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Soressi, M.; Dibble, H.L.

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Multiple Approaches to the Study of Bifacial Technologies

Multiple Approaches to the Study of Bifacial Technologies



Edited by
Marie Soressi and Harold L. Dibble



University of Pennsylvania Museum of Archaeology and Anthropology

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First Edition

This book is dedicated to the memory of

John Desmond Clark

one of the truly great pioneers
of world prehistory.

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PREFACE

This volume is based on the proceedings of a symposium held in Philadelphia during the 2000 meeting of the Society for American Archaeology. The symposium was entitled "From Coups-de-Poing to Clovis: Multiple Approaches to Biface Variability" and included most, but not all, of the authors represented here. Unfortunately, some of the presenters to that symposium were unable to contribute their work to the present volume.

The reason for organizing this symposium is that bifacial technology represents one of the most widespread, though highly varied, lithic technologies known. Bifaces have been used by archaeologists to document the evolution of human technology and cognition during the Pleistocene and as index fossils for a myriad of cultures in both the Old and New Worlds. They also provide some of the most convincing dimensions of stylistic variability observable in stone tool assemblages.

While it could be tempting to treat bifaces as a single technological unity, there is every reason to think that biface technology is every bit as complex and varied as any other chipped-stone technology. From the first African industries to the very recent cultures of the New World, each bifacial technology deals with some of the same technical constraints but at the same time each demonstrates subtle variation in skill and purpose. And, as with every other class of lithic evidence, there are a number of ways to approach that variability analytically. Up to the present, there has not been any attempt to provide a comprehensive overview of bifacial technology, in spite of its importance as a major and widespread phenomenon.

The contributors to this volume represent several different countries and include some of the major figures in modern lithic research. Their contributions cover a broad range of topics, utilizing material from the earliest Acheulian of the Old World to relatively recent industries of the New World.

Some of the chapters presented here deal directly with the origin and evolution of specific bifacial technologies. These studies range from the contribution by J. Desmond Clark and Kathy Schick on early African industries; Vladimir Doronichev and Lubov Golovanova on material from the Caucasus; and Janusz Kozłowski on leaf point industries from Central Europe.

The interpretation of biface formal variability is another major theme seen in many chapters, especially those by Nick Ashton and Mark White on British Lower Paleolithic bifaces; Michael Noll and Michael Petraglia, who compare African and Indian early biface

industries; the study by Shannon McPherron of Acheulian bifaces from the Near Eastern site of Tabun; and the chapter by Shott on the nature of variability among hafted projectile points from central Illinois. Finally, Marcel Otte presents a broad review of bifacial variability.

A related issue concerns the adaptive significance of bifacial technology in terms of manufacture, function, raw material economy, transport, and group mobility. Thierry Aubry and his colleagues compare Portuguese and French Solutrean manufacture, while Douglas Bamforth and Jack Hofman each present studies of Paleoindian assemblages from the Great Plains of North America. Marie Soressi and Maureen Hays provide a detailed functional and technological study to a series of Mousterian bifaces from the site of Grotte XVI in southern France.

While all of the chapters utilize a variety of analytical methods to study bifacial variability, the chapter by April Nowell and her colleagues presents a new and sophisticated method for analyzing morphology. They use this method to address the question of standardization of biface shape.

Finally, we are especially grateful to Derek Roe for providing the concluding chapter to this volume, which includes not only his comments on the individual chapters, but also a wealth of personal insights on the study of Paleolithic bifaces.

This book thus presents coverage on most of the major biface technologies known to prehistoric archaeologists. Is the scope too large? What is the point, after all, of comparing such disparate things as Mississippian projectile points and Acheulian handaxes? Technologically, morphologically, and functionally, they must represent different things made by two or more different species of hominids. But as important as it is to understand differences among different lithic types and industries, it is equally important to understand what they have in common. The one way to do that is to bring together such a wide variety of studies.

We also have tried to bring together scholars who represent different historical and intellectual traditions. Although archaeologists recognize and deal with variability in the archaeological record, we are less likely to confront variability in terms of how different specialists approach their material and what kinds of questions they ask of it. Not many North American archaeologists wonder whether or not the lithic assemblages they work on reflect modern cultural ways of behavior. By the same token, Old World scholars are not often confronted with arguments concerning resource specialized economy and mobility. Of course we all have a lot in common, but there are a lot of differences too, and much to learn from each other.

We are also hoping to fill an important void in lithic studies in general. As stated earlier, there has not been a comprehensive treatment on bifacial technology, in spite of the fact that it is without doubt one of the longest-lived human technologies documented in the archaeological record. From the very beginning of the discipline, bifaces have assumed an importance in archaeological inquiry well beyond the proportion of the lithic record that they represent. For example, where they exist—even if it is in small absolute numbers—bifaces almost automatically become the index fossil of their associated archaeological industry: handaxes in the Acheulian and Mousterian of Acheulian, Laurel leaves in the Solutrean, or Clovis and Folsom points, among others, in the Paleoindian. With such widespread importance given these artifacts, it is time to bring together a collection of chapters having them as a common theme.

By making the scope large, this volume can provide insights that could not be reached from a single temporal or geographical perspective. It presents examples of how bifacial technologies changed through time and according to different environments and to the evolution of human cognitive and physical abilities. And it gives an opportunity to address the issue of how bifacial technology reflects different technological and social system of past hunters-gatherers.

It is only a start, however, and the reader should be warned that he or she will not finish this book knowing “the answer” about bifacial technology, or more correctly, bifacial technologies. We still have a long way to go before we get to that point, but we hope that this volume will make a contribution toward it.

We would like to thank the enthusiastic participation of each author to the volume. We all owe a debt of gratitude to F. Clark Howell, Richard R. Davis and Paola Villa, who offered their insightful comments on the symposium and volume chapters.

Equally, we thank the organizers of the 65th Annual Meeting of the Society for American Archaeology for allowing us to hold this symposium. Thanks are also due to Maire Crowley for her help in preparing the manuscripts. Special thanks are due to Walda Metcalf, Matthew Manieri, Flint Dibble, and everyone in the Publications Department of the University of Pennsylvania Museum of Archaeology and Anthropology.

Spring 2003

Marie Soressi
Harold L. Dibble



1

BIFACE TECHNOLOGICAL DEVELOPMENT AND VARIABILITY IN THE ACHEULEAN INDUSTRIAL COMPLEX IN THE MIDDLE AWASH REGION OF THE AFAR RIFT, ETHIOPIA

Kathy Schick and J. Desmond Clark

Acheulean occurrences investigated in the Middle Awash span from the later Early Pleistocene (starting approximately 1 million years ago), to the earlier Middle Pleistocene (above and below tuff dated to 640,000 years ago), and later Acheulean technologies in the later Middle Pleistocene. Each stage is technologically and typologically distinct. Distinct patterns of variability have been found among these occurrences: their assemblage composition (sites with Mode 1 and Mode 2 technologies co-occurring throughout time); the technological, morphological, and typological characteristics of Acheulean bifaces; and the geological and environmental contexts of sites. Striking patterns observed among bifaces include strong intrasite homogeneity but intersite heterogeneity in their technological and morphological characteristics and raw materials. The variability of the Middle Awash is discussed as it relates to possible behavioral activities and group composition of the tool-makers. A recurrent pattern of association was observed at a number of sites between artifacts and remains of large animals (especially hippopotamus), strongly suggesting carcass processing with Acheulean tool kits. Acheulean evidence from the Middle Awash provides the longest and most complete sequence from any African region. It is an invaluable record of the evolving Acheulean Industrial Complex and hominid adaptive patterns in Early and Middle Pleistocene times.

The Middle Awash paleoanthropological research area extends along the Awash River in the Afar Depression, with deposits bearing Acheulean sites found on both the eastern and the western side of the river (de Heinzelin et al. 2000) (Figure 1.1). The archaeological evidence investigated in the Middle Awash from later Early Pleistocene (c. 1 million years ago) through Middle Pleistocene times, or from later early Acheulean to later Acheulean times, is summarized here and overall patterns observed among the Acheulean occurrences are discussed.

The Acheulean archaeological record in the Middle Awash records occupation of this region during one of the most important and formative periods in human evolutionary history (de Heinzelin et al. 2000). It provides important evidence regarding Acheulean



Figure 1.1 Location of the Middle Awash study area.

biface technology, including methods and techniques of manufacture, raw material selection, stylistic variability, and chronological trends, as well as intersite variation in the predominance of Mode 1 (core-and-flake) versus Mode 2 (biface) technologies. The late Jean de Heinzelin provided the stratigraphic context for the research on the Acheulean reported here; we have relied heavily on his interpretation of the stratigraphic sequences for our analyses and interpretations.

Following pioneer research in the Afar conducted in the 1970's by Maurice Taieb (1974) and by Jon Kalb (Kalb 1978; Kalb et al. 1980, 1982a, b, c, d, e), the Middle Awash research project began work in the region in 1981, conducting archaeological and paleontological surveys, undertaking archaeological excavations at Bodo and Hargufia, and obtaining the first radiometric dates for the area (Clark 1987; Clark et al. 1983, 1993). In 1990, the focus of archaeological research was on Pleistocene deposits in the eastern part of the study area (Clark et al. 1994). Since 1991, investigations into the Acheulean have concentrated on the Bouri peninsula to the west of the modern Awash River.

The Middle Awash region contains a deep, complex rift basin-related succession of sediments and volcanic deposits. Tectonic forces, including faulting, uplift, and differential subsidence, and subsequent erosion have produced localized windows into parts of this sequence. The stratigraphic work of Jean de Heinzelin combined with absolute, radiometric age determinations provide the framework for arranging many of these disparate windows into a general chronological structure of deposits. Thus, they also provide the foundation for an Acheulean sequence here.

