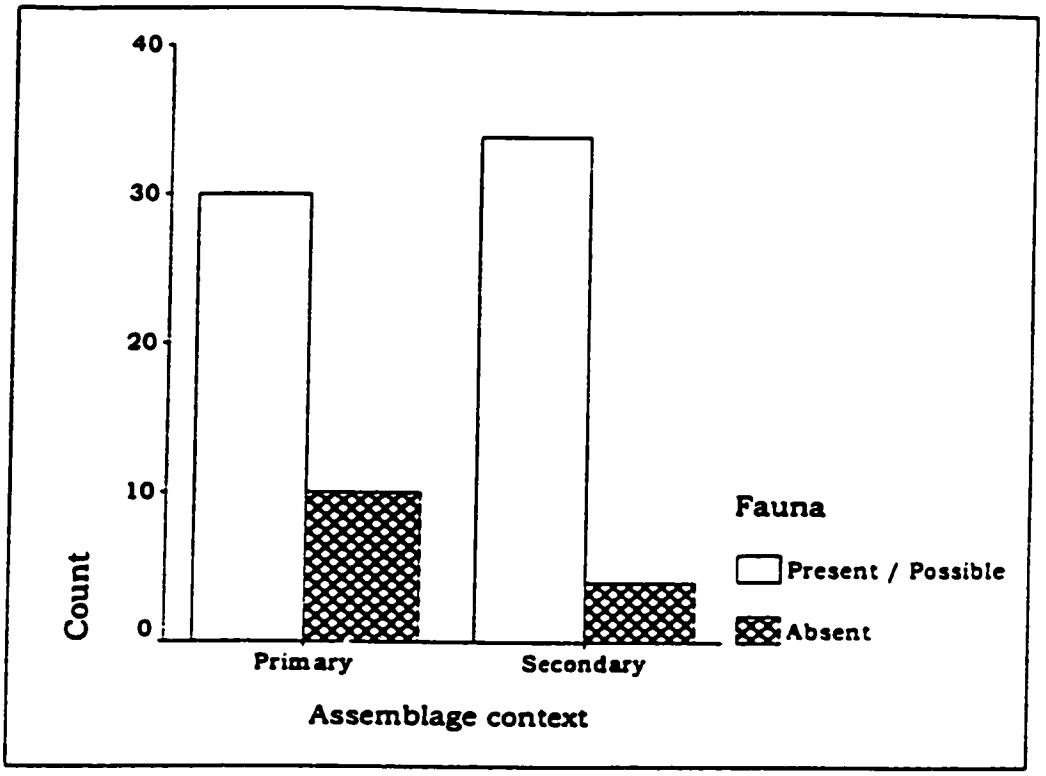


Figure 4.56 Assemblage context by number of tools

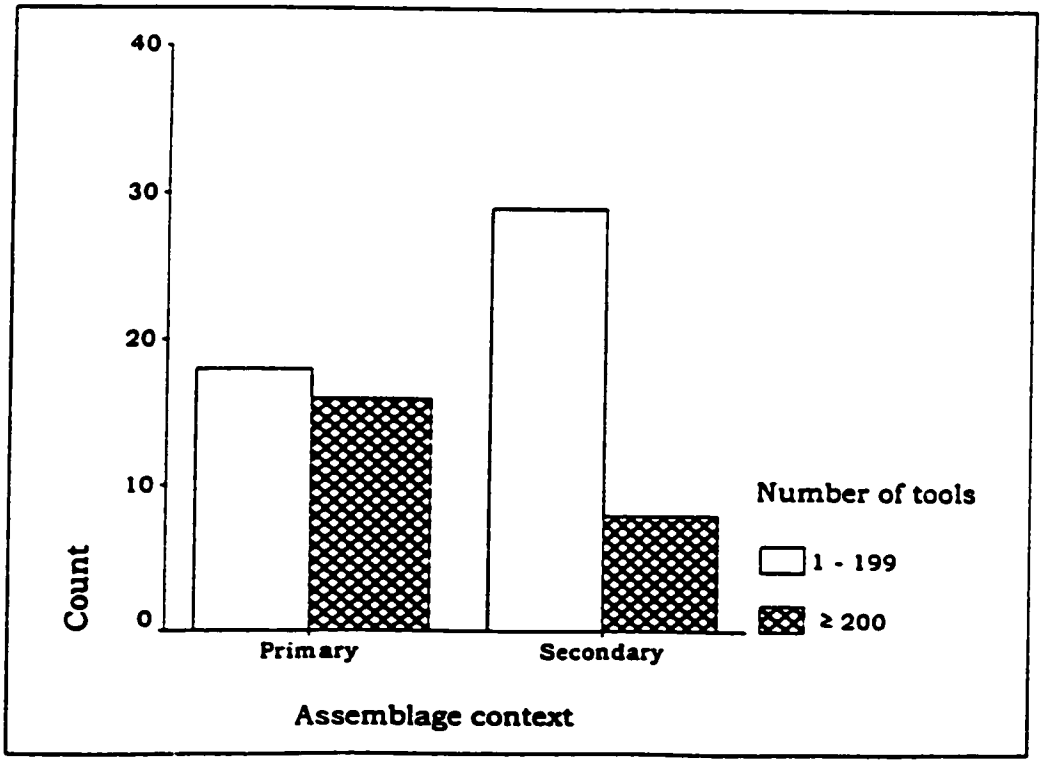


Figure 4.57 Amount of artifact abrasion by number of tools

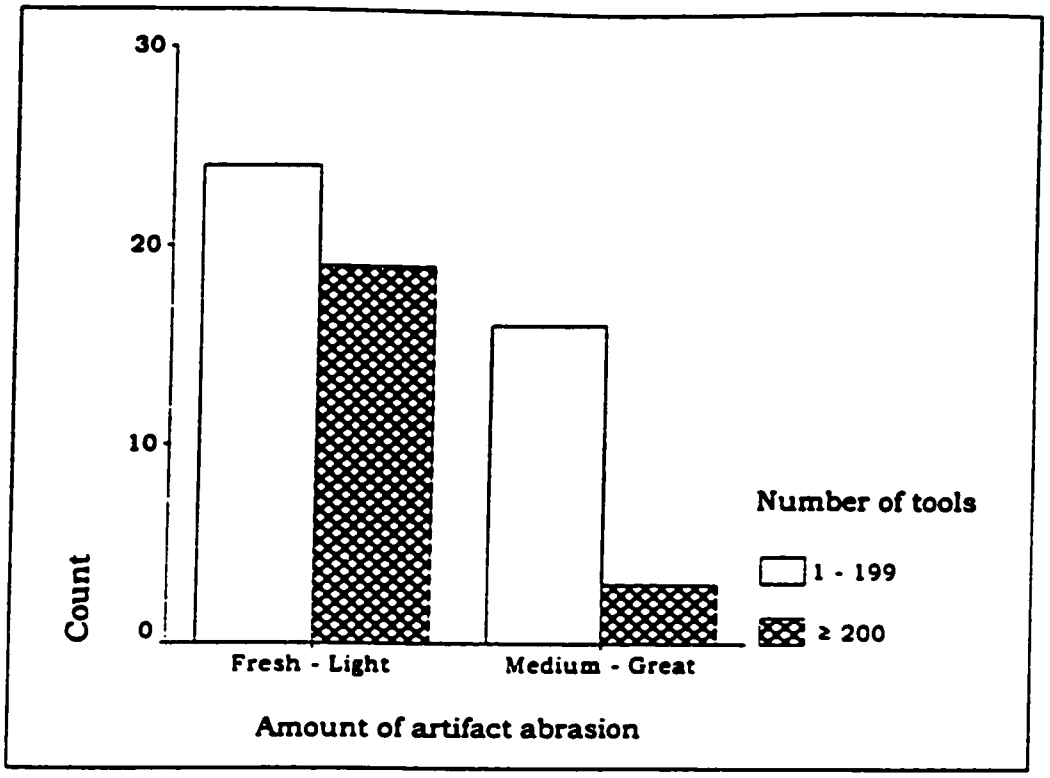


Figure 4.58 Site environment by fire

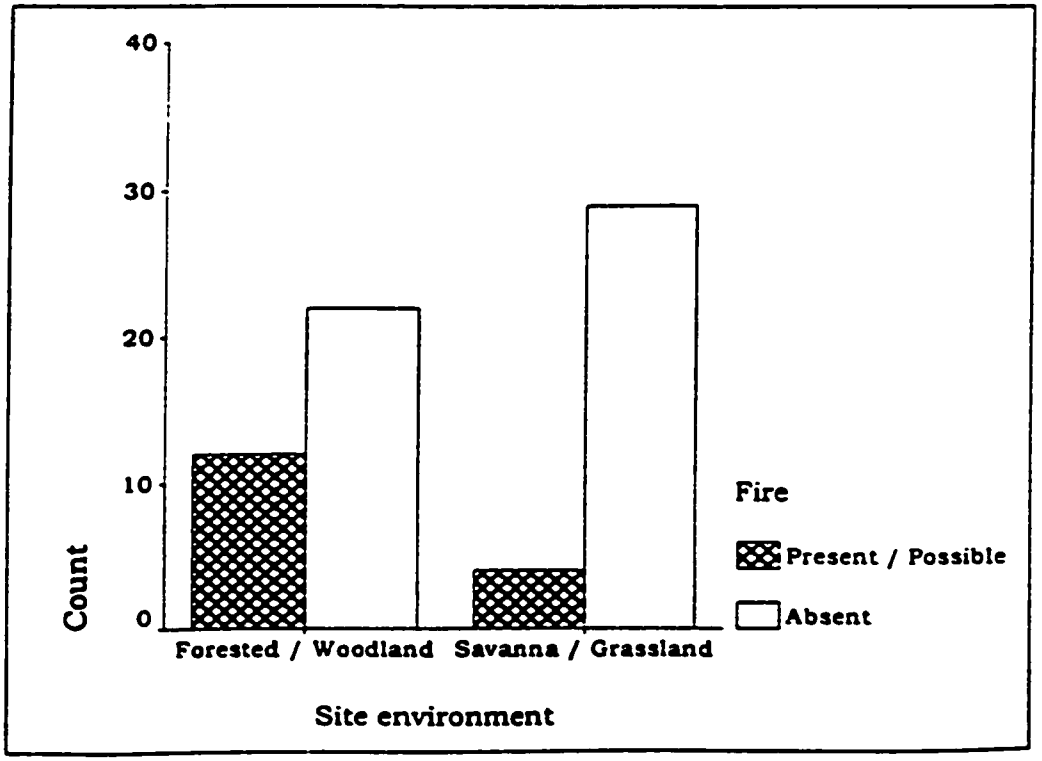


Figure 4.59 Site environment by worked organic material

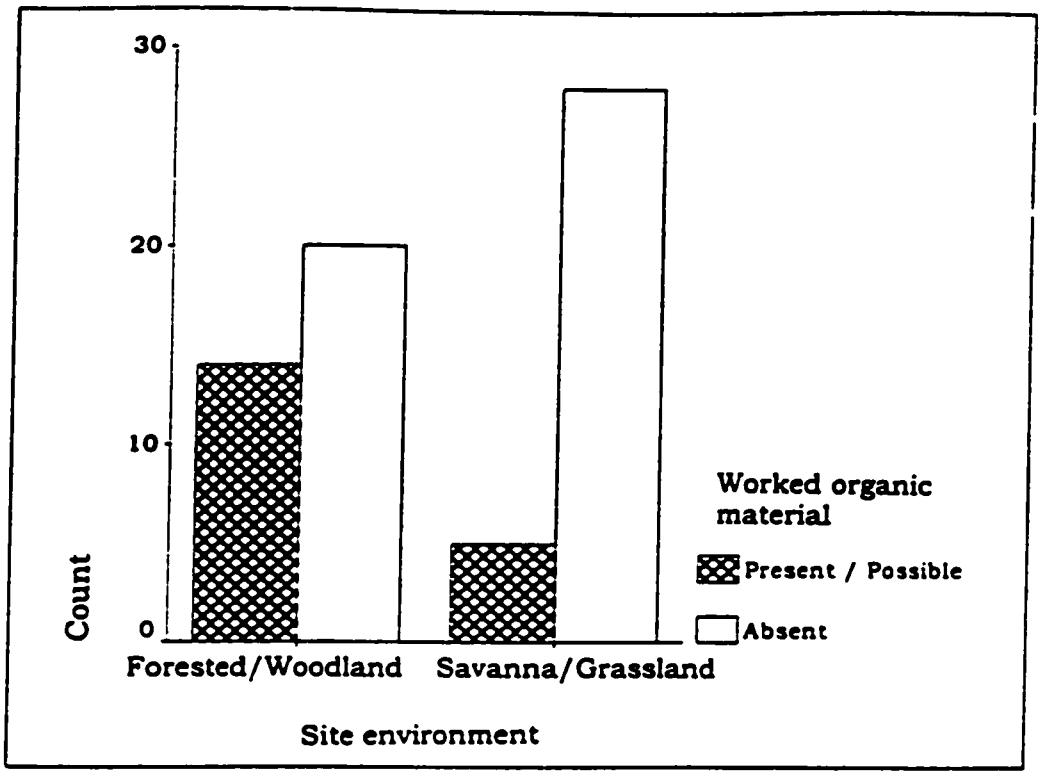


Figure 4.60 Hominid remains by cutmarked bone

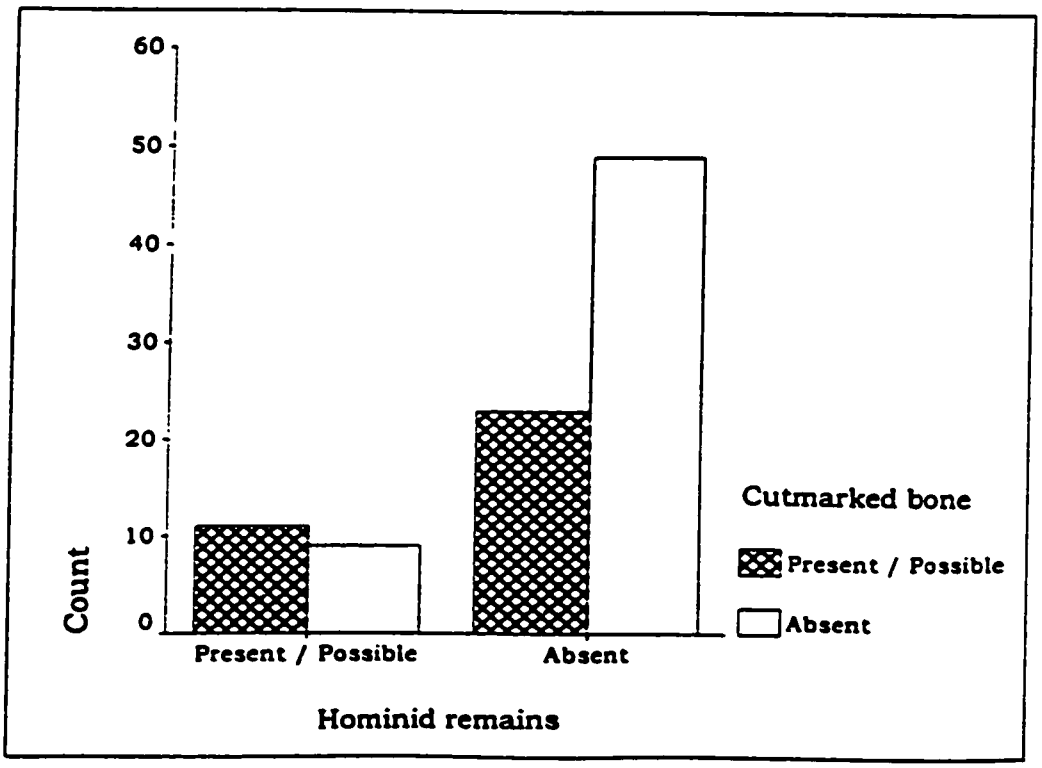


Figure 4.61 Fire by worked organic material

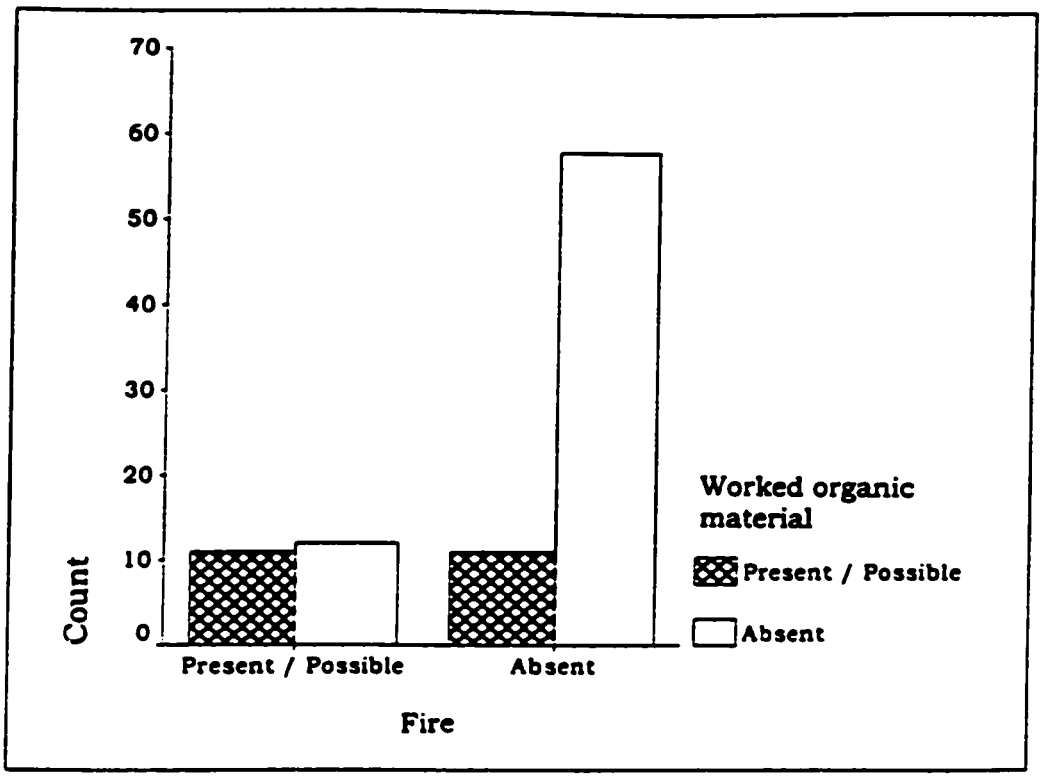


Figure 4.62 Fire by cutmarked bone

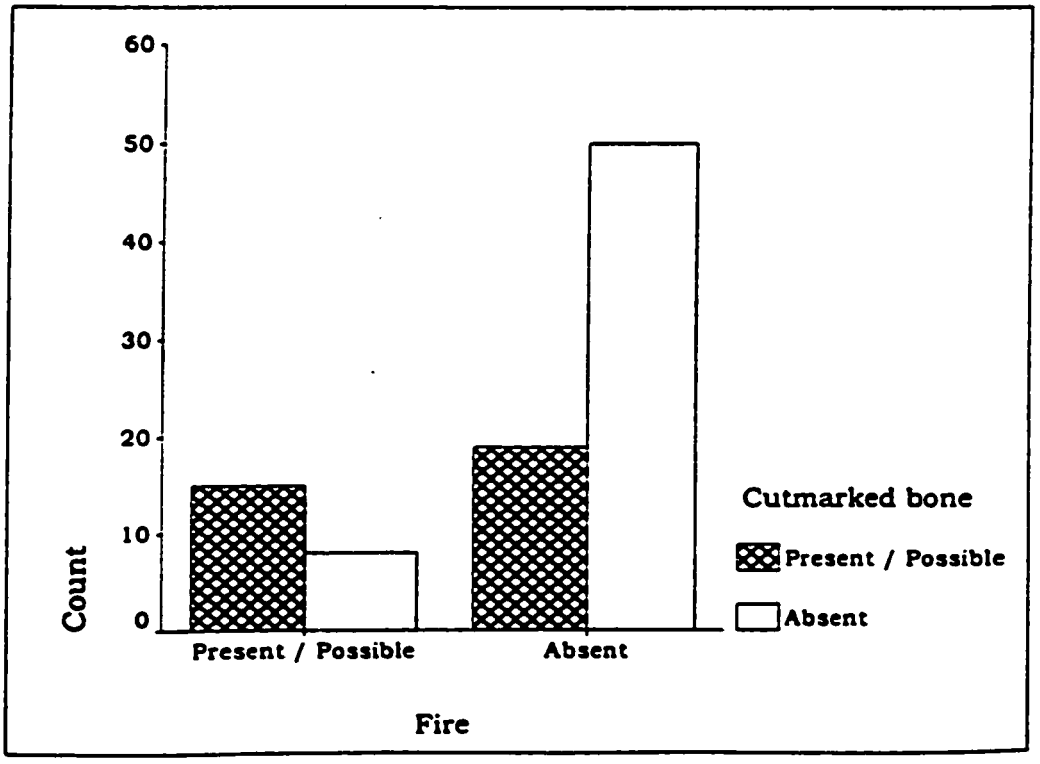


Figure 4.63 Fire by number of tools

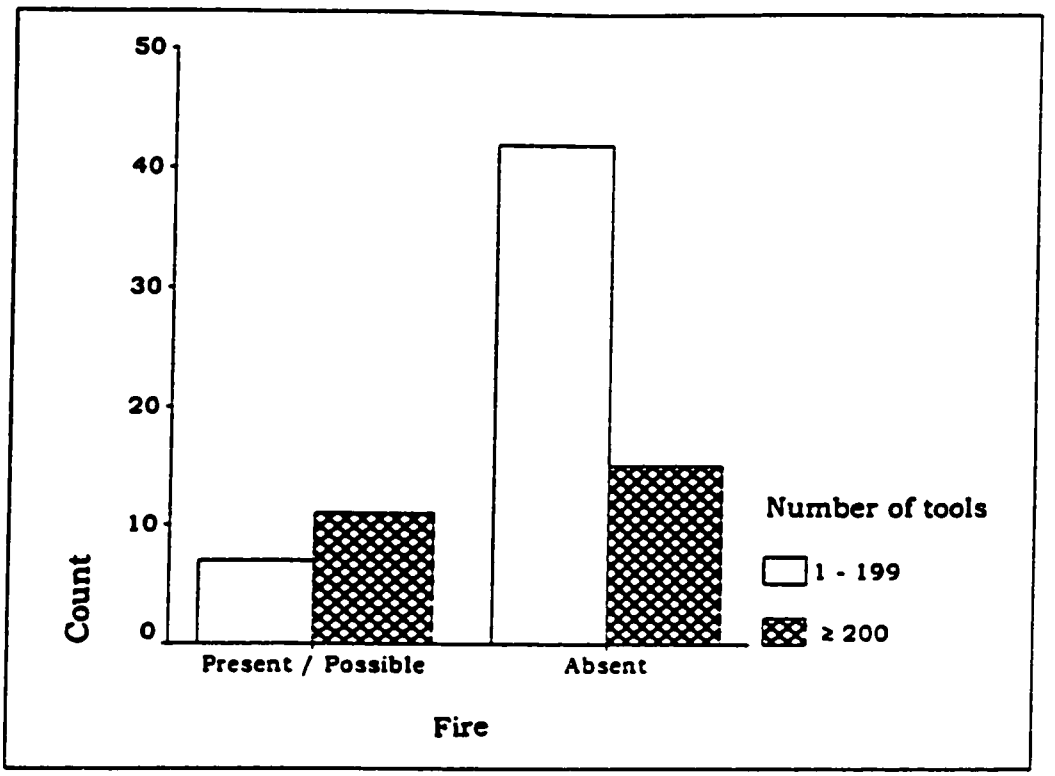


Figure 4.64 Fire by amount of debitage

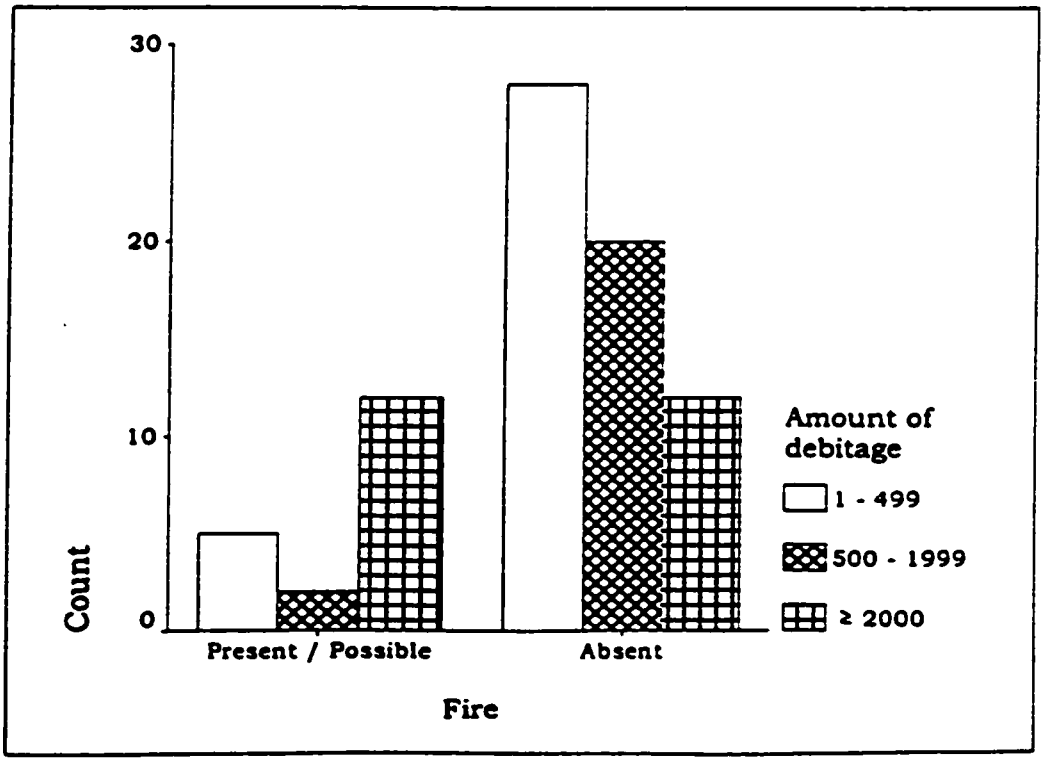


Figure 4.65 Worked organic material by cutmarked bone

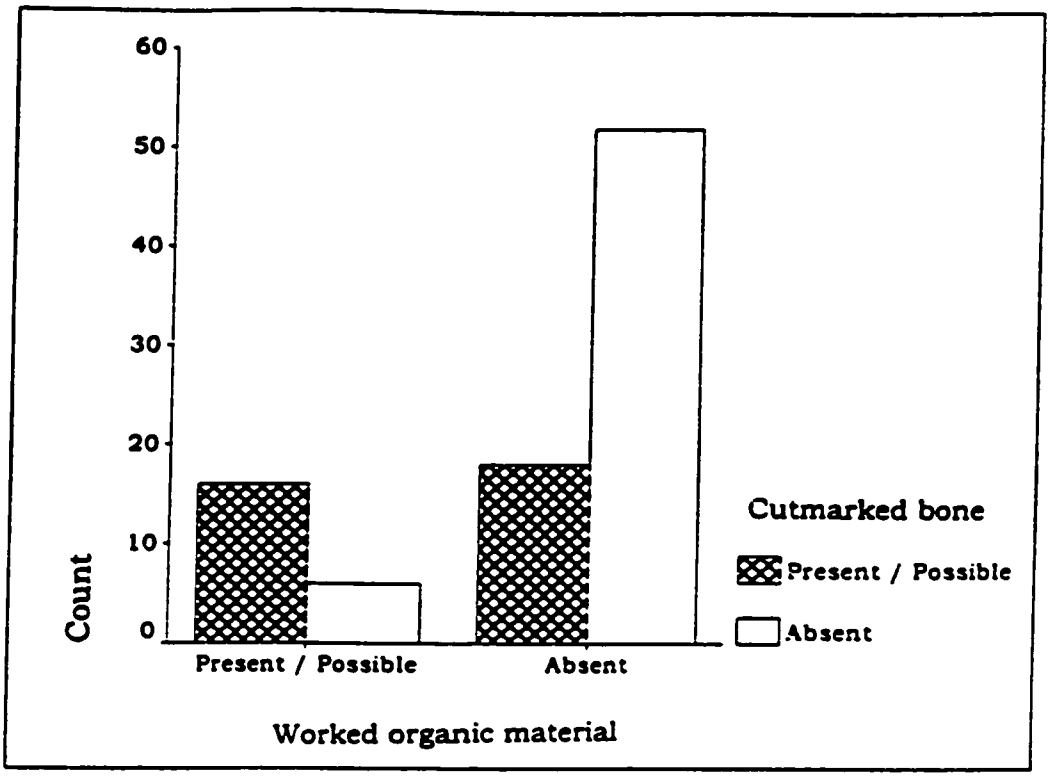


Figure 4.66 Cutmarked bone by amount of debitage

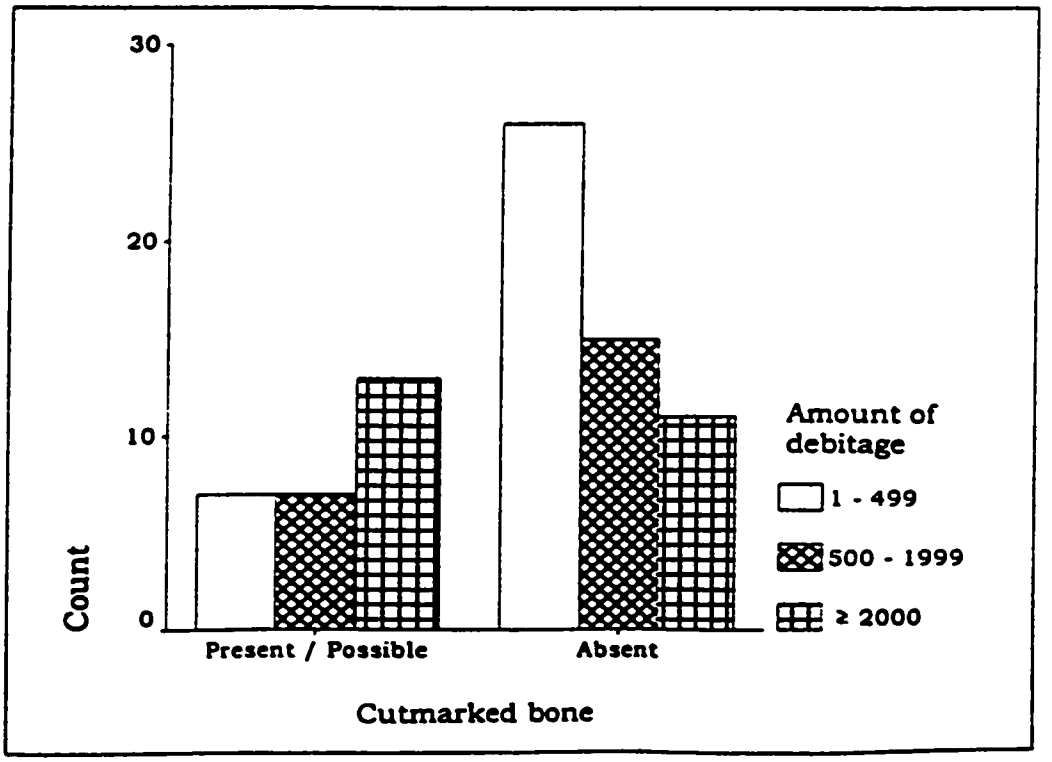


Figure 4.67 Number of artifacts by number of tools

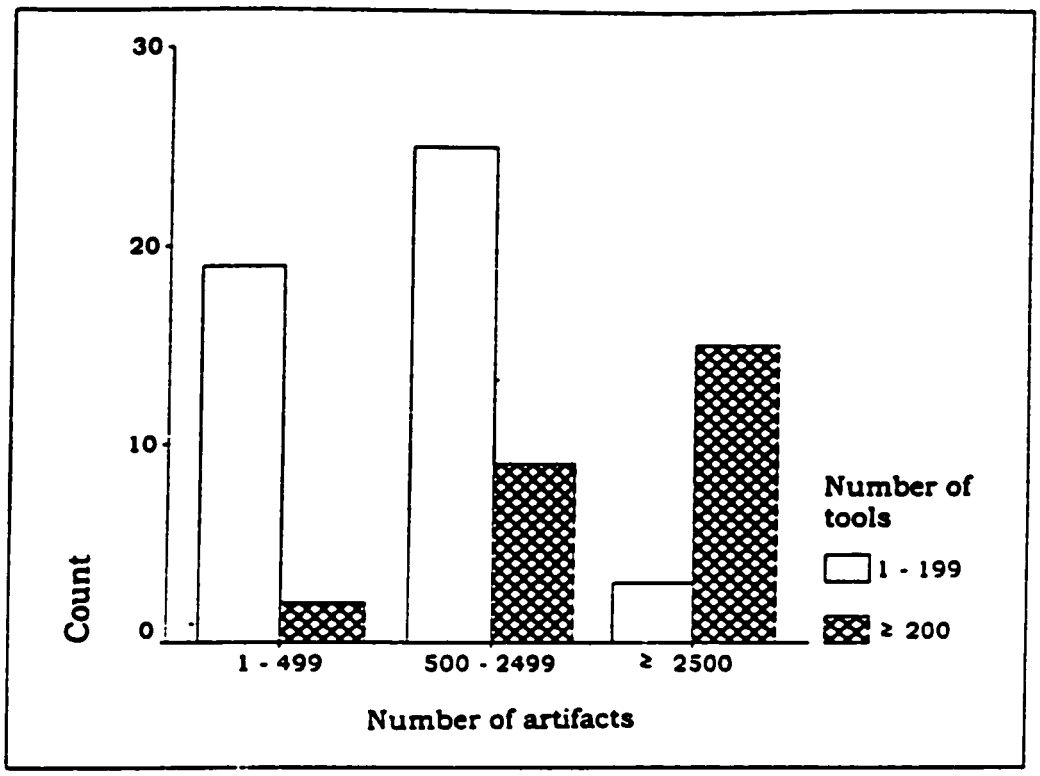
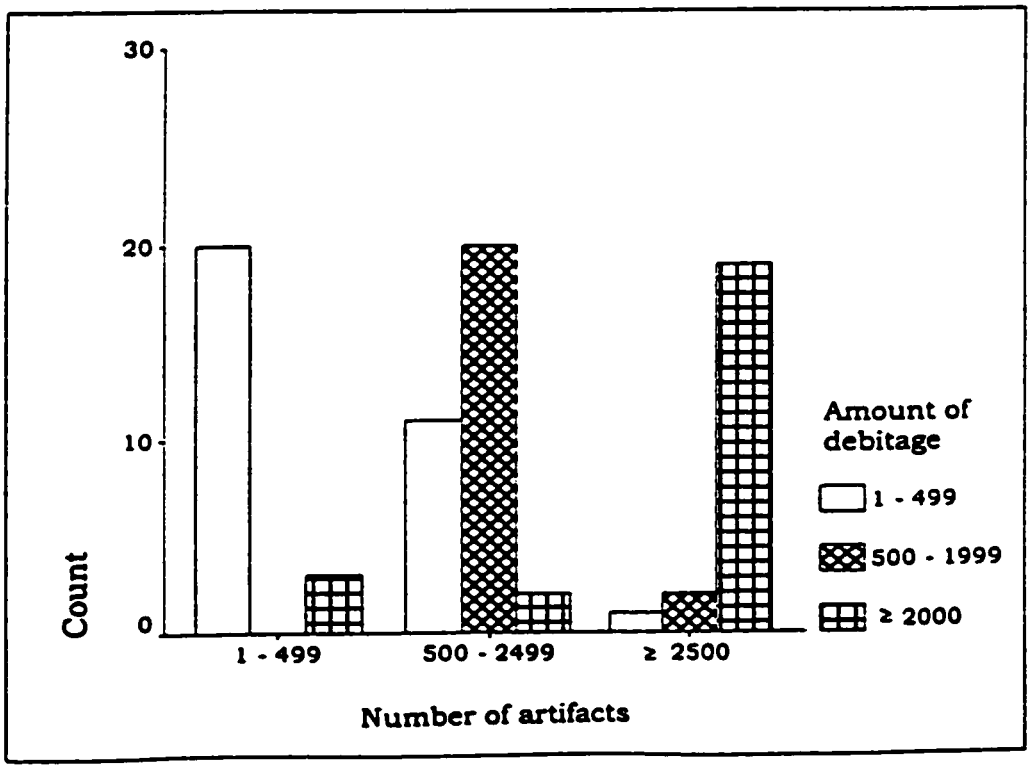


Figure 4.68 Number of artifacts by amount of debitage



Chapter 5
Discussion and Conclusions

If we occasionally forget that one continent is relevant to another, the very evidence for the surge of modern humans around the globe should be sufficient reminder that it all joins up.

Gowlett (1998:64).

The goal of this study was to ascertain if the Acheulean was a period of complete behavioural stasis or not and if there was observable change in the Acheulean , did it occur progressively or relatively rapidly. Identifying Acheulean behaviour took the form of examining published literature from a number of archaeological sites within Africa, the Middle East and Europe. Variables were subjected to a Chi-square test to determine if any paired variables were statistically significant. Even if pairs of variables were not found to be statistically related, behavioural patterns could still be identified in many of these relationships. Because this study was an exploratory data analysis of published literature, some limitations became evident.

5.1 Limitations

In organizing a synthesis and comparative review of Acheulean sites, it proved most difficult to compile information from the vast and diverse literature. Only Lower Palaeolithic sites that have had published reports or monographs were included in this thesis. With few exceptions, it is much more common for short reports in journals to be published rather than large monographs.

Does older published data provide the same kind of information as more recent publications? Early attempts at documenting and assessing hominid behaviour produced very little information as flakes, debitage and faunal remains were not usually collected (McBurney 1950:170; Roe 1981:1-33; Trigger 1989:99; Woodcock 1981:3-4). Bradley and Sampson (1986:42-43) note that waste flakes are usually the largest single find in Acheulean assemblages and as such, are the most valuable in conducting statistical analysis. Without collecting all archaeological material and closely observing stratigraphical relationships, much important behavioural information was lost in early publications. As archaeological techniques and methods have changed through time, so too did the amount of information about prehistoric adaptations. There appeared to be tendencies for more assemblages in primary context to be excavated after the 1950s that resulted in a larger amount of hominid remains, evidence for fire, worked organic material, cutmarked bone and artifacts since behavioural questions were starting to be asked.

Until the 1960s, detailed records of where artifacts were found were not normally kept as early excavations were usually minimally supervised haphazard treasure-hunting episodes. Many of these early excavations were only undertaken for monetary and selfish interest, such that most "of the pieces got into the hands of those who collect...so that they were not accessible for scientific study, and hence were totally lost for that purpose" (Grahmann 1955:513). Conway (1996a:7) noted that at the end of the 19th century, a local collector in Britain was reputed to have acquired over 80,000 individual bifaces. The problem with collections such as this is that all artifacts are completely out of context. In the future, if one is to follow the outline of this thesis in an effort to compile a database of Acheulean sites, it is imperative to excavate new sites with current techniques and re-excavate older sites so that every artifact is collected. In cases where a site has been destroyed or stripped clean of archaeological material, original field notes are essential. While it might never be totally possible to remove collector biases especially in excavations conducted by non-professionals, great strides have been made in the field of archaeology between the 1960s and the early 21st century, perhaps none so clear as in the collection of every artifact. It is feasible that artifact collections of today will in some way reflect artifact collections of tomorrow. The future probably lies in a multitude of more advanced computer animated technologies to aid in the interpretation of artifact patterns.

The 50 sites used in this thesis represent only a tiny number produced by hominids during the Acheulean, while archaeological evidence from the past 2.5 million years represents only a fraction of the activities of early hominids (J.G.D. Clark 1982; Roebroeks *et al.* 1992:558). As Wolpoff (1980:vii) notes, a constant source of controversy in palaeoanthropological studies are that conclusions are being made about behavioural events covering millions of years and involving possibly hundreds of thousands of individuals using a handful of specimens and artifacts. Future work will undoubtedly help to provide greater numbers of fossils and archaeological material and subsequently behavioural information. While Acheulean studies might not be considered an exact science, every thesis, journal publication and book on some aspect of the Lower and Middle Pleistocene aids in a deeper understanding of early hominid behavioural issues. While behavioural resolution will