The modern Awash River cuts the study area into western and eastern portions as it runs northward toward the Gona and Hadar site areas. Perennial and seasonal streams draining into the Awash River dissect the study area, exposing Acheulean-bearing deposits on both sides of the river. West of the river, most sites are concentrated in the Bouri region; in the east, most are found farther to the north in the Meadura, Hargufia, Dawaitoli, Bodo, and Maka drainages (Figure 1.2). Work during the 1990 field season concentrated in the eastern Middle Awash study area, primarily in the Bodo, Dawaitoli, and southern Hargufia drainages. From 1993 to 1996, intensive work has been undertaken in the western Middle Awash on the southern end of the Bouri peninsula.

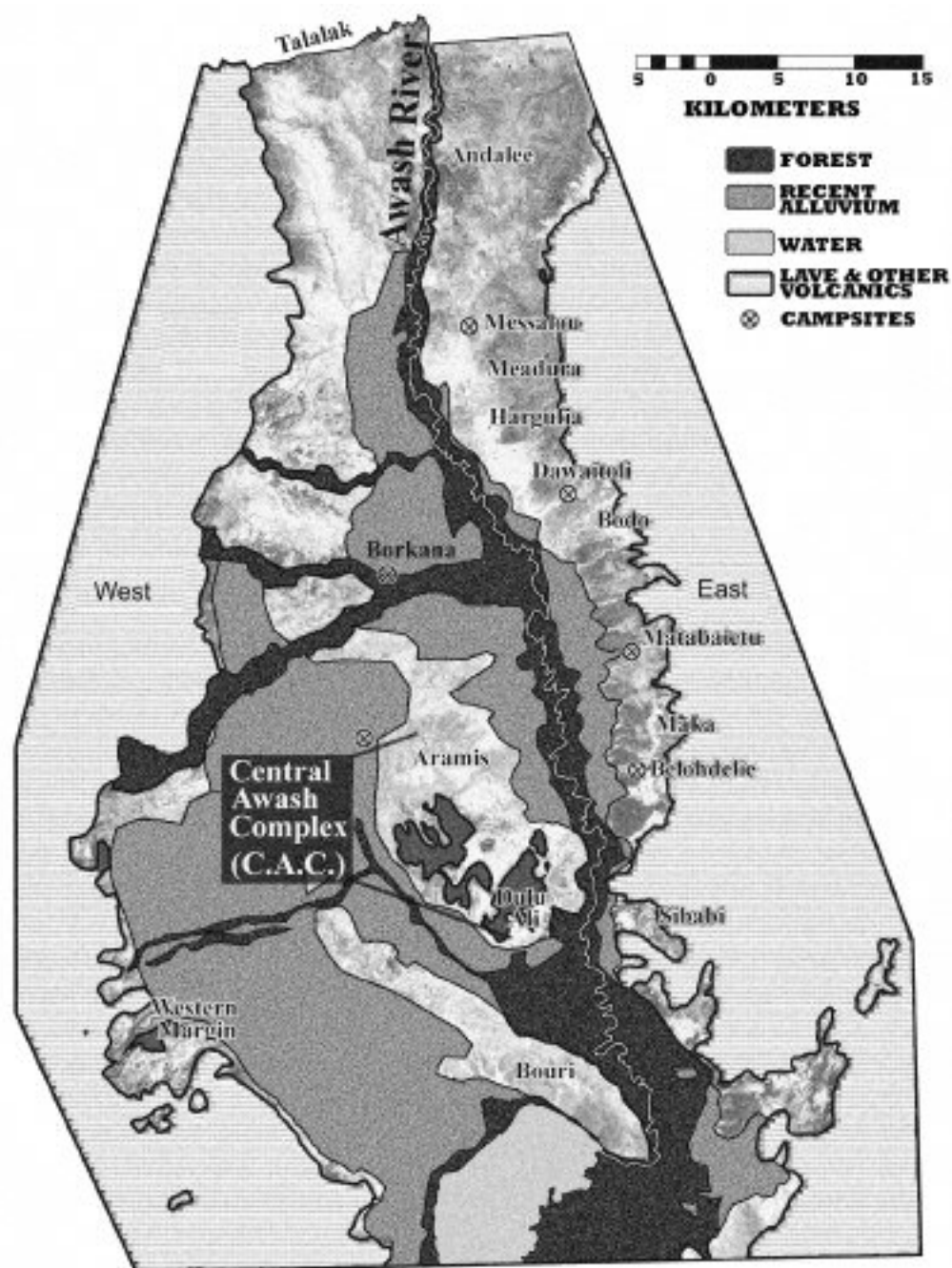


Figure 1.2 Middle Awash study area.

Table 1.1 Stratigraphic Position of Sites Investigated in the Eastern Middle Awash Study Area

?	LATE MIDDLE PLEISTOCENE			MAK-A2 (Modes 1 & 2)	?	LATE ACHEULEAN
MIDDLE PLEISTOCENE	DAWAITOLI FORMATION	U-T MEMBER <i>(following or contemporary with Member U-3)</i>		BOD-A1 (Mode 1), BOD-A11 (Modes 1 & 2)	MIDDLE ACHEULEAN	
				UPPER BODO SAND UNIT (UBSU) BOD-A2, -A8, A-10 (Modes 1 & 2); BOD-A9 (Mode 1)		
			[FAULT F6] ⇒	[FAULT F6] ⇓		
		U-3 MEMBER	HAR-A2 (Mode 1), HAR-A3, HAR-A4 (Modes 1 & 2) ; DAW-A5 (Modes 1 & 2), DAW -A6 (UPPER) and DAW-A9 (Modes 1 & 2)			
		U-2/U-3 INTERFACE	DAW-A7 (Mode 1), DAW-A8 (Modes 1 & 2)			
		U-2 MEMBER	DAW-A6 (LOWER) (Mode 1)			
		Hargufia/Dawaitoli/ Bodo Tuffs [0.64 myr]				
		U-1 MEMBER	BOD-A3, -A4, -A7, and DAW-A11 (Mode 1)			
EARLY PLEISTOCENE		?EARLY PLEISTOCENE “MIDDLE BODO BEDS”	MAK-A1 (Modes 1 & 2) BOD-A5, -A6 (Mode 1)		EARLIER ACHEULEAN	

The sites attributed to the Early and late Middle Pleistocene are placed according to technological characteristics and/or faunal associations. Most sites are situated within the Dawaitoli Formation Middle Pleistocene deposits and, on technological grounds, fall within the Middle Acheulean period. The sites in the U-T Member of the Dawaitoli Formation are separated by Fault F6 from those in the U-1, U-2, U-3 Member sequence, but show similar technological characteristics and faunal associations and may either be penecontemporaneous with or following Member U-3. A provisional date of 0.64 myr (see Chapter 4) has been derived toward the base of the Dawaitoli Formation for a tuff deposited between sites in Members U-1 and U-2. (Table by Kathy Schick)

The majority of the Early Palaeolithic sites found thus far in the Middle Awash study area fall within the time span of the Acheulean Industrial Complex in Africa. Some sites contain only Mode-1 technologies (i.e., simple core and flake technologies), although more commonly sites contain both Mode-1 and Mode-2 (i.e., bifacially flaked core tools) artifacts (Clarke 1961); the latter typically involves numbers of Acheulean handaxes and/or cleavers. As sites studied may or may not contain the typical Acheulean tool forms (e.g., handaxes or cleavers), but all were within the time range of the Acheulean Industrial Complex, we will refer to them writ large as "Acheulean-age sites." Acheulean-age sites found in the eastern Middle Awash are primarily of Middle Pleistocene age. Those studied in the western Middle Awash area have been found from two general time periods—some in late Early Pleistocene sediments and others in deposits of Middle to late Middle Pleistocene age.

Acheulean-Bearing Deposits of the Eastern Middle Awash

Archaeological fieldwork was conducted on the eastern side of the Awash River in 1981 and 1990. After conducting a careful survey in 1981 of the Bodo locality that had previously yielded the hominid cranium (Conroy et al. 1978; White 1984, 1985, 1986), intensive survey was then carried out further upstream in the Bodo drainage, and then also in the Dawaitoli and Hargufia drainages, where sites were recorded, mapped, and, in some instances, excavated and collected (Clark et al. 1983, 1993; Clark 1987). Preliminary survey was also conducted further north in the Meadura and Messalou drainages.

The main focus of archaeological research in 1990 comprised survey and analysis, as well as limited excavation, of archaeological localities in the Bodo, Dawaitoli, and Hargufia drainages (Clark et al. 1994). The geologist and the archaeologists conducted initial surveys in these three drainages jointly. As geological surveys identified the stratigraphic relationship and succession of sedimentary units, as well as fault zones, simultaneous archaeological surveys identified site localities and the nature of technologies within the respective sedimentary units.

Dawaitoli Formation: Middle Acheulean Sites

The majority of the Acheulean-age sites investigated in the eastern Middle Awash are contained within the Dawaitoli (U) Formation (Table 1.1). An integrated thickness of more than 45 m of deposits in the Dawaitoli Formation is subdivided into Members U-1, U-2, U-3, and U-T, the latter in fault contact with the other Members and either contemporary with or following U-3 (Figure 1.3). The pooled results of laser-fusion dates for a tuff at the base of Member U-2 suggest an age of 0.64 million years ago. Some of the identified Acheulean-age sites are below this tuff (in Member U-1) and a larger number are above it (in Members U-2, U-3, and U-T). The faunal assemblages throughout the Dawaitoli Formation as well as the Acheulean technologies observed in its upper Members, U-3 and U-T are virtually indistinguishable from one member to another and appear to have been deposited in fairly rapid succession or without significant time gaps between them. Thus, the majority of Acheulean sites identified in the Dawaitoli Formation in the eastern Middle Awash appear to be of Middle Pleistocene age (Table 1.1). (In addition, two sites have been noted that could be of Early Pleistocene age on the basis of fauna, as well as one other of uncertain age that might, on technological grounds, provisionally be attributed to the earlier Acheulean).