never become absolutely clear, it is essential to continuously discover more sites and offer comparative reviews of artifactual material to document hominid adaptations and behavioural variability through time and space. When regions are compared to one another through time, it becomes possible to observe the spread of hominids across the globe and the development of their technologies and adaptations. In the future, continued work of this nature needs to be undertaken so that

a more comprehensive and representative view of hominid behaviours during the Lower Palaeolithic can be examined.

There are literally hundreds of Lower Palaeolithic sites known throughout the Old World. Most were discovered before systematic excavation practices and chronometric dating techniques were developed and many have not been described in accessible manuscripts. Symposia are beginning to address the great range of diversity within and between Lower Palaeolithic sites. Occasionally, an article or conference proceeding changes the course of how one views the archaeological record. A great accomplishment was the 1975 Wenner-Gren conference at Burg Wartenstein. The output was the collection of articles specifically dealing with Middle Pleistocene issues in the compilation *After the Australopithecines* (Butzer and Isaac 1975). The review of the Lower Palaeolithic of northeast Asia by Yi and Clark (1983) was again one of those rare studies that crossed international lines. Other noteworthy undertakings were the publication of some of the papers presented at a workshop in Tautavel, France, in 1993, dealing with the earliest occupation of Europe, and the Third World Archaeological Congress held in New Delhi, India, in December 1994. These conferences resulted in perhaps two of the most comprehensive books on the global distribution of the Lower Palaeolithic (Petraglia and Korisettar 1998; Roebroeks and van Kolfschoten 1995). These works should all be commended for bringing together vast literature on an immense time period (Nelson 1983:194). Rather than becoming focused on a single time period or geographical region, the above works (including this thesis) are essential to further document the range in Lower Palaeolithic hominid behaviour across time and space.

A database of Acheulean single-activity low-density sites not subjected to great amounts of taphonomic disturbance (i.e., primary context) would provide important behavioural resolution. Another avenue for future research could be to calculate the amount of debitage produced from both hard and soft hammer modes of production. If either produces characteristic kinds or amounts of debitage, it may be possible to document the processes of reduction. Perhaps it may be found that different hominid species made tools in different ways according to raw material limitations. Conducting experimental studies of artifact production might lead to a greater understanding of the degrees of artifact curation and probably site function. Further studies of ecological and environmental data of Acheulean sites would probably provide greater insights into hominid behavioural abilities.

5.2 Results and Conclusions

Almost all archaeological material is an indirect reflection of past hominid behaviour due to taphonomic effects (Schick 1986; Schiffer 1987, 1995). Variables that addressed taphonomic issues included the kinds of assemblage formational processes, assemblage context, amount of artifact abrasion and degree of assemblage disturbance. All taphonomic variables tended to show that archaeological material that had been subjected to lesser degrees of disturbance preserve the most evidence for hominid behaviour in the form of larger numbers of artifacts, evidence of fauna, hominid remains, fire, worked organic material, cutmarked bone, curation and site function. Attributing hominid behaviours to artifactual concentrations may not, in fact, be accurate and thus serious consequences can arise if taphonomic issues are not examined in detail for each excavation.

From what cultural evidence remains, hominid adaptive and behavioural abilities are reconstructed. Understanding lithic reduction sequences enable one to observe a small glimpse of discrete hominid actions from one time and place. A recurring problem is that the farther back in time one goes "the more complex forms of social organization disappear from the archaeological record" (Stiles 1979:2). This is especially relevant for the Acheulean and Oldowan.

While Oldowan/Developed Oldowan sites seem to be only found in Africa, many Acheulean sites are known scattered across much of the western Old World. Prior to 800,000 years ago, many more sites are known from Africa than the Middle East and Europe. Perhaps the most significant global question facing the field of Palaeolithic archaeology is the issue of hominid colonization of Eurasia (Bar-Yosef and Belfer-Cohen 2001; Gamble 1998b; Mann 1982; Martinez *et al.* 1997; Petraglia and Korisettar 1998). After the Middle Pleistocene (particularly around 500,000 years ago), there is a large increase in the number of sites known throughout Europe and the Middle East. Aguirre and Carbonell (2001:15) indicate that a demographic explosion in hominid populations, sites and activities occurred around 500,000 years ago. With more discoveries, the age of hominids entering Europe and successfully living there could be pushed back from the commonly accepted date of 500,000 years ago (Roebroeks and Kolfschoten 1994, 1995) to closer to the Brunhes/Matuyama boundary, as it was only after that date that hominids are generally accepted to have began to permanently settle Europe (Aguirre and Carbonell 2001; Bar-Yosef and Belfer-Cohen 2001:25). The data obtained when site location and age of assemblages were compared supports an initial occupation of Europe prior to 500,000 years ago, but not earlier than 800,000 years ago.

Fire is generally only thought to have become common in Middle to Upper Acheulean populations after 500,000 years ago (James 1989); a tendency observed, though it is possible that a larger data set would have enhanced this pattern since evidence for fire was somewhat ambiguous. The positive identification of fire in archaeological sites is difficult to identify due to natural taphonomic processes that can provide misleading information. However, fire must have influenced many aspects of early hominid behaviour such as shelter in the form of protection from both the elements and carnivores/scavengers, warmth, social bonding, the consumption of new food sources normally toxic in their raw state and the softening and killing of bacteria in raw meat (Clark and Harris 1985; Pennisi 1999; Stahl 1984; Wrangham *et al.* 1999). Both fire usage and cave occupation may have been behavioural consequences of hominids spreading into and throughout the European continent sometime after 780,000 years ago. There appeared to be more evidence of fauna in assemblages when fire was present. Fire also seems to be slightly better represented in living sites where a range of animal consumption behaviours and stone tool activities were carried out. Short-term, specific activity behaviours (such as single and multiple animal hunting/butchering and lithic procurement) may have become more common after the Middle Pleistocene when fire usage became more regular in hominid adaptations, particularly in northern regions.

Faunal exploitation is believed to have become more intensive after 800,000 years ago due to an overall increase in the amounts of animal remains within archaeological deposits. As cutmarked bone with microscopic use-wear characteristic of stone tool butchery marks was found to increase over time within the Acheulean, this variable was a good indication that fauna was more successfully obtained either through hunting or scavenging.

Acheulean hominids are believed to have been terrain-opportunists adapting to various environmental and resource circumstances (Cachel and Harris 1998; Spencer 1997). Specifically after the Middle Pleistocene, Acheulean hominids appeared to inhabit fluctuating ecological conditions including more forested/woodland environments of Europe. Acheulean hominids were inquisitive and adaptive beings who occupied unexplored lands outside of Africa, pursued alternative and opportunistic food resources on a more regular basis and thrived in ecological zones of forested/woodland regions separate from savanna/grassland environments of earlier hominids. Beginning with the Early Acheulean, hominids seem to have used fire on a more regular basis, although the sample size of 25% of assemblages with possible evidence of fire is problematic. Through time in the Acheulean, hominids acquired larger amounts of fauna (either through hunting

or scavenging), engaged in more shaping of wood and other perishable organic materials, and occupied caves (especially throughout the European mainland). The more frequent acquisition of faunal material, including more successful carnivore/scavenger confrontations can partly account for Acheulean hominids colonizing regions outside of Africa (Isaac 1981, 1983b; Svoboda 1989). Greater exploitation of the natural environment seemed to increase during the Acheulean, but more specifically after the Middle Pleistocene with the emergence of archaic *Homo sapiens* in Africa.

The number and types of artifacts (such as tools, utilized material and debitage) have all been shown to increase over time within the Acheulean. This could be indicative of hominids manufacturing greater numbers and varieties of lithics because of longer terms of residency at specific places. Another reason to account for larger numbers of artifacts could be population increase through time. Larger hominid populations would leave more archaeological material to be discovered, perhaps accounting for why the number of Acheulean sites increase after 800,000 years ago.

From the Early to Middle Acheulean, there appears to be more evidence of curation. More curation would be expected if hominid populations were mobile. A reason that Acheulean populations would be more able to travel and transport resources greater distances than Oldowan hominids could be their ability to adapt to different environmental, lithic and faunal circumstances. For instance, while Oldowan hominids tended to occupy sites immediately close to water, Acheulean hominids frequented site locations further from water sources. After the Middle Pleistocene, Acheulean hominids began to occupy a greater range of site locations, environments, elevations and layouts (such as caves). There was a tendency for cave sites to show evidence of expedient behaviours since raw material could usually be procured in the immediate vicinity, while open air sites more often showed that curation occurred.

After the Middle Pleistocene there is more technological variation across the Old World than earlier times as both the Levallois and Clactonian tool kits emerge. What must be one of the most significant technological changes during the latter half of the Acheulean (post-800,000 years ago) was the introduction of Levallois production methods. Since the Levallois technology only begins after 800,000 years ago, this could be taken to show a major difference in the technological repertoire during the Acheulean. Levallois material appears to be found only in forested/woodland environments. Perhaps Levallois technology was an adaptation to non-savanna/grassland habitats and could have been a technological response to more forested/woodland environments.

Somewhere between the Oldowan and the end of the Acheulean, many behaviours either developed or became more complex. The first kinds of hominid behaviours known to produce archaeological occurrences are in the form of lithic reduction sequences. With the beginning of the Oldowan, hominids produced cores and flakes using hard hammer (including bipolar) percussion. Prior to 800,000 years ago, hard hammer percussion was used almost exclusively in assemblages. It is only after 800,000 years ago where there is a trend for more soft hammer percussion in the reduction process in order to refine tools such as bifaces. Experimental studies quantifying symmetry and the kinds of reduction techniques seem to indicate that technological differences exist between the early and later phases of the Acheulean. Bifaces in the Middle East generally decrease in relative thickness through time and become more refined and symmetrical through the use of soft hammer percussion and resharpening (Bar-Yosef 1994a:250, 1998:234; Crompton and Gowlett 1993; Gilead 1970; Gowlett 1986:257; Graham 1970; Isaac 1975a:532, 1986:223; Klein 1983:29; McPherron 1995, 2000; Saragusti et al. 1998; Vaughan 1998; White 1998a:102; Wynn and Tierson 1990). At the end of the Acheulean approximately 200,000 years ago, a variety of regional technological subdivisions have been defined representing hominids who adapted to the use of different raw materials, albeit not necessarily different adaptations. The pace of technological change within the Acheulean has been acknowledged to be slow, even stasis-like (Villa 1983:171-172). While technological homogeneity and cultural conservatism could be evidence of either a mental or cultural threshold that still remained to be crossed (e.g., J.D. Clark 1987:823; Gowlett 1986:251; Klein 1983:31; Ludwig and Harris 1998:98-99), the focus of this thesis was to examine the evidence for indications of potential cultural/technological change during the Acheulean.

From examining many variables and associations between them, this study suggests that the Acheulean was not a stagnant period of 'sameness' representing behavioural or cultural stasis. Behaviour, and likely cognitive abilities, did experience change, especially after 800,000 years ago exemplified by the gradual introduction of the Levallois production method. Many of the variables examined in relation to time (Section 4.2.1) showed slight but noticeable differences (Table 5.1), particularly after 800,000 years ago. While long spans of time and large geographic areas are still unaccounted for during the Acheulean, it may be argued that noticeable changes within the Acheulean did increase after 800,000 years ago and was therefore not a period of complete behavioural stasis.

As Gowlett (1998:63) notes, "...the sameness of the Acheulean often rest[s] on assumption, so that studies outside Palaeolithic archaeology make generalizations which

may be invalid." These assumptions, generally made by people who do not work on Acheulean issues, are based on the belief that since technological changes were very slow, cultural change was almost equally stagnant. New evidence continuously challenges current beliefs and preconceptions on how complex early hominid behaviour was between 1.8 mya and 200,000 years ago. When observed in a detailed context, the Acheulean is diverse. When the time again comes for someone to attempt a general overview of the Acheulean, this thesis could serve as a starting point from which newly reported sites, assemblages and references can be added. This thesis has been written to aid in the further understanding of Middle Pleistocene hominid behaviour. A significant aspect of this work has been the accumulation of many references pertaining to individual sites. While this thesis is *not* an annotated bibliography, it *is* an analysis and comparison of Acheulean archaeological sites to document cultural change. It is hoped that this thesis will serve some use for others interested in a global view of hominid prehistory. Although this work is by no means conclusive of all Acheulean sites and low sample size was difficult to account for, it was felt that the amount of information collected would be sufficient to observe general relationships within the Acheulean. At best, it may be possible to witness some general patterns through time, though without examining more sites, assemblages and variables, the conclusions reached here should be taken as preliminary. Only with future discoveries, new theories and interpretations of pre-existing archaeological patterns will Acheulean behavioural resolution become more clear on a global scale.

Table 5.1 Acheulean cultural tendencies over time

Variables	Observations
Site location by age of assemblage	More site locations through time seemingly supporting a European occupation of pre-500,000 years ago.
Age of assemblage by fire	Fire slightly increases through time.
Age of assemblage by environment	Forested/woodland environments increase through time as hominids occupied more northern habitats.
Age of assemblage by site elevation	Site elevation appears to increase through time.
Age of assemblage by site layout	Cave usage increases through time.
Age of assemblage by fauna	Fauna acquisition increases through time.
Age of assemblage by cutmarked bone	Cutmarked bone slightly increases through time.
Age of assemblage by worked organic material	Worked organic material slightly increases through time.
Age of assemblage by number of artifacts	Number of artifacts (and subsequently tools, bifaces, utilized material and debitage) gradually increases through time.
Age of assemblage by amount of Levallois material	Evidence for Levallois technology only noticeable after 800,000 years ago.
Age of assemblage by artifact manufacturing techniques	Soft hammer percussion becomes more common through time.
Age of assemblage by artifact curation	More curation through time.
Age of assemblage by site function	More single-activity sites appear through time.

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Appendix I

(A) African Sites

1. Olorgesailie (1°34'S, 36°27'E), Kenya, was first discovered by J. W. Gregory in 1919 who found many bifaces eroding out of the surface (Potts *et al.* 1999:748). Louis and Mary Leakey conducted the first formal excavations between 1942 and 1945 and these were continued by Glynn and Barbara Isaac between 1961 and 1965 (Isaac 1977a). Olorgesailie was located near a Pleistocene lake basin as represented by fine-grained silts and sands, lacustrine, and deltaic sediments (Isaac 1977a:31; Potts 1989:477). Dozens of assemblages were excavated within Members 1 through 14 of the Olorgesailie Formation and surveys and excavations continue to uncover archaeological material (Isaac 1978d; Potts *et al.* 1999; Sikes *et al.* 1999). This site is notable for the preponderance of large bifacial tools and numerous bones of *Theropithecus oswaldi* (an extinct gelada baboon) in dense concentrations at DE/89 (Isaac 1977a:89-92). Two assemblages were examined in detail, I 3 and DE/89, since they contained the highest concentration of artifacts throughout the entire Olorgesailie sequence (Isaac 1977a). The site has been dated to between 990,000 and 450,000 years old using potassium-argon and is also placed immediately after the Jaramillo Normal Subchron at 900,000 years ago through palaeomagnetism (Baker and Mitchell 1976; Bye *et al.* 1987; Isaac 1977a; Potts 1989; Potts *et al.* 1999; Shipman *et al.* 1981; Sikes *et al.* 1999).

2. Kapthurin (0°30'N, 35°55'E) is located at about 1,100 m above sea level 10 kilometres to the southwest of Lake Baringo, Kenya, in a flat savannah landscape (Cornelissen *et al.* 1990). The site is dominated by fluvial and lacustrine deposits of clays, silts and gravel (McBrearty *et al.* 1996:565; Tallon 1978). The site was first discovered and excavated in 1966 and finds included a hominid mandible assigned to *Homo erectus* (Leakey *et al.* 1969; Tallon 1978). Kapthurin was re-excavated between 1980 and 1987 by Cornelissen *et al.* (1990) who discovered more skeletal evidence of either *Homo erectus* or archaic *Homo sapiens* and again in 1993 by McBrearty *et al.* (1996). Prior to 1993, 13 assemblages within the Kapthurin area were reported, while the later excavations resulted in 28 new archaeological assemblages, most of which contained well preserved faunal remains. Very recently, McBrearty (2000) proposed that the Acheulean to the Middle Stone Age transition might be seen in the Kapthurin Formation that would make

this site of utmost archaeological value since artifactual evidence highlighting this transition is often difficult to identify (Willoughby 1996a). The Middle Silts level (GnJj 19) was chosen for the exceptional early appearance of blades. The date of occupation of the Middle Silts Level is placed at less than 780,000 years ago due to the presence of a pumice volcanic tuff of normal polarity (representing the Brunhes Normal Chron) while Upper Acheulean artifacts are capped by a tuff K-Ar dated to around 240,000 years ago (Cornelissen *et al.* 1990:30-51; McBrearty *et al.* 1996:563; Tallon 1978).