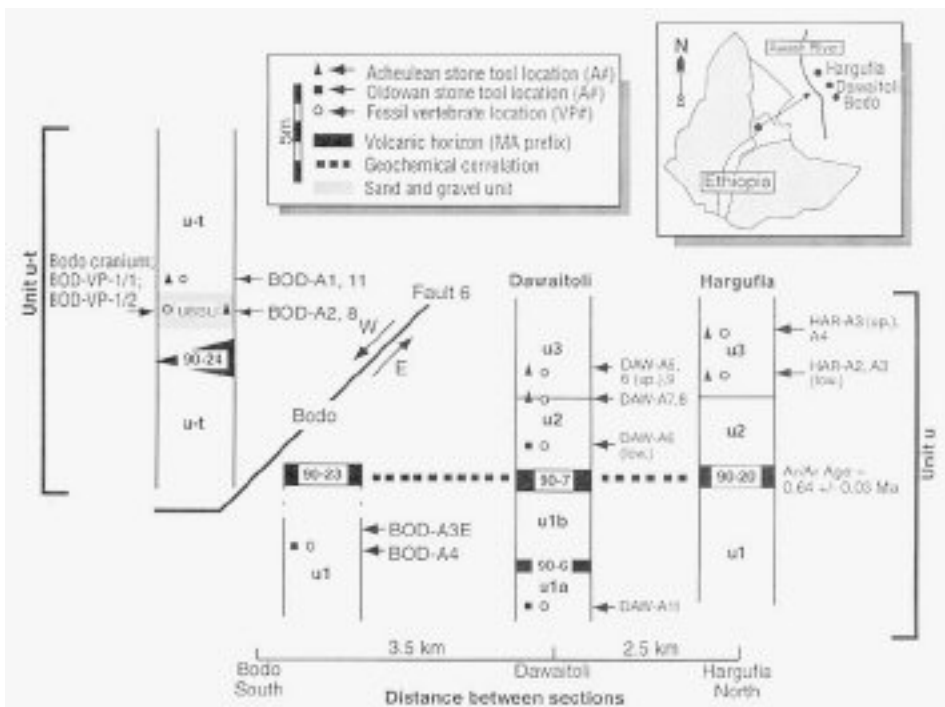


Figure 1.3 Schematic composite section of stratigraphy of the Dawaitoli Formation (eastern Middle Awash) in the region of the Bodo, Dawaitoli, and Hargufia drainages. (After Figure 1 in Clark et al. 1994)

Diachronic and Synchronic Variability: Mode 1 v. Mode 2 Sites

An interesting pattern has been observed with regard to technological variation over time and its association with changing environments (Clark et al. 1994). The earlier five sites (in Members U-1 and U-2) contain only Mode 1 core-and-flake assemblages (Figures 1.4 and 1.5). The later sites (beginning at the U-2/U-3 interface and throughout the remaining deposition of the Dawaitoli Formation), include many Mode 2, Acheulean occurrences ($n = 10$) (Table 1.1, Figures 1.6, 1.7, 1.8), as well as some others containing only Mode 1 assemblages ($n = 4$). Interestingly, the sediments in the earlier two Members (U-1 and U-2), in which only Mode 1 assemblages have been observed, indicate relatively low-energy floodplain deposition within more stabilized fluvial regimes. The later deposits (U-3 and U-T Members), in which Acheulean technologies become abundant, show a shift to higher energy deposition in a system of wadi or tributary stream fans. This change in sedimentary regime is likely to have been influenced by tectonic activity in the region.

It should be noted that the five Mode 1 sites in Member U-1 and U-2 existed well after the onset of Acheulean technologies in Africa. It is clear that no easy explanation for the absence of Acheulean technologies in these members can be given based simply on the environmental differences noted, although these may have contributed to the technological variation observed. In view of the association of the Mode 1 assemblages in Members U-1 and U-2 with more stable floodplain environments than observed for the Mode 2 assemblages that succeed them, we have suggested that these Mode 1 assemblages may



Figure 1.4 BOD-A3: Excavated cores and flakes. (Drawings by Betty Clark)

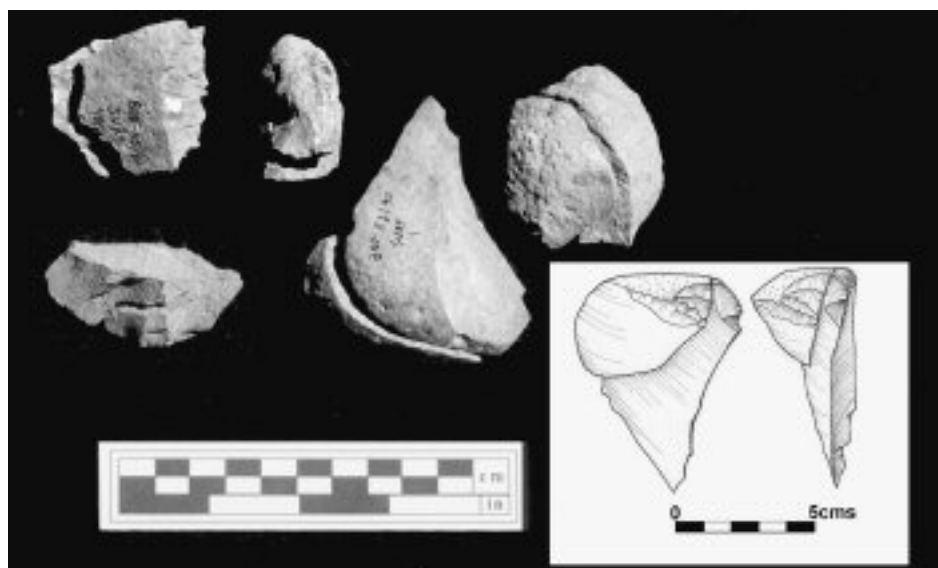


Figure 1.5 BOD-A3: Five conjoined pairs of surface flakes; inset: pair of flakes on lower right of photograph. (Photograph by Kathy Schick; drawing by Judith Ogden after a sketch by Jean de Heinzelin)



Figure 1.6 DAW-A8: Two of the surface bifaces found eroded out. (Photograph by J. Desmond Clark)



Figure 1.7 DAW-A6: Two Acheulean surface bifaces made on Kombewa flakes (a nearly parallel-sided cleaver and an ovate cleaver with an oblique bit) (dorsal view). (Photograph by J. Desmond Clark)



Figure 1.8 DAW-A6: The opposite face of the two cleavers on Kombewa flakes in Figure 1.7. (Photograph by J. Desmond Clark)

represent a behavioral facies of the Acheulean Industrial Complex within or in response to this geographic setting; whereas, Mode 2 assemblages correspond to adaptation within a system of shifting, silty, and sandy streams. In view of the presence in the shifting wadi fan environments of Members U-3 and U-T of some Mode 1 assemblages (many others dominated by Mode 2 biface technologies), it would appear that other factors also influence the technologies observed.

We have suggested that differences in activities, perhaps even influenced by age or sex composition of the hominid group, as well as by opportunities or necessities of the moment, could be critical factors dictating what technologies would have been produced, used, and discarded at a particular site location. In the earlier, floodplain sites, Mode 1 technologies appear to have been favored; in the later wadi fan sites, Mode 2 technologies were commonly favored, but Mode 1 technologies were sometimes the focus of the stone tool activities. Mode 1 technologies may also have been favored when stone tool-making or tool-using was conducted in a more expedient manner, using more local raw materials (typically much smaller cobbles likely obtained within gravel deposits in the region); whereas, Mode 2 technologies required transport not only of rock from more distant sources where large cores or flakes could be obtained either in the volcanic highlands or far upstream in higher energy channels, but also of shaped tool forms from areas of manufacture (as handaxes and cleavers are largely brought onto the sites in finished form).

The local raw materials evident among Mode 1 artifacts, whether the earlier ones in the floodplain fine-grained sediments or the later ones found in channel sands, include a range of basalts, as well as some rhyolite, ignimbrite, and chert. The flakes in these Mode 1 assemblages also have a lower mean size than flakes associated with the Mode 2 biface assemblages. The majority of bifaces on the eastern side of the Awash River were made on basaltic lavas, which vary in terms of color, fineness of grain, homogeneity, and vesicularity. As mentioned above, the large, Mode 2 bifaces were apparently made in closer proximity to the raw material sources in the basin and not at the archaeological occurrences in these sediments, as only very occasional retouch or trimming flakes are present. There are, however, some very large boulder cores present in the Bodo and Dawaitoli area (Figure 1.9), that would appear to have been used for production of large flakes for bifaces, and may have been imported by hominids. More rare use was made of varieties of obsidian, limestone, and chert for artifact manufacture.