3. Kilombe (0°06'S, 35°53'E), Kenya, lies 2,000 m above sea level on the western flank of the rift valley. It was discovered by John Gowlett and excavated between 1972 and 1974. The level EH Main was analyzed as it appears to be one extensive horizon of artifacts (n=1,096) where the tool forms (n=194) were dominated by bifaces (n=104) in relatively undisturbed context. It has an Early Acheulean date of between 1.4 and 1.2 million years based on reversed polarity (believed to be the Matuyama Reversed Chron) and an underlying phonolite layer K-Ar dated to 1.7 mya (Bishop 1978b; Gowlett 1978, 1986).

4. Olduvai Gorge (2°58'S, 35°22'E), Tanzania, was an obvious choice since artifactual material has been known in this region since the early 1900s and has been continuously excavated since 1951 by the Leakey family and others. Several monographs have been produced pertaining to its stratigraphy, artifacts, faunal and hominid remains. Olduvai Gorge represents the single longest continuous hominid archaeological sequence known, about 1.8 million years in duration (M.D. Leakey 1971, 1975, 1994). In order to provide an overview of the Olduvai Gorge sequence over the course of the Acheulean, 18 different assemblages were examined, dating from 1.6 million to 400,000 years ago.

The earliest assemblage is in Upper Middle Bed II (EF-HR), and was named for Evelyn Fuchs and Hans Reck who discovered it in 1931 (M.D. Leakey 1971:124). Artifactual material was found on a clay surface underlying gravel deposits that had an ancient channel flowing through it. Most artifacts in EF-HR were fresh and showed no evidence of abrasion. The assemblage is characterized by an extremely high ratio of bifaces, representing 53.8% of the entire tool industry while fossil bones were scarce (M.D. Leakey 1971:124-137). JK (Juma's Korongo) in Bed III was recorded during the 1931 and 1932 expeditions. This assemblage has been subdivided into four different stratigraphic levels of which two, the lower coarse grey sands (JK West A) and the fine-grained sands with clay lenses (JK West B), were analyzed in detail here. The material

throughout JK West included both fresh and heavily rolled specimens, so may not be in primary context (M.D. Leakey 1994:15).

The base of Bed IV contains three assemblages that have approximately similar stratigraphic levels, consisting mostly of claystone, sandstone and siltstone (Hay 1994:8). WK (Wayland's Korongo) Hippo Cliff contains the greater part of an extinct hippo skeleton (*Higorgopus*) in a former river or stream channel. It is associated with 51 artifacts, of which 14 are tools (M.D. Leakey 1994:36-39). PDK (Peter Davies Korongo) was first recorded in 1970 by Philip Leakey who noted bifacial tools eroding out from the base of Bed IV. A conglomerate 30 cm thick contained the majority of the 297 artifacts, most of which were in exceptionally fresh condition while faunal material was sparse (M.D. Leakey 1994:39-42). The Lower Channel of WK is a pebble conglomerate 50 cm thick which yielded 535 artifacts and was rich in fauna. Remains of over 21 individual mammals representing 17 taxa were preserved (M.D. Leakey 1994:42-44,137-138).

A total of five assemblages were examined from Lower Bed IV: HEB East, HEB Level 4 - The Channel, HEB Level 3, HEB West Level 2B and HEB West Level 2A. HEB (Heberer's Gullies) East was first discovered in 1969 by Kamoya Kimeu. A dense concentration of artifacts (numbering 971 specimens) was uncovered in HEB East within the northeastern section. Associated sediments were coarse to fine grained sand and claystone along an ancient channel (M.D. Leakey 1994:45-52). A shallow stream approximately 3 m wide is HEB Level 4 - The Channel. A total of 1,110 artifacts and faunal remains were found within a pebble conglomerate in various stages of abrasion suggesting the assemblage might not have been homogeneous (M.D. Leakey 1994:55). HEB Level 3 consisted of 20 to 30 cm of greyish red sand and 905 lithic artifacts. Most of the 81 bifaces were manufactured from green phonolite, the source of which is the Engelosen volcano, 9 kilometres to the north. A biface manufactured from an elephant bone and evidence of an elephant pelvis showing damage from being used as a mortar were also uncovered (M.D. Leakey 1994:58-61). HEB West Level 2B had 1,363 artifacts and some fossil bone spread throughout a sequence of 50 cm of sand. Some bifaces were found in mint condition within an area of about 60 cm wide (M.D. Leakey 1994:64-67). HEB West Level 2A consisted of fine-grained silty sand 20 to 30 cm thick with artifacts dispersed throughout the deposit. There were 726 lithic artifacts and 35 bifaces that show much similarity in size, shape and technique of manufacture "which suggests quite strongly that one craftsman or one school of craftsman was responsible" (M.D. Leakey 1994:68-69).

Upper Bed IV (WK-Upper Channel) was comprised of sandy claystone, sandy conglomerate and siltstone. This level contained 10,904 artifacts with 192 bifacial tools representing the largest number of such artifacts uncovered during the 1970s at Olduvai Gorge. A pelvis and femur of a *Homo erectus* (termed Olduvai Hominid or O.H. 28) were found within the Upper Channel (M.D. Leakey 1994:75-87). WK East A was composed of 60 to 70 cm of reddish bedded sands with large cobbles and small boulders forming the lowest level in the southern part of the trench. A total of 17,783 artifacts were found within these sands. Above this was 50 to 70 cm of cross-bedded sands also reddish in colour with which a number of small channels were found intersecting (M.D. Leakey 1994:89-103). WK East C in Upper Bed IV was comprised of 1.3 m of bedded sands and a reddish-brown clay with the lowest 40 to 50 cm containing 4,983 artifacts and a large concentration of faunal material (M.D. Leakey 103-107). The deposit was overlain by a one meter aeolian tuff of the Masek Beds described below. The accumulated fauna from both WK East A and C belong to 31 taxa and a minimum of 32 individual mammals (M.D. Leakey 1994:139-141). Upper Bed IV, PDK trenches I-III lies 25 m east of WK East A and was first excavated in January 1970 (M.D. Leakey 1994:107). The deposits were 80 cm of bedded reddish sands with which the 1,746 artifacts and a minimum number of 16 mammals were found. Overlying this was a further 60 cm of sandy clay almost devoid of artifactual material (M.D. Leakey 1994:107-113).

The Masek Beds are stratigraphically positioned above Bed IV and include three assemblages; FLK, HK and TK Fish Gully. FLK was excavated in October 1968 with the discovery of a hominid mandible (O.H. 23) about half a meter above an extensive Acheulean industry. Artifactual material numbering 2,465 specimens and the remains of 23 taxa of over 24 individual animals were found associated in sand and rubble deposits that reached a thickness of 80 cm (M.D. Leakey 1994:116-134,144). Water alignment of artifacts was almost non-existent as many lithics (particularly the 22 large bifaces) were in fresh condition (M.D. Leakey 1994:18). It is peculiar that the bifaces were almost exclusively made from tabular white quartz cobbles and not on flakes as is usual in the African Acheulean (M.D. Leakey 1975:490). HK (Hopwood's Korongo) was first excavated in 1931. A total of 450 bifaces were recovered from a fine-grained sand overlain by a silty clay. The remains of a single hippo were found; and it is believed to have been butchered since several stone tool cutmarks are present on the bones (M.D. Leakey 1994:123). Further excavations in 1969 uncovered more hippo skeletal parts, 700 other faunal fragments and 349 artifacts in rubble mixed with silt and sand. Most of the tools were in fresh condition, indicating little post-depositional movement (M.D. Leakey

1994:123-126). TK (Teal's Korongo) Fish Gully in the Masek Beds was recorded in 1932 with excavations in 1962 that produced 68 bifaces and other smaller artifactual material (M.D. Leakey 1994:127). Further excavations in 1970 found 623 artifacts (with nine large elaborately trimmed bifaces) and abundant catfish remains in coarse quartz sand overlain by sandy clay (M.D. Leakey 1994:126-129). Almost all of the Olduvai Gorge assemblages dating to within the Acheulean (Beds III, Base of Bed IV, Lower Bed IV, Upper Bed IV and the Masek Beds) are associated with sediments containing clay, silt and sand in varying proportions suggesting that occupation was close to, or along, ancient channels or streams.

5. Isimila (7°54'S, 35°36'E), Tanzania, was first surveyed by F. Clark Howell in 1954 and then excavated by him between 1957 and 1958. Glen Cole and Maxine Kleindienst continued excavations during July and August 1958 and Carl Hansen and Charles Keller between 1969 and 1970 (Cole and Kleindienst 1974; Hansen and Keller 1971; Howell *et al.* 1962, 1972). The 15 to 18 m of deposits alternate between different concentrations of clay, silt and sand with little evidence of disturbance (Hansen and Keller 1971:1204; Howell *et al.* 1962:60). Many assemblages are known throughout Sands 1 to 5, but only three (K 19 Sands 3, K 6 Sands 1, 1b and K 14 Sands 1, 1a) were analyzed since these levels were described in the most detail. These Acheulean levels all date to between 400,000 and 200,000 years ago based on U-series dating (Howell *et al.* 1972).

6. Gadeb (40°N, 10°E), Ethiopia, was excavated by J. Desmond Clark and Hiro Kurashina during the winter of 1977. The site is situated along the Webi Shebele river on the southeast plateau of Ethiopia at elevations between 2,300 and 2,400 m (J.D. Clark 1987). More than 20 localities have yielded Acheulean and Developed Oldowan assemblages. Most are found on the banks and channels of shallow streams in association with gravel deposits (Clark and Kurashina 1979b). The 8E assemblage was examined because of its numerous stone artifacts (>20,000) including bifaces (n=200). The artifacts were stratified in deposits overlying a pumice mud flow K-Ar dated to 1.48 mya and thus the date of occupation has been placed at 1.2 to 1.0 mya (J.D. Clark 1987:810). Some of the earliest evidence of obsidian use can be found at Gadeb; four obsidian bifaces were recovered, the material for which came from at least 100 kilometres to the west (J.D. Clark 1987:814; Clark and Kurashina 1979a:96-97).

7. Bodo (12°06'N, 42°04'E) is located in the Middle Awash Valley, Ethiopia. It was first discovered in the 1960s and excavated from 1975 to 1978 by J. Desmond Clark and Tim White, with further fieldwork in 1981 and 1990. Fresh artifacts of a variety of sizes are found throughout the site. They lack any specific orientation and are associated with fine-grained silty sediments, suggesting no significant alteration by fluvial activity (J.D. Clark 1987:822). Many archaeological units have been identified throughout the Middle Awash area and this region has become one the major centres for the discovery of early hominids (J.D. Clark 1987; Clark *et al.* 1984, 1994). The assemblages examined were two of Developed Oldowan affinity (BOD A1 and HAR A2) where associated sediments were potassium argon dated to between 1.0 million and 800,000 years ago, and two Acheulean ones (BOD A2 and HAR A4), potassium argon dated to between 800,000 and 600,000 years ago (Clark *et al.* 1984, 1994). A cranium believed to be transitional between *Homo erectus* and archaic *Homo sapiens* has been found. Parallel cutmarks on the cranium believed to have been produced by stone edges may be evidence of intentional defleshing (J.D. Clark 1987; Conroy *et al.* 1978:67; Rightmire 1996; White 1986).

8. Melka-Kunture (8°41'N, 37°38'E), Ethiopia, was first discovered in 1963 by Gerard Dekker and excavated in 1965 by a Franco-Ethiopian mission led by Jean Chavaillon (Chavaillon *et al.* 1979). Melka-Kunture is a river valley site with fluviatile geological deposits consisting of pebbles, sands and clay in varying proportions (Chavaillon *et al.* 1979). Melka-Kunture has yielded a succession of Lower Palaeolithic assemblages spanning approximately 1.8 million to 250,000 years ago and includes 30 separate assemblages with between 2,000 and 12,000 stone artifacts each. As Chavaillon *et al.* (1979:90) mention, "[t]his alone demonstrates that Melka-Kunture cannot be studied as a single whole, without considering in detail differences between...levels." Three assemblages were examined including Garba IV, Garba III and Garba I. Based on the proportion of choppers and the occurrence of both robust australopithecine and *Homo erectus* fossils, Garba IV is believed to date to the Oldowan Industrial Complex around 1.5 mya; quite a late date for an Oldowan assemblage (Chavaillon *et al.* 1979; Piperno and Piperno 1974-1975). Based on stratigraphical evidence, Garba III is believed to belong to the Middle Acheulean (between 700,000 and 350,000 years old), while Garba 1 is placed in the Upper Acheulean (between 350,000 and 200,000 years old) when both *Homo erectus,* archaic *Homo sapiens* and the Levallois technique are present (J.D. Clark 1988:266). At Melka Kunture, there appears to be changes in location of settlement over

time. In the Oldowan level (Garba IV), hominids preferred to settle on or near pebble beaches and used local raw material, while Acheulean hominids (Garba III, I) were less dependant on the proximity to water and raw material sources since they often manufactured tools away from the site (Chavaillon *et al.* 1979:95).

9. Kalambo Falls (8°30'S, 31°15'E), Zambia, was discovered by J. Desmond Clark and John Hodges in 1952 and subsequently excavated in 1956, 1959 and 1963 (Badein 1981:131-136; J.D. Clark 1962, 1969). Kalambo Falls is quite extraordinary as much organic material such as charcoal and wood has survived. Many large bifaces, cores and flakes of Upper Acheulean type suggest a date of between 400,000 and 200,000 years ago, while chronometric dates do not exist (J.D. Clark 1969, 1975; Schick 1992; Sheppard and Kleindienst 1996). Several assemblages have been identified by J.D. Clark (1969:238-239) within areas A and B of the site. Level B5 Lower (fine sand) was examined in detail as it was the focus of extensive studies by Kathy Schick (1992) who used the level as a model to show how sedimentary contexts (through fluvial disturbance and winnowing) can distort our understanding of hominid behaviours.