Figure 1.9 BOD-A8: One of the very large boulder cores found in the vicinity. Flakes derived from such cores would have been suitable for production of Acheulean handaxes and cleavers. (Photograph by J. Desmond Clark)

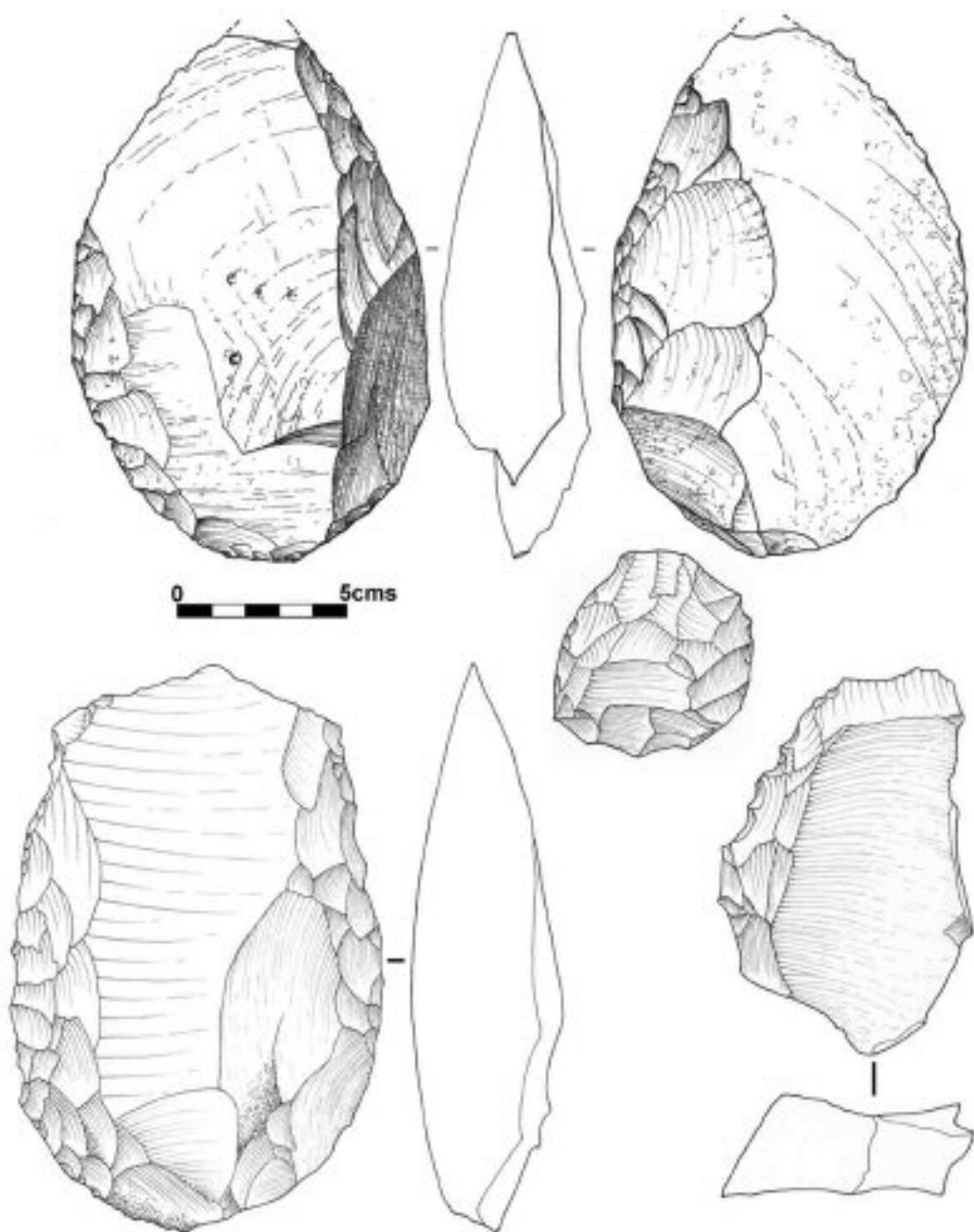


Figure 1.10 The two cleavers on Kombewa flakes in Figures 1.7 and 1.8, a core, and a retouched piece. (Drawings by Judith Ogden [upper] and by John ["Chip"] Colwell from sketches by Jean de Heinzelin)

Special Technological Patterns

Looking at the eastern Middle Awash Acheulean assemblages in general, there are no well-made proto-Levallois cores such as those at the south end of the Afar rift at Arba, approximately 80 km south of Bouri, where use of fine-grained rhyolite outcropping there may have favored this technique. In the Middle Awash, one possible substitute for such cores are those which we have designated “giant cores” or very large, multifaceted polyhedrons (Figure 1.9). These show evidence of predominantly plain striking platforms, but a few have platforms that show some preparation prior to flake removal. Another special method of removing large flakes from boulders produces Kombewa flakes from time to time, where a large boulder flake or split boulder serves as the core to remove another large flake, producing a large flake with two bulbar surfaces and a lenticular cross-section (Figures 1.7, 1.8, and 1.10). Such Kombewa flakes often required and received little further modification or thinning except for minor shaping along one or both lateral edges. These may have been fortuitous byproducts of intensive boulder reduction, but may also have been deliberately carried out occasionally.

A particularly striking aspect of many Acheulean localities in the eastern Middle Awash is the remarkable uniformity seen in morphology and technology among bifaces within the assemblage at that particular locality. At some of the localities investigated, biface characteristics such as planform, overall size, or tip or bit morphology were markedly similar among a large proportion of the bifaces present (Figures 1.11 and 1.12). This would appear to indicate a strong adherence to particular technological procedures and stylistic conventions in the manufacture of numbers of the bifaces discarded at that particular locality. This is particularly striking because bifaces appear, by and large, to have been manufactured elsewhere, at some distance, and then transported to the site of discard. Whether such conventions were followed by one hominid or shared within a group is not known, although the large number of bifaces often involved might suggest sharing of manufacturing norms within a group.



Figure 1.11 HARA4: One of the nicely made bifaces found in the 1990 excavation. (Photograph by Kathy Schick)

Acheulean-Bearing Deposits of the Western Middle Awash

After the 1990 field season archaeological research into the Acheulean of the Middle Awash concentrated on the western side of the river, primarily on the Bouri peninsula. Acheulean-age deposits here cover the earlier and later Acheulean periods more completely than do the deposits on the east side, and extend our understanding of variability and technological change in the Acheulean of the Horn of Africa. The work on the west side of the Awash River reported here was undertaken during 3 field seasons in 1993, 1995, and 1996 (Asfaw et al. 1997; de Heinzelin et al. 2000).

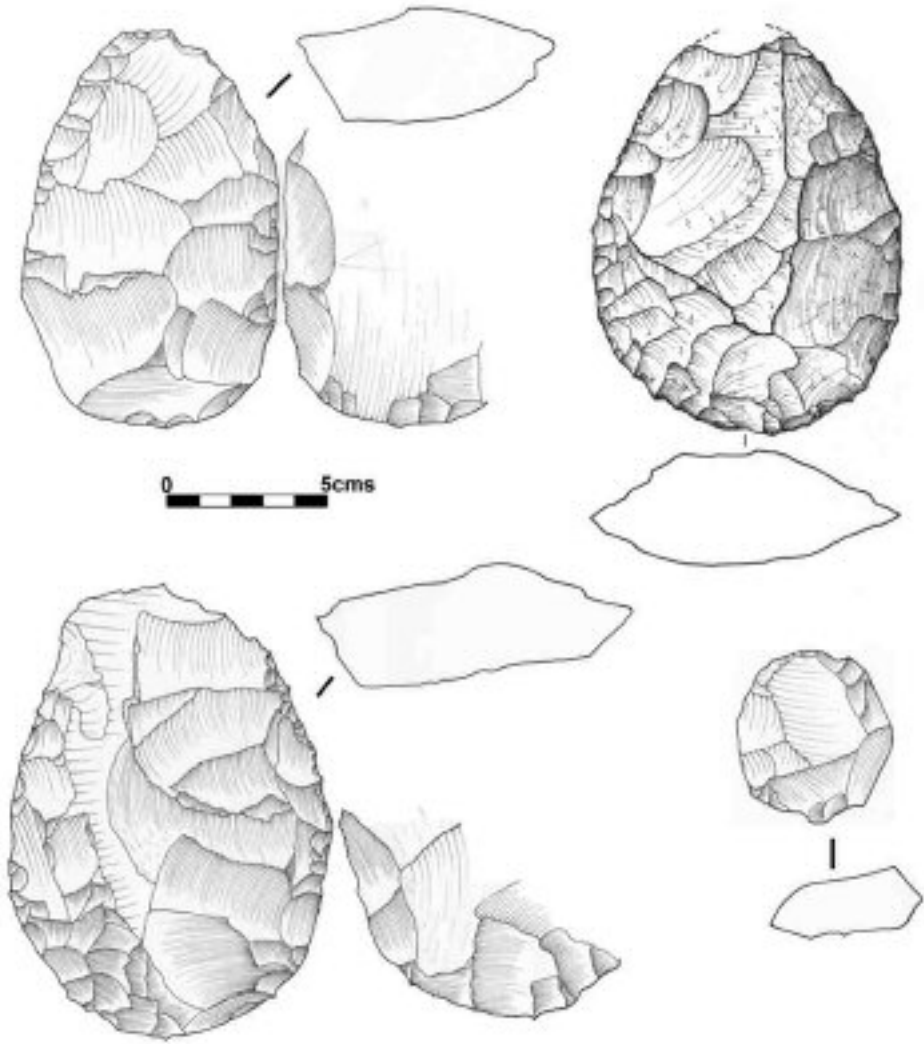


Figure 1.12 HAR-A4: Three of the four well-made bifaces and one retouched piece found in the 1990 excavation. (Drawings by Judith Odgen [upper right] and by John Colwell, after sketches by Jean de Heinzelin)

Stratigraphic Units: Ages and Archaeological Associations

Investigation of Acheulean-age archaeological sites at Bouri has concentrated on the central and eastern side of the peninsula. The sedimentary succession at Bouri has been divided into three Members: the Hata Member (Pliocene age, 2.5 Ma); the Daka Member

Table 1.2 Relative Stratigraphic Sequence of Geological Deposits and Associated Archaeological Sites in the Bouri Formation of the Western Middle Awash

BOURI FORMATION	MIDDLE PLEISTOCENE	HERTO MEMBER	BOU-A11 (Modes 1 & 2)	LATER ACHEULEAN
			BOU-A10 (Modes 1 & 2), ?BOU-A8 (Mode 1)	
			BOU-A9 (Modes 1 & 2) and BOU-A13 (mostly Mode 1)	
		[MAIN FAULT] ⇓		
	EARLY PLEISTOCENE	DAKA MEMBER	BOU-A15 (Modes 1 & 2), ?BOU-A1 (Modes 1 & 2) BOU-A2 (Modes 1 & 2)	EARLIER ACHEULEAN
			BOU-A3 (mostly Mode 1) BOU-A4 and -A5 (Modes 1 & 2)	
			BOU-A6 (Modes 1 & 2), BOU-A7, -A14 (mostly Mode 1), BOU -A17 (Modes 1 & 2)	CUT-MARKED BONE, <i>A. garhi</i>
			HEREYA PUMICE UNIT [1.042 mya]	
			↑ [BOURI DIASTEME]	
	PLIOCENE	HATA MEMBER	MAOLEEM VITRIC TUFF [2.496 my]	

Although stone artifacts have not yet been found in situ in the later Pliocene deposits of the Hata Member, cut-marked bone has been found (as well as remains of *Australopithecus garhi*). Between the Hata Member and the Daka Member is the period of paleosol formation and periodic erosion identified here as the Bouri Diasteme, which may represent a time gap of approximately 1.5 myr between these two members. Earlier Acheulean sites have been found within the Bouri Formation in the Early Pleistocene deposits of the Daka Member (with a basal date of 1.042 myr). On the other side of the main fault, sites with later Acheulean technological characteristics are found in the Middle Pleistocene deposits of the Herto Member. (Table by Kathy Schick)

(Early Pleistocene, c. 1.0 Ma); and the Herto Member (primarily Middle Pleistocene, between 400 Ka and 100 Ka) (de Heinzelin et al. 1999) (Table 1.2).