10. Mwanganda (10°09'S, 33°46'E), Malawi, was excavated by J. Desmond Clark in 1965 and 1966 (Clark and Haynes 1969). Based on U/Th dating of soil carbonates, the site has been estimated as pre-Middle Stone Age and is placed at around 300,000 years old (Kaufulu and Stern 1987:736). All the stone artifacts were made of local quartz and quartzite. Almost all (99%) of the 315 artifacts were fresh and unabraded (J.D. Clark 1970b:335; Clark and Haynes 1969:394). The stratigraphic sequence consists of a shelly limestone band suggestive of lake margin habitats and a bed of silty fine sandstone representing a coastal plain environment (Kaufulu and Stern 1987:735). This site is of interest since the remains of a single elephant was found (denoted as Area 1) believed to have been butchered by early hominids (Clark and Haynes 1969). Associated with the carcass were many light-duty flake tools rather than bifaces, challenging the idea that bifaces were used for butchering activities (J.D. Clark 1970b; Clark and Haynes 1969; Haynes 1970; Kaufulu and Stern 1987).

11. Montagu Cave (33°55'S, 20°E), South Africa, was discovered in the 1880s and partially excavated in 1919, resulting in the removal of approximately three quarters of the deposits (Keller 1973:95). A more recent excavation was conducted from 1964 to 1965 by Charles Keller (1970, 1973) who collected around 275,000 artifacts. The site is

relatively dated based on typological grounds to the Late Acheulean between 250,000 and 150,000 years ago. Material suitable for radiometric dating was not present in the 1970s (Keller 1973:80), while the site has not been re-examined using newer dating techniques. The mouth of the cave is approximately 42 feet across and 47 feet from front to back (Badein 1981:183-186). Stratigraphic levels were defined by numbers 1 to 8 with one being the youngest and eight the oldest. Levels 3 and 5 were the only sequences containing Acheulean artifacts (Keller 1973). No faunal material was found in the cave. Based on the preponderance of lithic debitage (99.1% from Layer 3 and 98.6% of Layer 5), the cave is believed to have served primarily as a workshop with expedient manufacturing processes. Layer 3 was composed of sterile red sand and sandy silt 30 to 60 cm thick while layer 5 consisted of silty coarse white quartz sand and clay sized sediments. Upon microscopic analysis, it was found that layer 5 accumulated primarily from the disintegration of the bedrock walls of the cave (Keller 1973:10). A site such as this is rare for at least four reasons: Montagu Cave is located about 2,500 kilometres south from where many of the East African prolific Acheulean sites are found, Acheulean sites are only rarely found in caves, it is possible to investigate chronological variation in the Acheulean at a single site and a monograph was produced where every artifact was meticulously classified.

12. Elandsfontein (28°32'S, 25°36'E), also known as Hopefield or Saldanha, South Africa, was first excavated by Ronald Singer in 1951. He uncovered well-made bifaces and flake tools, many bovid remains and more than 60 fragments of an early archaic *Homo sapiens* skull (Deacon 1975:556-557; 1998; Singer and Wymer 1968). The bulk of archaeological material has come from deflated sand dune surfaces (Deacon 1998). Based on faunal, taxonomic and lithic typological comparisons, the site has been tentatively dated to between 700,000 and 400,000 years ago. Material for radiometric dating is lacking (Klein 1988:8; Klein and Cruz-Uribe 1991:29).

13. Duinefontein 2 (33°43'S, 18°27'E), located about 35 kilometres north of Cape Town, South Africa, was discovered by Richard Klein and Graham Avery in 1973 and extensively excavated in 1997 and 1998. Based on U-series and faunal analysis, the site has been placed at between 400,000 and 150,000 years ago (Klein *et al.* 1999). Three horizons have been identified. Horizon 1 is a level intermediate between the surface fine white drift sands. Horizon 2 is characterized by wind blown red sand 90 cm thick and contains most of the archaeological sequence. Horizon 3 is made up of red sand and

ironstone and some archaeological material (Klein *et al.* 1999:156-159). Horizon 2 is believed to have been a water-edge attritional death site where carnivores and the occasional hominid came to feed (Klein *et al.* 1999:153). An attritional profile can be defined as the underrepresentation of adult animals in their prime, and the over-representation of very young and old individuals who are more susceptible to accidents, starvation, disease and predation (Klein and Cruz-Uribe 1984:56). Primary flaking was not done at the site since debitage is rare (Klein *et al.* 1999:172). Almost all faunal remains were fresh and unweathered with many in near-anatomical position suggesting little post-depositional movement (Klein *et al.* 1999:172-173). Klein *et al.* (1999:177) noticed that only 12 (1%) of 1,086 taxonomically identifiable bones show stone tool cut marks. Therefore, hominids were unlikely to have been the leading agents of accumulation of faunal remains, although they were probably attracted to the vicinity by the congregation of other animals.

14. Ain Hanech (40°20'N, 30°60'E), in northeastern Algeria, was first discovered in 1947 by Camille Arambourg. The lithic assemblage closely resembles a North African variant of the Oldowan. Based on technological, biostratigraphical and palaeomagnetic evidence (normal polarity representing the Olduvai Subchron), the site has been dated to between 2 and 1.7 mya (Sahnouni 1998:20; Sahnouni and Heinzelin 1998:1083). Ain Hanech has yielded many animal bones and may be indicative of short-term hominid involvement with animal carcasses. Through microwear analysis, evidence of meat-cutting and bone working was believed to have been found on three lithic pieces (Jaeger 1975; Sahnouni 1998; Sahnouni and Heinzelin 1998:1098). All archaeological material (2,157 lithic pieces of which most were made of limestone and flint) have been found within a 1.20 m thick bed of silt (Sahnouni 1998:38-73). A total of five stratigraphical levels have been identified (see Sahnouni 1998:14-15 for description). The only assemblage examined in detail was Layer 3, Gray Clay, since it was the focus of recent excavations. This assemblage is associated with fine silt, sand and gravel and 355 fossil animal bones (Sahnouni 1998; Sahnouni and Heinzelin 1998).

15. El Kherba is located 350 metres southwest of Ain Hanech, Algeria. It was excavated by Mohamed Sahnouni between 1992 and 1993. A total of 510 lithic artifacts with an average of 49.5 artifacts per m^2 were found while several were excavated in association with an elephant femur (Sahnouni 1998:30; Sahnouni and Heinzelin 1998:1088). The artifacts and faunal material from El Kherba were found in a similar silt

matrix as at Ain Hanech (Sahnouni 1998:37). As El-Kherba was only preliminarily studied, no radiometric (or other) dating has been conducted.

16. Tighenif (35°25'N, 0°15'E), formerly known as Ternifine or Palikao, Algeria, was discovered in 1870. The first systematic excavations were undertaken from 1954 to 1956 and again from 1981 to 1983 (Freeman 1975:726; Geraads *et al.* 1986). Based on normal polarity (the Brunhes Normal Chron), Tighenif has been placed near the end of the Lower Pleistocene around 700,000 years ago (Geraads *et al.* 1986:385-386; Jaeger 1975:409-410). This site has yielded three mandibles of *Homo erectus*, rich mammalian and micro-fauna, an associated Acheulean assemblage, and one of the earliest undisputed bone artifacts (a zebra distal metacarpal retouched on the proximal end) in this part of Africa (Dauphin *et al.* 1994; Geraads *et al.* 1986:380; Sahnouni 1998:2). Geraads *et al.* (1986:380-382) identified 11 stratigraphic levels that all vary between different concentrations of sand and clay. All artifactual, hominid and faunal material were found in level 2 associated within nodular grayish clay. At the time of occupation, the surrounding area was dry steppe or savanna while the site is believed to have been located on the shore margin of a small lake (Geraads *et al.* 1986:384).

17. Cape Ashakar (35°48'N, 5°48'W), Tangier, Morocco, was first discovered and preliminarily excavated between 1871 to 1876. Excavations continued between the time of 1902 to 1912, 1929 to 1931 and 1936 to 1938. Archaeological sequences were divided into 11 localities by Howe (1967). Zones B1, B2 and B3 were grouped together in the Plateau Gravel level (consisting of fluviatile gravel deposits). This level was believed to be within the Upper Acheulean (400,000 to 200,000 years ago) on account of the types of artifacts present. No faunal remains were found within the site (Howe 1967:39-61). Even though this site was excavated long ago, and the resulting publication was written in 1967, it was decided to use this site since a monograph has been published; one of only a few detailed descriptions for a North African site.

(B) Middle East Sites

1. The Yiron Plateau (19°41'N, 27°53'E), Upper Galilee, Israel, was excavated in the summer of 1979 by Milla Ohel. While no radiometric dates currently exist, the artifact types and sediment sequences place it within the Final Acheulean between 250,000 and 150,000 years ago (Ohel 1986a:155). The site is 670 m above sea level and of exceptional

size, approximately 16,000 m^2. Eight archaeological units have been identified at the Yiron Plateau and include Y13, Y18, Y25, Y27, Y28, Y41, Y51 and Y53. More than 20 test pits have been excavated at Y25 and have produced 13,357 artifacts from clayey sands. Y25 is believed to have been occupied seasonally (Ohel 1986a). A variety of natural factors made for an ideal camping locality: two perennial springs, protection from the elements, easy observation of game from on top of a plateau and many plants, potential animal food and lithic resources in close proximity (Brosh and Ohel 1981; Ohel 1982, 1983a, 1983b, 1986a, 1986b).

2. Avivim (33°05'N, 35°28'E) is located 600 to 700 m above sea level in the Upper Galilee, Israel, within five kilometres of the Yiron Plateau (Ohel 1990:5). It has been suggested that the area surrounding the Yiron Plateau was exploited by hominids who occupied different parts of the landscape at different times of the year as the lithic assemblage of Avivim is remarkably similar to that of the Yiron Plateau (Ohel 1990:90). Surface collections were done in 1979 (Ohel 1990:13). Only two areas were examined from the Avivim site: A 43 (Nahalit) and A 63 (Mul Ha'amud). Both are believed to date to the Final Acheulean (250,000 to 150,000 years ago) on account of the presence of Levallois cores and some blades.

3. Gesher Benot Ya'aqov (33°00'28"N, 35°37'40"E), Israel, was first discovered in the early 1930s. It had limited excavations in 1937, 1951 and 1968 (Bar-Yosef 1975:589; Stekelis 1960). It was re-excavated by Naama Goren-Inbar from 1989 to 1991 and from 1995 to 1997. Different raw materials were found to have been purposely selected for different kinds of tools at Gesher Benot Ya'aqov. Limestone pebbles were preferably selected for chopping tools, flint for cores, flakes and flake tools, while basalt was used primarily for bifaces (Goren-Inbar *et al.* 2000:946). Probable tools made from elephant long bones have been discovered, as well as organic material such as wood, bark and seeds (Belitzky *et al.* 1991; J.D. Clark 1975:636-637; Goren-Inbar 1998; Goren-Inbar and Belizsky 1989; Goren-Inbar and Saragusti 1996; Saragusti and Goren-Inbar 2001). Most of the 13 to 14 assemblages are in lacustrine and lake-margin deposits meaning that a lake probably existed within the vicinity of the site (Fiebel *et al.* 1998). Only two assemblages from Gesher Benot Ya'aqov were examined: Layer II-6 Level 4 (with an extraordinary dense concentration of bifacial tools), and Layer II-6 Level 1 that had many artifacts surrounding an elephant skull (Goren-Inbar *et al.* 1992b, 1994; Saragusti and Goren-Inbar 2001). A date of younger than 780,000 years ago has been proposed based

on K-Ar dating of the underlying Yarba basalt level, and normal (Brunhes) palaeomagnetic polarity (Goren-Inbar *et al.* 1992a, 1994, 2000; Stekelis 1960:65; Verosub *et al.* 1998).

4. The Evron Quarry (32°33'N, 35°7'E), on the coastal plain of the Western Galilee, Israel, is located 45 kilometres northwest of Gesher Benot Ya'aqov. This site had three trial trenches dug in 1949, further excavations in 1976 and 1977 and was last excavated in 1985 (Prausnitz 1969:129; Ronen 1991; Ronen and Amiel 1974). Ronen (1991) has identified a dozen stratigraphic layers with Layer 4 yielding in-situ Acheulean material in yellow gray sands. As radiometric dates are lacking, the site has been placed in the Upper to Final Acheulean, somewhere between 500,000 and 100,000 years ago using artifact typology, biochronological comparisons and stratigraphic positioning (Ronen 1991:212; Tchernov *et al.* 1994:331).

5. Holon (32°01'N, 34°46'E), south of Tel Aviv, Israel, was excavated from 1963 to 1964 and also in 1970. Two small test pits were dug in 1995 for dating purposes (Porat *et al.* 1999). Using ESR and luminescence dating, the site has been placed within the Final Acheulean approximately 200,000 years ago (Bar-Yosef 1994a:246; Porat *et al.* 1999; Yizraeli 1967). Five units labeled A to E were identified throughout the sequence. All stages of biface production were found in Stratum Level C in sandy clay sediments (Porat *et al.* 1999; Yizraeli 1967). As three bone tools were found during the original excavations (Yizraeli 1967:152), future work at this site would probably be very rewarding.

6. Kissufim (31°23'N, 34°24'E) is located in the Western Negev, Israel, and was discovered through surveys in 1964 and 1969 (Ronen *et al.* 1972). Five stratigraphical units have been identified. Some lithics were recovered from silty clay loam deposits of an old stream channel within Unit 3. The artifact content consisted of many refined bifaces, flake tools, blades and a very high proponent of Levallois flakes, representing 32% of the entire flake industry (Ronen *et al.* 1972:73-74). Based on technological refinement and the high Levallois index, the industry has been placed within the Final Acheulean somewhere between 250,000 and 150,000 years ago, what Desmond Clark calls the 'Evolved Upper Acheulean' (J.D. Clark 1975:637).

7. Berekhat Ram (31°31'N, 34°40'E) is located in the Golan Heights, 125 kilometres northeast of Jerusalem, Israel. It was excavated by Naama Goren-Inbar in 1980 and 1981 (Goren 1982). The stratigraphical sequences consist of 10 units (Goren-Inbar 1985). Only Unit 7, paleosol B, comprised of colluvial and alluvial deposits of red clay was examined since it yielded the most artifacts. No fauna has been preserved. Even though the site has yielded material typical of Upper Acheulean industries (including highly finished bifacial tools and much debitage) and is primarily characterized by Levallois flakes (Goren 1982; Goren-Inbar 1985), it has been chronometrically dated to between approximately 500,000 and 350,000 years ago using $^{40}Ar/^{39}Ar$ dating. The archaeological horizon is located between two basalt flows (Bar-Yosef 1994a:249; Feraud *et al.* 1983).