Although cut-marked fauna has been discovered and described in the Hata Member (de Heinzelin et al. 1999), the earliest lithic assemblages discovered thus far in situ on the Bouri Peninsula are of early Acheulean facies within the Daka Member. Sedimentation of the Daka Member began after an erosional disconformity with the underlying Hata Member, with an estimated time gap of 1.5 million years between the 2.5-million-year-old Hata Member and the early deposits of the Daka Member.

On the southwestern side of the main fault, the Herto Member represents another period of deposition that follows the Daka Member after an unspecified amount of time. A number of later Acheulean archaeological occurrences have been documented within

35 m of exposures within the Herto Member. No radiometric dates have yet been obtained for this Member, although the later Acheulean technologies at sites within these deposits would almost certainly indicate Middle Pleistocene age; dates for the Herto Member may be expected to fall between approximately 400,000 and 100,000 years ago.

Daka Member, Bouri Formation: Earlier Acheulean

The Daka Member provides a sequence of earlier Acheulean sites in alluvial deposits that begins in the Early Pleistocene c. 1.04 Ma ago. It should be noted that the site sequence within the Daka Member represents a relative chronology only and may not represent any substantial time lapse from one stratigraphic position to another, as the fauna is relatively uniform throughout this Member.

Characteristic of the Daka Member occurrences is their common association with shell horizons that are believed to relate to lakeside beaches or shallow water deposits in distributary channels, rather than the shifting wadi fans associated with the Middle Acheulean sites on the east side of the river. With the two exceptions of BOU-A1 and BOU-A4, sites investigated in the western side of the Middle Awash research area did not tend to contain the high concentrations of bifaces sometimes observed on the east side of the Awash (e.g., in the Dawaitoli drainage). The artifacts at most of the western sites tended to be relatively fewer in number and more sparsely distributed than in most eastern Middle Awash sites; such occurrences could represent relatively brief activity

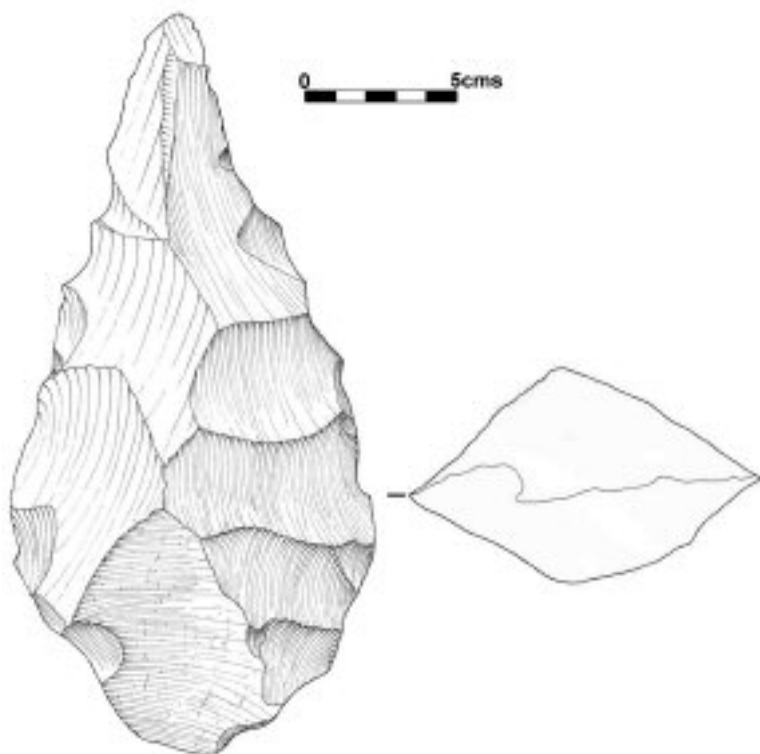


Figure 1.13 BOU-A6: Lanceolate bandaxe. (Drawing by John Colwell after a sketch by Jean de Heinzelin)

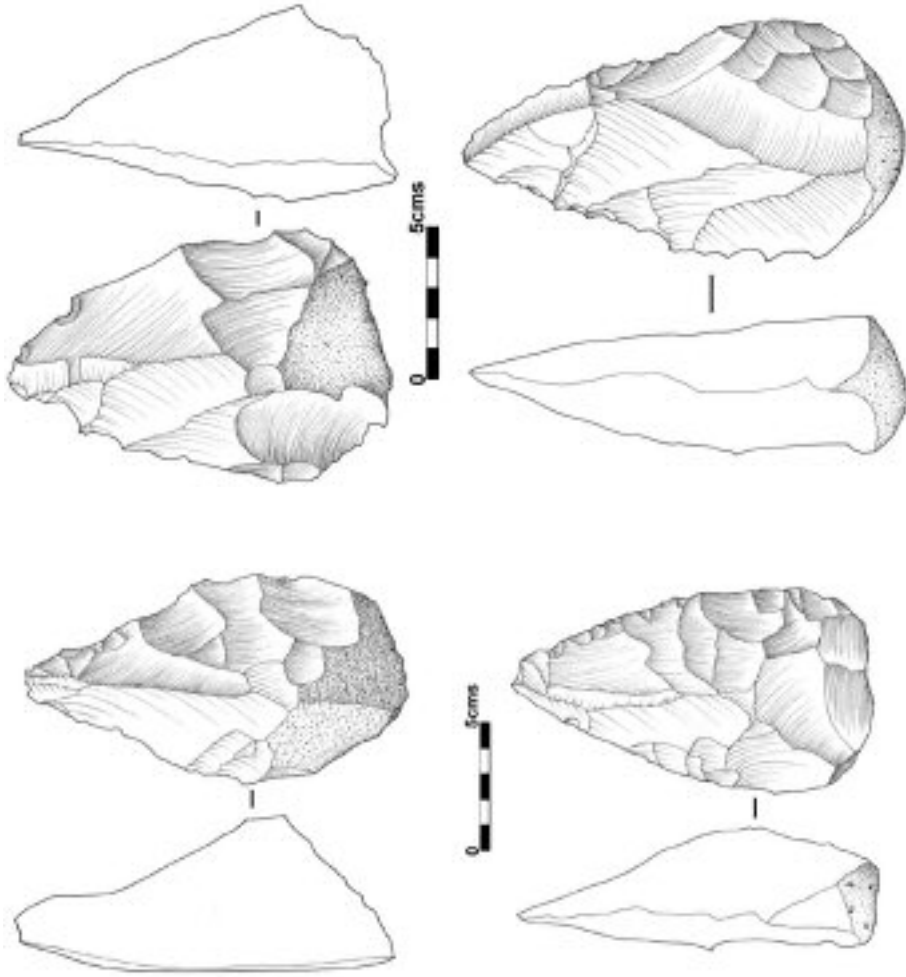


Figure 1.14 BOU-A4: Orate and subtriangular thick bifaces. (Drawings by John Colwell after sketches by Jean de Heinzelin)

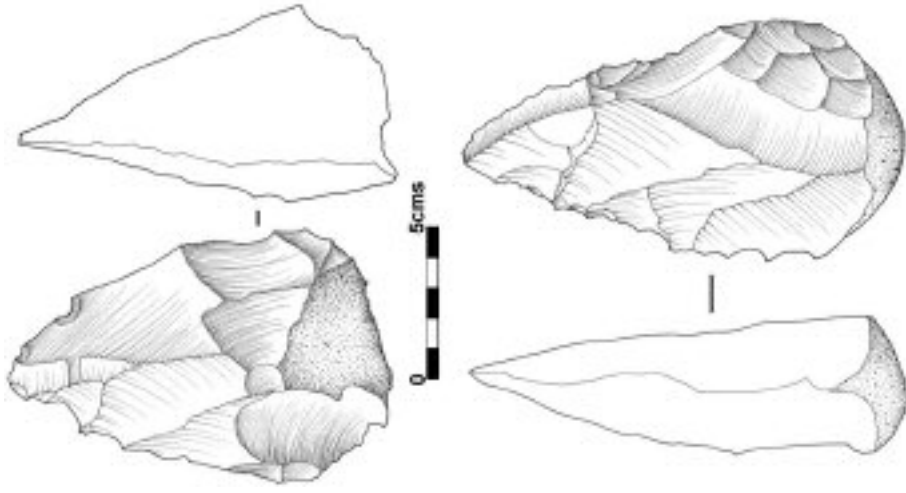


Figure 1.15 BOU-A1: Two excavated handaxes (top: lanceolate with a cortical butt, made on a cobble; bottom: lanceolate, high-backed with a thick butt). (Drawings by John Colwell after sketches by Jean de Heinzelin)

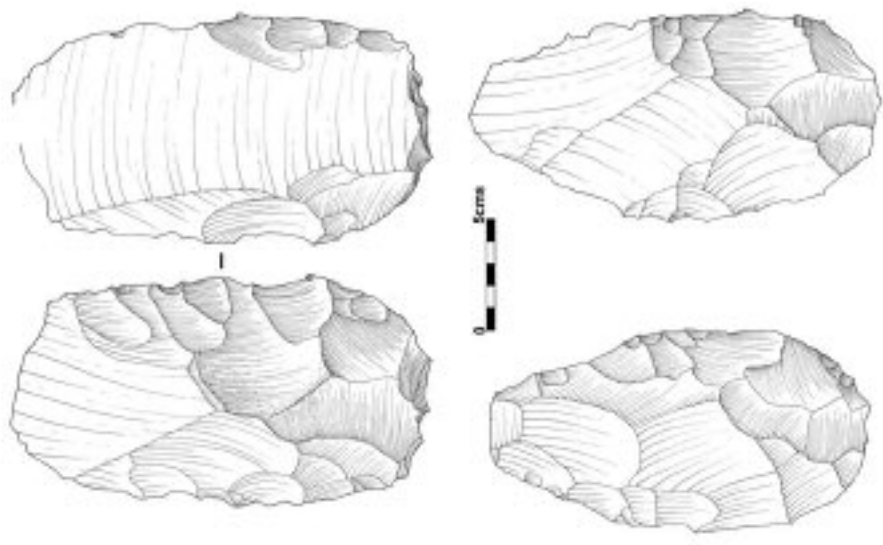


Figure 1.16 BOU-A1: Three excavated cleavers (top: parallel-sided; bottom: two ultraconvergent). (Drawings by John Colwell after sketches by Jean de Heinzelin)

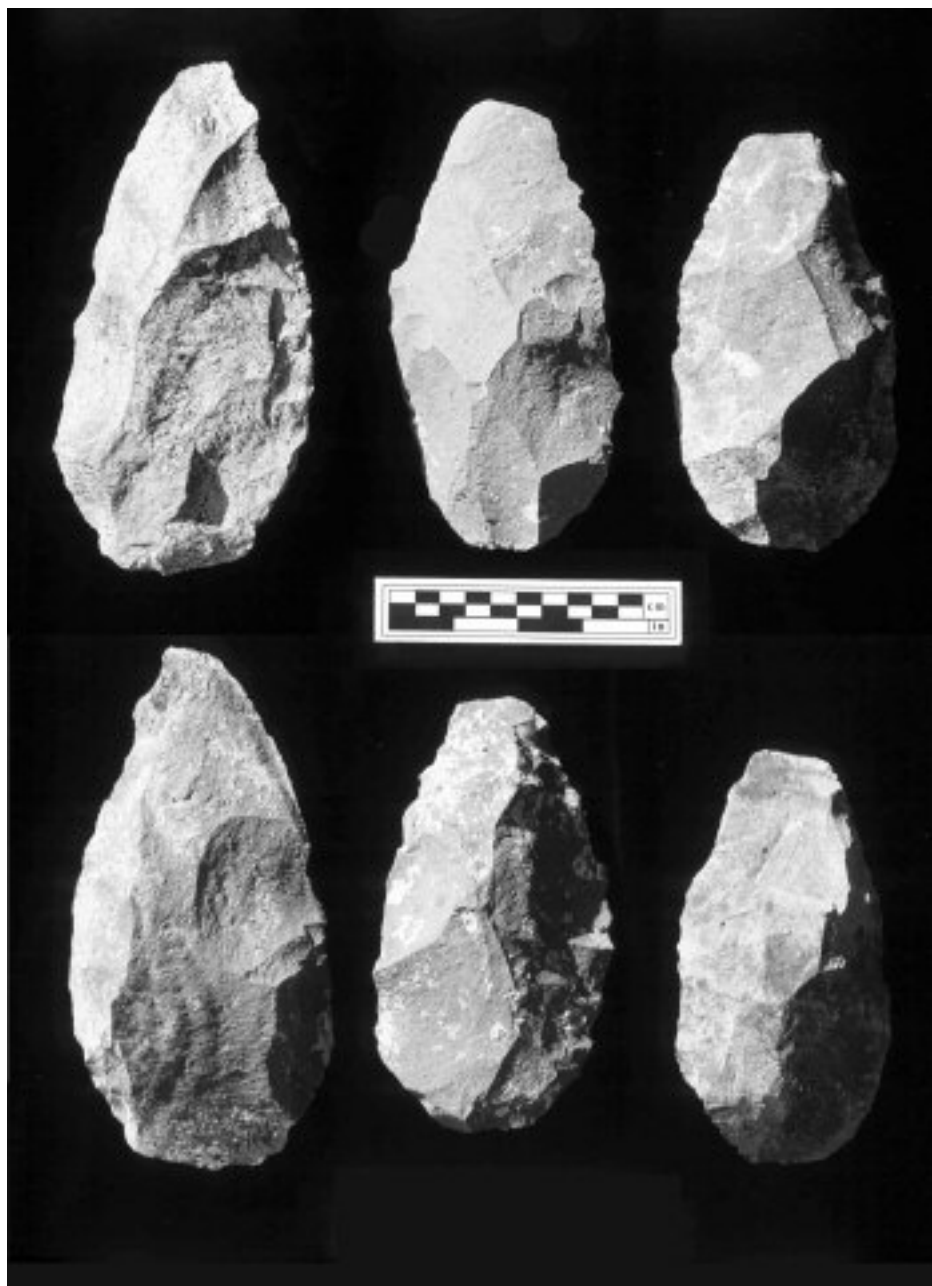


*Figure 1.17 BOU-A1: Three excavated bifaces (top), opposite face (bottom).
(Photographs by Kathy Schick)*

episodes. The artifacts in Daka Member assemblages conform in terms of their technology and typology to those in early Acheulean assemblages in other parts of Africa (e.g., hard hammer percussion, bold flake scars, and larger bifaces with fewer flake removals than later Acheulean forms) (Figures 1.13–1.17), and their date of 1.0 Ma is well in line with stylistic trends observed at that time in the Acheulean of Africa.

Herto Member, Bouri Formation: Later Acheulean

The Herto Member block, at least 35 m thick, on the southwest side of the main fault, exposes younger sediments adjacent to the older Daka sediments to the northeast. Acheulean artifacts within Herto Member sediments can typologically be assigned to a later Acheulean facies than those within the Daka Member. These later Acheulean artifacts are found deposited within a series of beds laid in mostly shallow lacustrine settings interspersed with incipient paleosols and land surfaces.

Bifaces at many Herto Member localities tend to be very finely made (in a fine-grained silicified limestone at one locality) or often rather diminutive (Figures 1.18 and 1.19). These Herto sites are sometimes associated with the remains of large animals, particularly hippos, and may represent butchery activities in these lacustrine settings. Additional sites subsequently located somewhat higher in Herto Member sediments than the ones investigated and discussed here contain Acheulean bifaces along with Levallois flaking, and would appear to date to an even later phase of the Acheulean. These are to be reported at a later date.

Earlier and Later Acheulean: Overall Patterns

The considerable technological difference between the earlier, Daka Member Acheulean sites and the later, Herto Member sites reflects general technological advances within the Acheulean period. The earlier technologies in the Daka Member sites overall exhibit larger, more crudely shaped and less symmetrical bifaces, hard hammer flaking, and rare retouched pieces; whereas, the later, Herto Member sites, which are likely hundreds of thousands of years younger, tend to show more refined and symmetrical biface (sometimes quite small), soft hammer flaking, and more common retouched pieces. Hominid remains have now been found in each of these time periods, as well, and reflect biological evolution during the intervening time span. The Daka Member sites are associated with *Homo erectus* (or *Homo ergaster*)-like hominids; whereas, the Herto Member sites are apparently associated with a number of fossil hominids from the Late Middle Pleistocene.

In each general period of time, in the Daka Member and the Herto Member, there is considerable technological variation among sites, with some dominated by Acheulean tool forms such as handaxes and cleavers, and others containing primarily Mode 1 technologies (a pattern also observed in the eastern Middle Awash, as discussed above). A particularly striking aspect of the western Middle Awash Acheulean sites is their common association with fossil remains of large animals, especially hippos. Overall, the western Middle Awash Acheulean sites represent a valuable record of Acheulean technologies and of hominid activities and adaptation in earlier and later Acheulean times.



Figure 1.18 BOU-A8: The four finely made bifaces, made in silicified limestone and showing evidence of soft-hammer technique, found in the vicinity of the bippo/artifact locality that was excavated. (Photograph by Kathy Schick)