8. 'Ubeidiya (32°41'N, 35°34'E) is located in the central Jordan Valley, Israel, at 200 m below sea level. It was first excavated in 1960 by L. Picard, G. Haas and M. Stekelis with sporadic excavations until the mid 1990s by others, noticeably Ofer Bar-Yosef and Eitan Tchernov (Bar-Yosef and Tchernov 1972; Bar-Yosef and Inbar 1993:5-12). A proliferation of fauna and lithics characteristic of the Early Acheulean and Oldowan have been found. As this site is located in the middle of the continental 'Out of Africa' corridor with which hominids and other mammalian species likely spread into Eurasia during the Lower Pleistocene (see Section 2.3.1), establishing accurate dates for 'Ubeidiya is essential (Bar-Yosef 1998; Bar-Yosef and Goren-Inbar 1993:21; Tchernov 1987). Based on reversed polarity (the Matuyama Chron), biostratigraphy, with lithics typologically similar to those from Olduvai Upper Bed II (EF-HR), 'Ubeidiya has been dated to around 1.5 to 1.4 mya (Bar-Yosef 1998; Tchernov 1987). Hominids made different tool forms on specific raw materials at this site: core choppers and polyhedrons on flint, sub-spheroids on limestone and bifaces on basalt (Bar-Yosef and Goren-Inbar 1993:111). Dozens of assemblages have been identified and excavated (Bar-Yosef and Goren-Inbar 1993), but only two were examined in detail here. The level I 15 a is the largest assemblage excavated at 'Ubeidiya, and produced 1,260 artifacts. It is composed of a beach conglomerate overlying a whitish mud-clay layer covered by a sandy pebble breccia. These sediments were accumulated mostly by colluvial and lake wave activity (Bar-Yosef and Goren-Inbar 1993:94). Layer I 26 c was comprised of a shore-line conglomerate of gravel, sand and clay with 1,121 artifacts (Bar-Yosef and Goren-Inbar 1993:24).

9. Wadi Qalkha is located in southern Jordan. It has been dated to the Final Acheulean (250,000 to 150,000 years ago) by the presence of finely made bifaces, evidence of Levallois technology and biostratigraphy since material for radiometric dating is absent (Henry 1995a:45). Only 61 artifacts (10 of which were bifaces) were found eroding out of a deposit of alluvial silts and sands (Henry 1995a:44).

10. Adlun (33°24'N, 35°16'E), in Bezez Cave, is located along the coast of southern Lebanon. It was first excavated by Dorothy A. E. Garrod from 1958 to 1963. This site contains much lithic and faunal material in sandy and gravelly beach deposits and spans the Final Acheulean to the Neolithic (Copeland 1983; Roe 1983b). Many trenches and levels were excavated, but only Level C was examined here. This level is temporally restricted to sometime between 250,000 and 150,000 years ago based on artifact typology, biostratigraphy and beach terrace stratigraphy. No absolute dates are available for any part of the sequence (Kirkbride 1983; Kirkbride *et al.* 1983).

11. Latamne (35°18'N, 36°36'E) is located in northwestern central Syria. It was first excavated in 1960, surveyed in 1961 to 1962, excavated again in 1964 and 1965 by Desmond Clark and again in 1993 by P. Sanlaville (Bar-Yosef 1994a; J.D. Clark 1966, 1967, 1968, 1975; Sanlaville *et al.* 1993). Most of the stratigraphical sequences at Latamne are fine-grained silts and sands (J.D. Clark 1968:10). A total of 3,724 artifacts were uncovered by J. Desmond Clark; 104 are bifaces that are in generally fresh condition with minimal abrasion (J.D. Clark 1967:14). Faunal material was scarce (Bar-Yosef 1994a:239; J.D. Clark 1968:18). Based on TL dating, the site has been given an age of about 700,000 to 500,000 years ago (Bar-Yosef 1994a:240; Sanlaville *et al.* 1993).

12. Dmanisi (41°17'N, 44°17'E) is located in the Republic of Georgia about 85 kilometres southwest of Tbilisi. The site contains some of the earliest evidence of *Homo erectus/Homo ergaster* remains outside of Africa as evidenced by a hominid mandible discovered in 1991 and most recently two hominid crania in 1999 (Dean and Delson 1995; Gabunia and Vekua 1995; Gabunia *et al.* 2000). Based on pollen and faunal analysis, the environment around the site is believed to have been alpine vegetation of a well-watered woodland region (Liubin and Bosinski 1995). The lithic technology is comprised of non-biface core-chopping tools. Over 1,000 Oldowan-like artifacts have been found (Gabunia and Vekua 1995; Gabunia *et al.* 2000). Through $^{40}Ar/^{39}Ar$ dating, normal polarity (the Olduvai Subchron), cranial fossils similar to *Homo ergaster* remains

recovered from Koobi Fora, and the associated core and flake lithic industry, the site has been given an Early Pleistocene age of about 1.77 million years. This site is of great importance since it could pre-date 'Ubeidiya and may be the earliest hominid site out of Africa (Bar-Yosef 1998:235; Bar-Yosef and Belfer-Cohen 2001; Bosinski 1995; Brauer and Schultz 1996; Dean and Delson 1995; Liubin and Bosinski 1995).

(C) European Sites

1. Markkleeberg (51°17'N, 12°24'E), Germany, was first discovered in 1895. All of the archaeological material comes from sand and gravel deposits (Grahmann 1955:522). Much of the artifacts consist of tools and flakes that have survived haphazard collections of the early 20th century as well as bombing from World War II. The site is assigned to the Final Acheulean (between 250,000 and 150,000 years ago) based on the presence of blades (Grahmann 1955) and has not been re-examined with current archaeological dating methods. This site with such an early publication date was examined since it appears to be the only conclusive account of the artifactual material, and a monograph has been made; one of the few for sites in Europe.

2. Bilzingsleben (51°16'24"N, 11°3'39"E), Germany, known locally as Steinrinne, produced evidence of archaic *Homo sapiens* remains by the year 1818 (Harmon *et al.* 1980). Occupation took place on the shore of a small lake as seen in the sandy and silty deposits associated with the archaeological material (Mania and Vlcek 1981). This site has subsequently produced skeletal evidence of late *Homo erectus* (as seen by the large angular almost round crania), over 1,500 kg of faunal remains, antler and bone materials (some of which showed intentional flake removals suggesting they were shaped as tools), many flakes, cores, traces of charcoal and burnt flint tools (Bhattacharya 1977:60; Mania and Mania 1988; Mania and Vlcek 1981; Mania *et al.* 1994; Schick and Toth 1993:281; Svoboda 1987; Vlcek 1978). Nine stratigraphic sequences have been identified (Harmon *et al.* 1980:133). The archaeological and faunal assemblage examined in detail came from the sandy deposit of Layer 3. Based on $^{230}Th/^{234}U$, amino acid racemization and ESR dating, the site is placed at no later than 280,000 years ago up to possibly around 450,000 years ago (Harmon *et al.* 1980; Mania and Vlcek 1981; Schwarcz *et al.* 1988b).

3. The Ariendorf Gravel Quarry (50°32'N, 7°18'E) is located 28 kilometres south of Bonn in the Lower Central Rhineland, Germany. It was excavated between 1981 to 1983 by Elaine Turner (1998) and has been divided into three horizons. The only level examined was Horizon 1 which dates to between 600,000 and 400,000 years ago based on $^{40}Ar/^{39}Ar$, TL dates, biostratigraphy and palaeomagnetism representing the Brunhes Normal Chron (Kolfschoten 1990; Turner 1998:114-117). The assemblage consisted primarily of debitage, some of which could be refitted, all within fluvial gravel deposits (Roebroeks *et al.* 1992:553-560; Turner 1998:114-118). Horizon 2 revealed small concentrations of faunal remains with only 37 lithic artifacts while Horizon 3 only contained a few bones and two Levallois flakes (Turner 1998:118).

4. Kärlich-Seeufer (50°30'N, 7°50'E) is located in the Central Rhineland, Germany, 170 m above sea level. It was excavated from 1980 to 1982 and from 1987 to 1992 by Sabine Gaudzinski who identified 10 levels labeled A to J (Gaudzinski *et al.* 1996). Many archaeological finds such as 128 lithic artifacts, 7,331 pieces of wood, up to 12,000 palaeobotanical remains and 1,100 bones of seven animal species have been preserved in Unit D. Artifacts are associated with a sandy debris flow up to 2.4 m thick (Gaudzinski *et al.* 1996). Based on biostratigraphic, geological and palynological analysis, the site is believed to date to around 400,000 years ago (Gaudzinski *et al.* 1996).

5. Vértesszöllös (47°37'N, 18°23'E), Hungary, was first discovered in 1962 and excavated between 1963 and 1965 by M. Kretzoi and L. Vertes (1965). Fossils intermediate between *Homo erectus* and archaic *Homo sapiens* have been found intermixed within travertine deposits (Henning *et al.* 1983; Kordos 1994; Kretzoi and Dobosi 1990; Thoma 1981). Since no Acheulean or Levallois material has been found, and based on the preponderance of small sized choppers and chopping tools (Svoboda 1987), it has been claimed the site represents an extension of the Clactonian or chopper-chopping tool tradition (Bhattacharya 1977:64-65; Kretzoi and Vertes 1965). The most recent dates based on U-series and biostratigraphy suggest an age of between 500,000 and 200,000 years ago (Kordos 1994).

6/7. Torralba del Moral (41°08'N, 2°30'W) and Ambrona (41°10'N, 2°30'W) are two sites located in Soria, Spain about 2.5 to 3 kilometres apart. Both sites are between 1,100 and 1,150 m above sea level (Butzer 1965:1718). Torralba was first discovered by railway workers in 1888 while Ambrona was found during the first archaeological expedition in

the area from 1907 to 1911 (Howell 1966:113). Excavations were further conducted at Torralba from 1961 to 1963, 1973, 1980 to 1981 and 1983 by various workers, notably F. Clark Howell (Butzer 1965; Freeman 1994; Freeman and Butzer 1966; Howell 1966; Howell *et al.* 1995). Five stratigraphic members (I-V) subdivided into 12 beds were defined by Butzer (1965) for both the Torralba and Ambrona sequences, and Freeman (1995:600) more recently noted that 10 'major' archaeological horizons have been identified at Torralba within these 12 stratigraphical beds. Two levels from Ambrona were examined and include lower unit 3 that was composed of an upper gray colluvium of sand and gravel and an upper unit 5 composed of red alluvial deposits of silt, sand and gravel. Torralba was examined as a whole as published material on individual assemblages is lacking. Since radiometric dates do not exist, both sites have been biostratigraphically dated based on the large animal component to around 600,000 years ago (Howell *et al.* 1995:36; Santonja and Villa 1994:62).

The density of animal bones at Ambrona has always been higher than the density of stone artifacts (Butzer 1965:1718; Howell *et al.* 1995:70-71). Both Ambrona and Torralba have been interpreted as representing evidence of large animal processing as elephant remains were cutmarked, sliced and battered by stone tools. (Freeman 1975:678, 1994; Howell *et al.* 1995:70-76). However, this view is not universally accepted since a scanning electron microscopy (SEM) analysis by Shipman and Rose (1983), as well as microwear studies by Nicolas Toth, produced very little evidence of intentional cutmarks. A feature of both sites is that some lithic pieces could be refitted and bone and ivory was found to have been shaped and polished, perhaps the earliest recorded evidence for ivory working in the archaeological record (Bhattacharya 1977:43; Freeman 1994; Freeman and Butzer 1966:14; Howell 1966:138-140; Howell and Freeman 1983; Howell *et al.* 1995:76-77).

8. El Castillo cave (42°47'N, 6°01'W) is located in northern Spain, 30 kilometres from the coast mid-way up a mountain (Valdes *et al.* 1992:97). It was discovered and first excavated in 1903 by Alcalde del Rio (Freeman 1975:715). Many archaeological sequences can be found within El Castillo beginning in the Acheulean and lasting until the Upper Palaeolithic (Gamble 1986:196). Level 24 contains 490 artifacts and cave bear fossils; though it has not been determined if the fossil bear bones are present due to natural causes or intentional transport (Straus 1982:88). The site dates to around 100,000 years ago based on U-series dating and has been termed 'Mousterian of Acheulean Tradition (MTA)' because of the high Levallois content (Bischoff *et al.* 1992:60). Its late date of

occupation has proved useful in documenting the transition from the Acheulean to Middle Palaeolithic in western Europe (Valdes *et al.* 1992:99-100).

9. The site of Gran Dolina (42°22'N, 3°30'W), Sierra de Atapuerca, is located in the Burgos region of Spain and was discovered in 1976. Between 1978 and 1997, 19 excavation seasons were carried out (Carbonell *et al.* 1999b:319). The sequence has been subdivided into 11 levels (Trinchera Dolina (TD) 1-11) representing occupations during the Lower and Middle Pleistocene. Based on palaeomagnetism, biostratigraphy, U-series and ESR dating, the occupation levels span approximately 990,000 to 200,000 years ago (Pares *et al.* 2000).

The TD6 Aurora stratum, composed of mud sediments and clasts from the walls of the cave are 2 to 2.5 m thick (Pares and Pares-Gonzalez 1999:333-335). This level has been the most intensively studied because of the abundance of archaeological material and for it having an early date of occupation. TD6 is dated to between 990,000 and 780,000 years ago by biostratigraphy, reversed polarity (the Matuyama Chron), ESR and U-series dating of materials from an overlying deposit (TD8) estimated to be 600,000 +/- 52,000 years old (Cuenca-Bescos *et al.* 1999; Falgueres *et al.* 1999:351; Made 1999; Pares and Perez-Gonzalez 1999). While TD6 clearly belongs within the time of the Acheulean in Africa, there is a peculiar absence of bifaces and a closer resemblance to the Oldowan (Mode 1) tradition, so it has been dubbed 'pre-Acheulean' (Carbonell *et al.* 1999a, 1999c; Cuenca-Bescoc *et al.* 1999; Falgueres *et al.* 1999:351; Garcia and Arsuaga 1999; Mallol 1999, 2000; Pares *et al.* 2000). Successful refitting of artifacts suggest that flaking might have occurred in the site itself, little post-depositional movement has taken place, or that material dropping from the entrance could have broken and remained in place. The excavators at the site tend to believe that hominids were the main agents responsible for the artifactual accumulation and that the occupation levels (especially TD6) represent an *in-situ* horizon (Carbonell *et al.* 1999c:668-670).