0 5cms

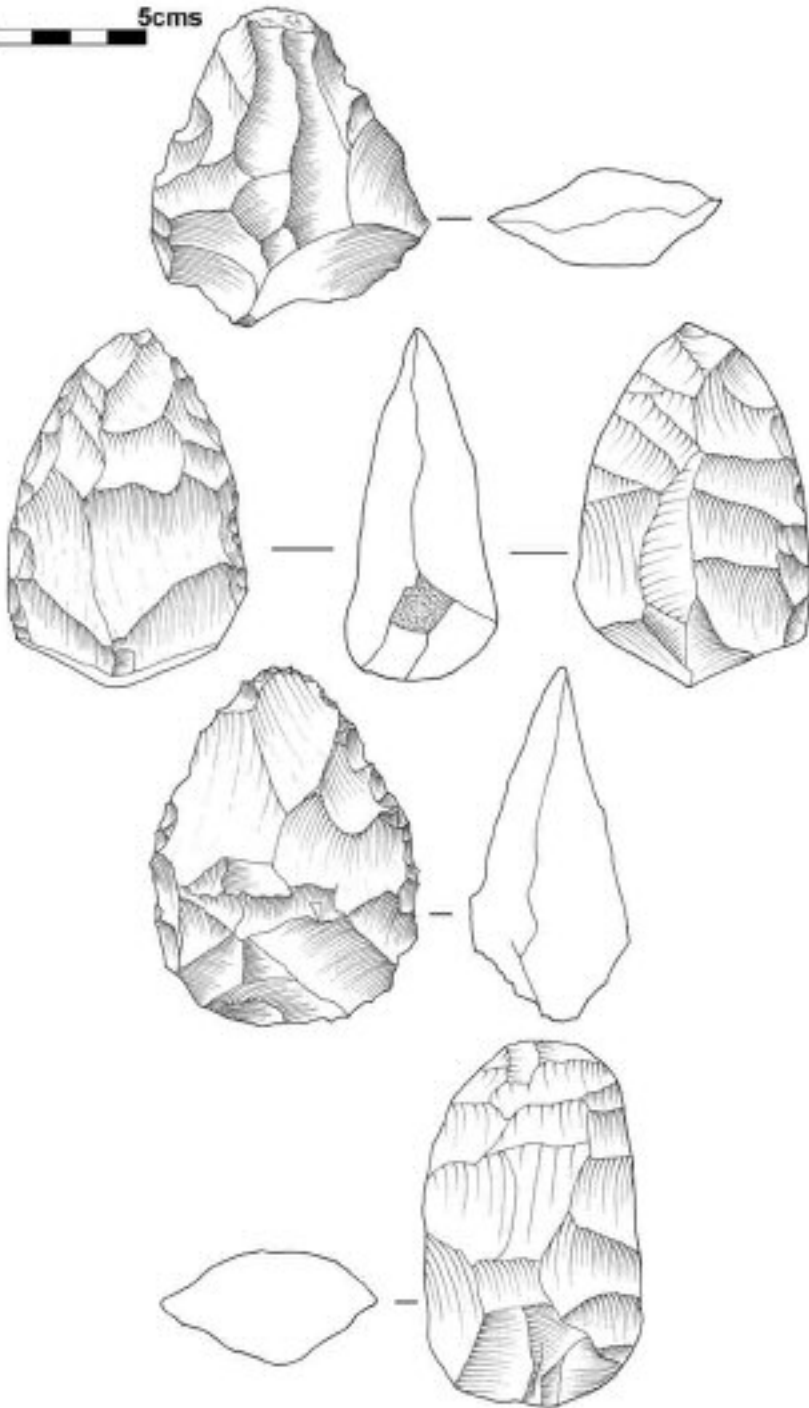
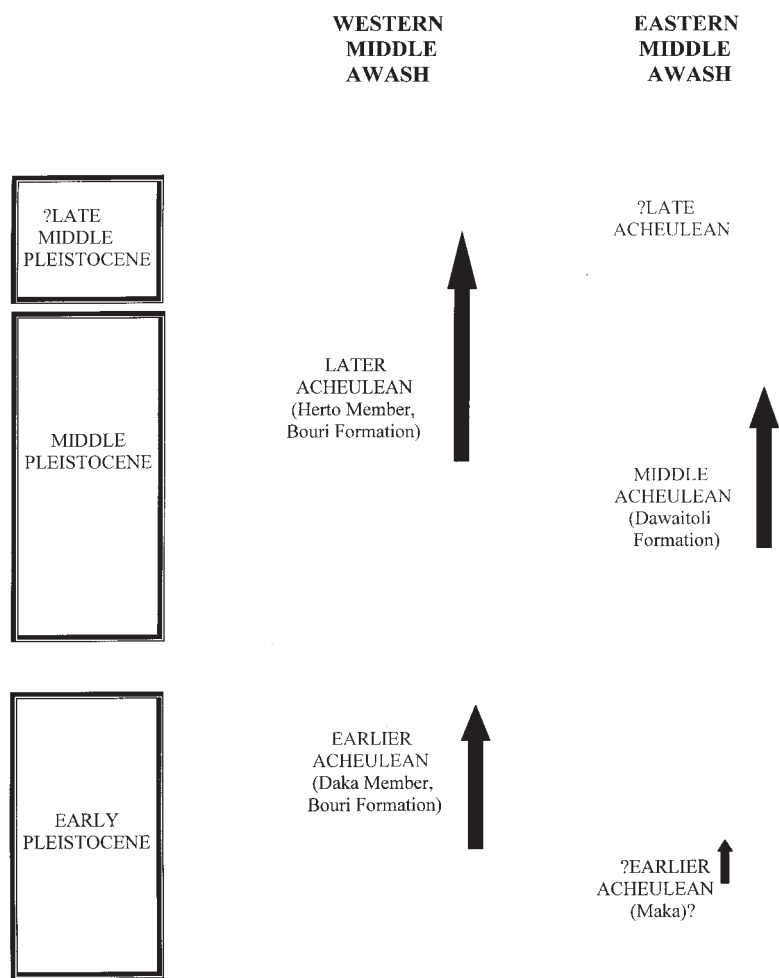


Figure 1.19 BOU-A10: Four small cordiform or subtriangular bifaces found in proximity to the gridded area at the site. (Drawings by John Colwell after sketches by Jean de Heinzelin and Tim White)

Table 1.3 Approximate Stratigraphic and Chronological Sequence of Deposits and Associated Acheulean Sites in the Eastern and Western Middle Awash Areas Combined



Note that the western Middle Awash sites reported here appear to represent earlier Acheulean technologies (from the Early Pleistocene Daka Member, starting c. 1.0 million years ago) and later Acheulean technologies (from the later Middle Pleistocene Herto Member, starting c. 400,000 years ago). The eastern Middle Awash sites appear to fill in much of the gap between time periods represented by the western sites, with most sites falling within Middle Pleistocene Dawaitoli Formation (starting perhaps c. 600,000 years ago), although there may be some overlap with later Daka Member sites and earlier Herto Member sites. (Table by Kathy Schick)

The Middle Awash Acheulean

Overall Chronology

Taken as a whole, the Middle Awash deposits record some critical parts of a long sequence of Acheulean occupation in the Ethiopian Rift during Early and Middle Pleistocene times. Although the very earliest Acheulean has not yet been discovered here, the Middle Awash evidence provides important information on occupation in later Early Pleistocene and Middle Pleistocene times.

The Acheulean sequence here is actually composed of three parts, with some time gaps intervening between different portions of the record (Table 1.3). The earlier Acheulean record is best represented by the sites in the Daka Member of the Bouri Formation, starting sometime around 1 million years ago and extending into the later Early Pleistocene or, perhaps, the early Middle Pleistocene (Tables 1.1 and 1.3). The archaeological record picks up again on the eastern side of the Awash River, with Middle Acheulean sites appearing within Middle Pleistocene deposits of the Dawaitoli Formation, starting before 0.64 Ma and extending into the Middle Pleistocene (Tables 1.1 and 1.3). The Herto Formation of the Bouri Formation in the western deposits presents a record of later Acheulean times, with technologically and typologically advanced bifaces present, and occurrences containing simple Mode 1 flakes and fragments associated with hippopotamus carcasses. The latest Acheulean may be represented on the eastern side by MAK-A2 and on the western side by later sites in the Herto Member that remain to be investigated.

Mode 1 v. Mode 2 Technologies

These occurrences show well the contemporaneity of both Mode 1 (Oldowan) and Mode 2 (Acheulean) tradition during the Acheulean period. Although Mode 2 Acheulean artifacts dominate most of the Bouri Formation sites investigated on the western side of the Middle Awash study area, Mode 1 assemblages are also present throughout the Daka and Herto Members. On the eastern side of the Middle Awash study area, only Mode 1 (Oldowan) artifacts are found in the lower units of the Dawaitoli Formation, associated with floodplain sands, silts, and clays. Where Mode 2 bifaces are prominent in the upper units, associated with channel sand deposits, strictly Mode 1 assemblages are found at some sites. Sites containing numbers of Mode 2 handaxes and cleavers always contain quantities of Mode 1 cores and flakes, as found in virtually all Acheulean occurrences.

Because Mode 1 assemblages are found alongside Acheulean biface sites throughout most of the Middle Awash record, it would appear that ecological change is not likely to provide the whole answer to the differentiation between Mode 1 and Mode 2 assemblages in the Acheulean record here. We have suggested that the interaction of these two technological Modes may depend partly on the composition of the hominid group that made the tools. Age, sex, technological skills, and necessities and opportunities of the occasion are all possible interacting factors, although not easily identified in the prehistoric record.

The fact that the Mode 1 occurrences are all relatively low density and relatively restricted in area may suggest relatively brief activities by an individual or a small group in transit. That smaller, probably local raw materials are more often used indicates perhaps that the artifacts are all made from material ready to hand. The small flake and core sizes could even be an indication of manufacture by elderly, females, or juveniles, but this need not necessarily be so. Taking these factors into consideration, it might be suggested the Mode 1 assemblages in both floodplains and tributary channels/deltaic contexts are the lithic component of a hominid group