A total of 87 hominid fossil specimens of at least six individuals have been found at Gran Dolina, with 45 post-cranial pieces within TD6 (Lorenzo *et al.* 1999). Based on comparative analysis with *Homo erectus* hominids from Africa and Neanderthals from Europe, it is believed these fossils represent an intermediate evolutionary link between *Homo ergaster* and *Homo neanderthalensis* and have been given a new species name, *Homo antecessor* (Arsuaga *et al.* 1993, 1999; Bermudez de Castro *et al.* 1997, 1999a, 1999b; Carbonell *et al.* 1995, 1999a; Carretero *et al.* 1999; Lorenzo *et al.* 1999; Rosas and Bermudez de Castro 1999). Both animal and hominid remains were randomly mixed and

evidence for stone tool cut marks have been found on 25% of all hominid bones (Fernandez-Jalvo *et al.* 1999:615-619). Cannibalism may have been practiced at Gran Dolina as seen in the intentional breakage of hominid body parts that yield the most nutritious values such as ribs, radial fragments, femurs and skulls (Bermudez de Castro *et al.* 1999b:697; Carretero *et al.* 1999; Diez *et al.* 1999; Fernandez-Jalvo *et al.* 1999:620). All the information collected thus far from TD6 has only been from a six m^2 test pit, with future excavations planned for the year 2008 (Carbonell 1999b). As more information is uncovered, this exceptional place will continue to inspire debate as it is one of the few securely dated sites within the palaeomagnetic reversal over 780,000 years ago, and thus, is one of the oldest archaeological sites in Europe (Aguirre and Carbonell 2001:14-15).

10. Isernia La Pineta (42°27'N, 14°14'E) is an open-air site located in central Italy that had rescue excavations in 1979 and a full scale excavation in 1980 (Coltorti *et al.* 1981:58). All archaeological material is associated with fluvial sediments composed of mud, sand and gravel (Coltorti *et al.* 1981:58, 1982:174). Two assemblages about 300 m apart were examined; Sector 1 and Sector 2 (Coltorti *et al.* 1981). Based on potassium-argon, reversed polarity (the Matuyama Chron) and comparative faunal analysis, the site has been given an age of more than 780,000 years (Coltorti *et al.* 1982:173; Gamble 1986:177; Howell *et al.* 1995:61; Schick and Toth 1993:257). Isernia La Pineta is comprised of an Oldowan-like, non-biface industry that could provide important information about the earliest occupation of Europe (Coltorti *et al.* 1982).

11. Pontnewydd Cave (51°40'N, 3°01'W), Wales, lies at 90 m above sea level. It was first discovered in 1832 and was excavated almost continuously from 1978 to 1995 (Aldouse-Green 1995, 1998). Pontnewydd has been divided into at least nine stratigraphic units (Collcutt 1984). The Lower Breccia bed was the only assemblage examined here and was created as a result of a mass debris gravel flow entering the cave (Collcutt 1984). This level contained the most archaeological remains (370 artifacts), and many animal bones (Currant 1984; Green 1984b). The site has produced evidence of seven archaic *Homo sapiens* or early Neanderthal fragments (mostly molar teeth and one juvenile mandible) in association with Acheulean bifaces and Levallois materials thus is dated to around 300,000 to 200,000 years ago (Green 1986; Green *et al.* 1989; Stringer 1986). This Upper Acheulean date is further confirmed by U-series and TL dating on calcite that places the Lower Breccia Bed at over 200,000 years old (Aldhouse-Green 1995; Debenham *et al.* 1984; Huxtable 1984; Ivanovich *et al.* 1984; Molleson 1984; Schwarcz

1984).

12. Caddington (51°53'N, 0°25'W), England, is located at 190 m above sea level (Bradley and Sampson 1978). The site was first discovered in March 1890 by Worthington George Smith (1894) and was further excavated in 1954 by J. Dyer and again in 1971 by John Campbell (Sampson 1978). A total of four sections subdivided into Layers A to H have been identified (Campbell and Sampson 1978). Section 3, Layer G was examined in detail as it contained the Palaeolithic floor. This level was composed of mainly clay and coarse silt with smaller amounts of sand and fine silt (Campbell and Sampson 1978:76). Stratigraphical evidence brackets the site to between 400,000 and 200,000 years ago, since material suitable for radiometric dating is absent (Catt *et al.* 1978). The site proved to be a useful testing-ground for refitting artifacts and for examining the issue of why Levallois flakes are occasionally found in Acheulean industries. Tough replication studies, it was concluded that Acheulean biface production accidentally produced flakes similar to Levallois ones. Therefore, some Levallois materials could be an unintentional consequence of biface manufacture (Bradley and Sampson 1978:115, 1986).

13. Boxgrove (50°51'6"N, 0°42'9"W), Sussex, England, was discovered in the early part of the 20th century. The site was first excavated by Curwen (1925) followed by Calkin in the 1930s (Calkin 1934), Woodcock (1981) from 1971 to 1976 and most recently from 1982 to 1985 by Roberts (1986a). Remains include a Middle Pleistocene hominid tibia, as well as one of the largest *in-situ* areas of faunal and artifactual material in Britain (Roberts *et al.* 1994). The site has been divided into seven stratigraphical units and archaeological evidence has been recovered from four (Woodcock 1981:105-147). Only two assemblages were examined here. The Slindon Sand/Lower Brickearth assemblage contained fresh artifacts and faunal material on, or near, the edges of a small stream channel (Woodcock 1981:106). The Lower Chalk/Lower Brickearth/Channel deposits had the largest number of artifacts (n=363), bifaces (n=36) and faunal remains from Boxgrove (Woodcock 1981:113). The site has been placed to between 600,000 and 400,000 years ago using biostratigraphy, as material suitable for radiometric dating is lacking (Bergman *et al.* 1990:265; Roberts 1986b; Roberts *et al.* 1994, 1995; Woodcock 1981:371).

14/15. Lavant (50°53'2"N, 0°45'4"W) and Slindon (50°52'0"N, 0°38'6"W) are both known from raised beach assemblages from Sussex, England, discovered around the turn of the 20th century (Calkin 1934; Curwen 1925). The stratigraphy of both sites consist of

disturbed sand and gravel deposits. Based on artifact typology, the lithics point to a date of Middle Acheulean affinity between 600,000 and 400,000 years ago (Roe 1968a:295-305; Woodcock 1981, 1986).

16. Hoxne (52°21'N, 1°12'E), England, was the first Lower Palaeolithic site in the world as it was identified by John Frere in 1797 (Singer *et al.* 1993:1; Trigger 1989:87-89). Excavations conducted from 1971 to 1974 and in 1978 were the focus of a comprehensive monograph published in 1993, almost 200 years after its discovery (Singer *et al.* 1993). Nine stratigraphic beds have been identified, subdivided into many units (see Gladfelter 1993 and Wymer and Singer 1993 for details). Four archaeological assemblages were examined, all dated to between 400,000 and 200,000 years ago by TL, ESR, U-series and normal magnetic polarity (the Brunhes Chron) (Gladfelter 1998; Gladfelter *et al.* 1993). Upper Bed 4 and the Stratum C Bed 4 (Lower Industry) was primarily composed of fluviatile deposits of clay, mud and sandy gravel. The archaeological material within Stratum Bed 5 (Upper Industry) was found in brown silt while Bed 6 was made up of mostly coarse sandy gravel (Gladfelter 1993; Wymer and Singer 1993). Besides the abundance of lithics, many faunal remains from a variety of species have been found, some of which showed evidence of cutmarks as concluded by use-wear analysis (Keeley 1980:143-146, 1993; Stopp 1993).

17. High Lodge (51°50'1"N, 1°22'2"W), Suffolk, England is located 30 kilometres northeast of Cambridge (Rose 1992). It was first discovered in the late 1860s and was excavated in the early 1920s by J. E. Marr and Reginald Smith, from 1962 to 1968 by G. de G. Sieveking, and most recently in 1988 by Jill Cook (Ashton *et al.* 1992). All the archaeological material at High Lodge was deposited by low energy lacustrine processes, composed of gravel and clayey sands (Lewis 1992). The stratigraphical sequence at High Lodge consists of six main depositional units subdivided into Beds A-L with most of the artifactual material coming from the clayey-silts and sands of Beds B to E (Ashton 1992:39). Four archaeological levels were examined, including the Old Collections (consisting of random artifacts that found their way to the British Museum prior to 1930), Bed C2, Bed D and Bed E. These levels all range in age from about 500,000 to 400,000 years ago based on stratigraphy and technological characteristics of artifacts (Bridgland 1994, 2000; Lewis 1998).

18. Swanscombe (51°26'8"N, 0°17'7"E), Kent, England, has been excavated by many different researchers since its discovery in the early 20th century. Excavations are known to have been done during 1912, 1929 to 1930, 1932, 1935, 1937, 1948, 1955 to 1960 and 1968 to 1972 (Conway 1996a; McNabb 1996b). A recent monograph describes the work of John Wymer between 1968 and 1972 (Conway *et al.* 1996). Distinguishing the depositional history of the site has proved problematic due to the unsystematic excavation procedures used throughout its history (Conway 1996b). Some hominid remains were discovered in 1935 that are believed to be early examples of Neanderthals, or something on its way to becoming a Neanderthal (Stringer and Hublin 1999:873). For a detailed description of the Swanscombe sequence, see Conway (1996c). Two levels were examined and include the Lower Gravel Unit 4, composed of medium coarse sandy gravel within a sand matrix, and the Lower Middle Gravel composed of medium coarse sandy/very sandy gravel associated with large flints and clay clasts (Conway 1996c:69-76). These two levels are believed to have a date sometime after around 400,000 years ago based on lithostratigraphy and biostratigraphy. The most recent attempt at radiometric dating of the Swanscombe site was undertaken by Barton and Stringer (1997) who used gamma-ray emissions from the Swanscombe hominid skull; though the result were inconclusive (Stringer and Hublin 1999:875). Whatever the date, the mammalian remains from Swanscombe are among the oldest known from the Lower Thames Valley (Conway 1996c, 1996d; Currant 1996:163; Stringer and Hublin 1999:876).

19. La Cotte de St. Brelade (49°10'36"N, 2°11'15"W), Jersey, has been known since 1881 and has had various excavations since the late 1800s by both amateurs and professionals (Mourant and Callow 1986). Seven stages have been identified subdivided into Layers A to H (Callow 1986c:57). The assemblage examined from this cave site was Stage III, Layer A that has preserved a rich amount of artifacts, ash and bone. Based on dated levels above from both TL and U-series, an age of at least 200,000 years old has been suggested (Huxtable 1986; Szabo 1986). Coupled with the technological refinement of the artifacts, the strong indication of bone being used as a fuel source for fire (from evidence of hearths) and the presence of 12 Neanderthal teeth, an age of around 200,000 years ago corresponds nicely with its designation as Final Acheulean (Callow 1986a:384; Callow and Cornford 1986; Callow *et al.* 1986; Stringer and Currant 1986). Remains of mammoth and rhinoceros were stacked along the insides of the cave. Use-wear traces on flakes, as well as evidence of cutmarks on mammoth tusks may imply intentional hunting and butchering (Callow 1986d; Callow and Cornford 1986; Frame 1986; Jones and

Vincent 1986; Scott 1980).

20. Nantet (43°50'N, 6°18'E), southwest France, is located on a low plateau approximately 100 m above sea level (Villa 1983:176). It was discovered and excavated by Claude Thibault in 1964 and 1965 (Thibault 1968). A total of 1.2 m of deposits have been excavated divided into four layers consisting of sandy silts. While 428 artifacts were classified, no faunal material or any other cultural evidence has been uncovered (Villa 1983:176-181). No indication pertaining to age has been given other than Level 4 belonging to the Acheulean on artifact typology and comparative stratigraphic sequences of the surrounding region (Villa 1983:176).

21. Terra Amata (43°42'N, 7°7'E) is an open-air site located in Nice, southeast France at 26 m above sea level. The site was excavated under rescue operations by Henry de Lumley between January and July 1966 (de Lumley 1969). Seven occupation floors have been identified (de Lumley 1975:761-770). Only three are examined here and include the Dune, Beach and Lower Cycle where deposits are associated within pebbly, silty-clayey sands. These three levels are believed to date to between 250,000 and 200,000 years ago based on two TL estimates of burnt flint and limestone (Wintle and Aitken 1977). Refitting of artifacts has proved to be successful at Terra Amata suggesting that disturbance consisted of mostly vertical displacement (Villa 1983:65-79). A shaft of an elephant bone pointed by percussion and hardened in fire has been found, as well as probable evidence of a hominid footprint (Bhattacharya 1977:33; de Lumley 1975:769; Villa 1983:69-78).

22. Le Vallonnet (45°25'N, 6°46'E), southeast France, was discovered in 1958 and excavated in 1959 and 1962 by Henry de Lumley (Bhattacharya 1977:30; de Lumley *et al.* 1963). Based on extensive faunal analysis and normal polarity believed to be the Jaramillo Normal Subchron, it has been dated to between 950,000 and 900,000 years ago, thus standing as one of the oldest Lower Palaeolithic sites known from Europe (Eschassoux 1995; de Lumley 1975:750-752; de Lumley *et al.* 1988). However, White (1995) concluded from an examination of the artifacts that there appears to be no regular reduction sequence indicative of hominid involvement so that all the lithic material could simply be products of natural formation processes. During the summer of 1996, I was fortunate to be able to help excavate the Final Acheulean/Early Middle Palaeolithic cave site of Le Lazaret as a volunteer, located about 100 metres away from Terra Amata. During that field season, we aided in the faunal analysis from Le Vallonnet. Many pieces

were found to be modified by porcupines as observed from the characteristic gnawing markings. Even with the possibility that Le Vallonnet was never occupied by hominids, it was decided to continue to examine it since even Richard Klein (1999:319-320) notes that it possibly antedates the Brunhes/Matuyama boundary, one of the few sites throughout Europe to do so. Because sites dated to earlier than 780,000 years ago are very rare throughout Europe, the possibility that Le Vallonnet was occupied by hominids was enough to examine it in detail.