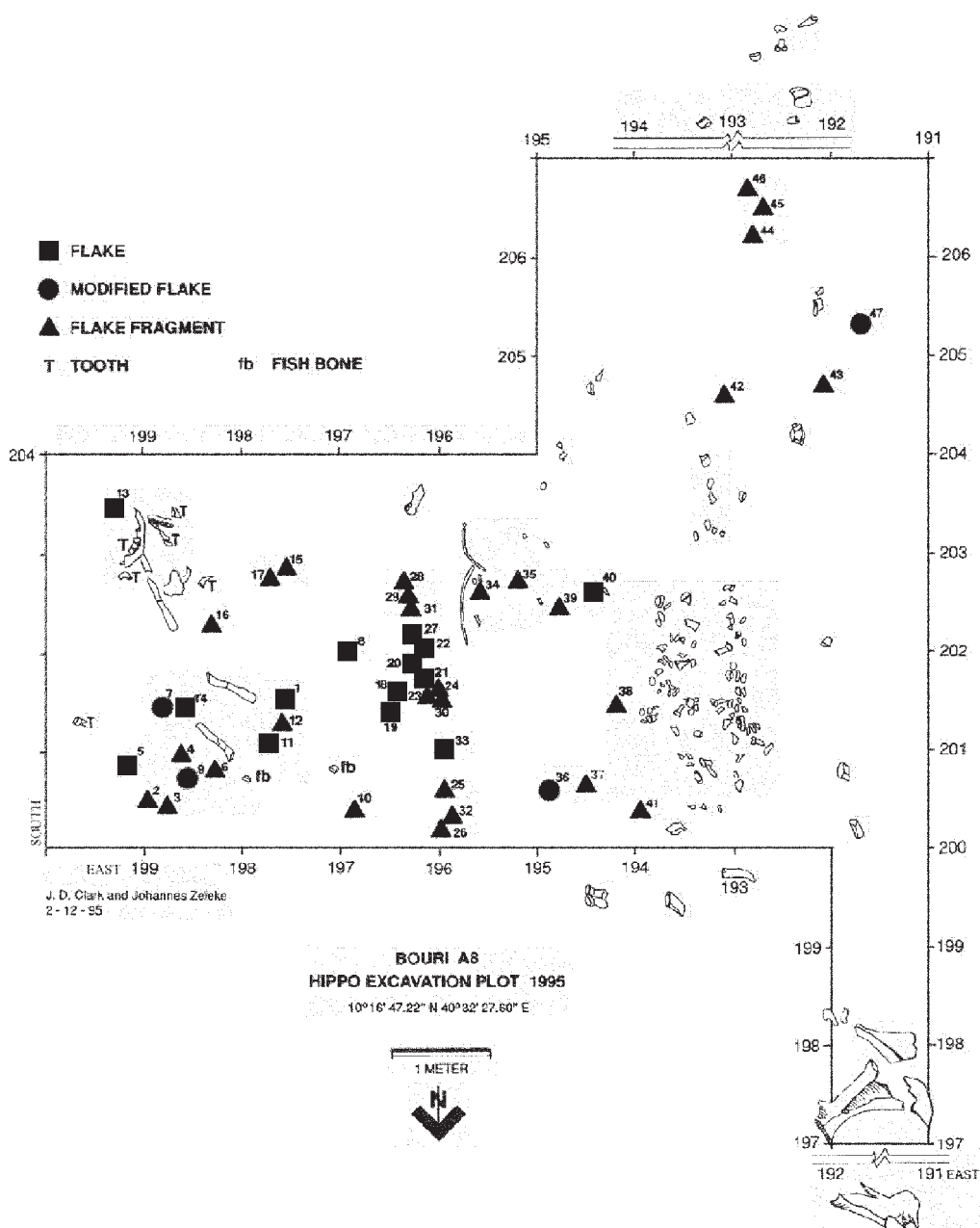


Figure 1.20 BOU-A8: Plot of surface and excavated artifacts and bones. (Drawing after a plot by J. D. Clark and Yohannes Zeleke)

when dealing opportunistically with a source of animal protein found in the course of foraging for food.

The occurrences with many Mode 2 bifaces, entailing acquisition of large flakes and sometimes giant cores from distant sources, could perhaps be an indication of greater male input to those sites, perhaps entailing regular traverses to and from raw material sources and a relatively high level of energy output overall involved in site formation. If not due to fluvial redistribution (Schick 1992), relatively large numbers of bifaces at a single locality may indicate revisitation of a preferred activity area by numbers of hominids or a hominid group.

Artifact Associations with Large Animal Carcasses

An interesting, recurrent pattern among many of the Middle Awash sites is the number of sites with large animal carcasses, especially hippopotamus, found in association with artifacts; in particular, this is found in the Herto Member of the Bouri Formation (Figure 1.20) and in the Dawaitoli Formation (Figure 1.21). As bifaces have been found by experiment to be very efficient in the butchery of large animals, the numbers of such occurrences strongly suggest that hominids were successfully processing carcasses of these large animals, whether obtained through hunting or scavenging. Hippopotami would have provided both meat and fat in quantity, and evidence of repeated acquisition of such resources by Acheulean hominids is strongly suggested by the Middle Awash patterns.

Processing hippo or other large game would have required that bifaces be resharpened. This is clearly seen in at least two of the hippo-related sites. Processing a hippo carcass must have taken half a day or more by a number of individuals using flakes and bifaces, and biface trimming flakes demonstrate this. Indeed, the reduced, almost diminutive, size of some handaxes in Herto Member sites may also be the outcome of continued use and resharpening.

The association at some of these sites of full-sized bifaces with the small flake and core component may be an indication of site reuse or of new individuals joining the group, but in every case the flake component always indicates the later stages of the reduction (Flake Types 4 to 6) (Toth 1985), suggesting the cores were reduced initially at another locale where the cortical flakes were left behind. An exception is the instance of a largely refitted cobble core from one hippo butchery site, in which case the core must have been carried in.

Visits to the modern shoreline of Yardi Lake on the southern side of the Bouri Peninsula showed remarkable comparability with the sediments and beach lines of shells in the Daka and Herto Formations. The present-day shoreline shows a reasonable number of whole and fragmentary shells of the same genera as found at the archaeological sites. Interestingly, a thick mat of root stems of *Phragmites* and other reeds 2 or 3 meters back from the shoreline also matched very closely the configuration of carbonate structures at one Daka Formation beach site, BOU-A1. Hippopotami still live in the Awash River and in Yardi Lake. From time to time, the death of these animals becomes a focus for butchering activity by the local Afar, leaving their carcass parts strewn on or near the lakeshore.

Raw Materials

When the Middle Awash Acheulean assemblages are compared with those from other Ethiopian sites, such as those at Gadeb, Melka Kunture, Arba, and Langano (Chavaillon 1979), each shows differences due most likely to the raw materials used. At Gadeb (Clark

1987; Clark and Kurashina 1974), use of lava cobbles resulted in the production of both biface and uniface forms. When ignimbrite was used, elongate and elongate ovates predominated. The latter type also predominated in refined form at Kalambo Falls (Clark and Kleindienst 1974). At Arba at the south end of the Afar Rift, flake bifaces were made from basalt lava and a fine, greenish rhyolite from outcrops in an adjacent valley with large quantities of flaking waste. This Arba assemblage (analyzed by Clark and Kurashina, unpublished) typologically belongs with the Herto Member artifacts, and contains bifaces in various stages of reduction from large quarry flakes and, significantly, several proto-Levallois cores, cleavers, cleaver flakes, bifacial handaxes, and unifacial handaxes.

A wide range of lavas was used for production of Middle Awash bifaces, with a great deal of variation seen among them in terms of color, phenocrysts, inclusions, cortex, and grain size of the ground mass. At any one Acheulean site here, however, raw materials tend to be fairly uniform, with most bifaces made from only one or two types of lava. Sources for these lavas are not found in the vicinity of the sites, indicating procurement at a distance of the raw materials for bifaces. It is most interesting that transport of manufactured bifaces to a site did not entail the mixing of many different and disparate rock sources, but rather a translocation of materials from a very limited set of distant sources. This might be an indication that these Acheulean sites may represent one or more visits by the same hominid group, as they might be expected to have introduced a more heterogeneous set of raw materials to a site if different groups were involved and coming from diverse localities. Two Middle Stone Age sites observed in the Middle Awash, in which more extensive use of exotic raw materials indicates either more extensive traversing of the landscape, multiple uses of a site by one or more groups coming from diverse areas, or the development of some kind of system of exchange, demonstrate this latter pattern.

There is some evidence for selection of better quality raw materials for bifaces over time. Raw material selection for Mode 1 cores and flakes appears to be more opportunistic, with use of a wider range of materials, presumably from more proximate sources.

Technological Patterns

The Middle Awash Acheulean sequence can be seen as representing general trends in the refinement of lithic technologies in the continent, also indicated at some other sites, such as Olduvai Gorge (Leakey 1971, 1994) and the Baringo Basin, and helps provide a framework against which other, more isolated sites might be compared. If we look at typology and chronostratigraphy, the earliest recognizable Acheulean in the study area is that in the Daka Member of the Bouri Formation on the western side of the Awash River. With its rough, but vigorous, hard-hammer technology and emphasis on the pointed handaxe forms, this area is very different from the Middle Acheulean in the Dawaitoli Formation on the eastern side of the river, and the Later Acheulean of the Herto Member on the western side.

Whereas the earlier assemblages are typified by hard-hammer flaking, less refined and symmetrical forms, and rare retouched pieces, the later assemblages show more refined, symmetrical (and often smaller) bifaces, soft-hammer flaking, and more common retouched pieces. Although the (earlier) Daka Member Acheulean bifaces and the (later) Dawaitoli Formation bifaces were usually made on large flakes, the Daka Member artifacts are often made on thick, cortical flakes struck from cobbles, whereas the Dawaitoli Formation sites show the use of flatter, often non-cortical, and commonly side-struck

flakes. Both, however, emphasize the importance of large side-struck flakes for the production of cleavers. The Herto Member sites exhibit the greatest biface refinement, with sometimes very well made, symmetrical, and sometimes quite diminutive handaxes present, often made by the soft-hammer technique.

Raw material necessarily affects technological features of a biface assemblage, both by nature of its texture and the form in which it occurs. Most bifaces in the Middle Awash were manufactured on large lava flakes. Finer grained lavas appear to have allowed retention of a cleaver form or completion of a fully worked handaxe form; however, where cobbles were available and used, as at DAW-A9, handaxes commonly retain unworked cortex butts.

Percentages of handaxes and cleavers at Mode 2 sites are variable, and both are more generally made on large flakes. The Kombewa technique, usually very uncommon, is seen in the early Acheulean of the Daka Member. In the Middle Acheulean of the Dawatoli Formation on the eastern side, double-bulbed Kombewa flakes are seen more regularly, although still in low frequencies. It is not always possible to be certain if the Kombewa method has been used; secondary retouch has often obscured the primary flake face, so the method may be more common than it appears to be.

The proto-Levallois method does not appear to have been used in the Middle Awash during most of the Acheulean sequence here. (Though, as we have noted, it appears in the late Acheulean Herto Member sites and is likely to be a common technological feature by the end of the Middle Pleistocene when Acheulean bifaces tend to disappear in favor of the greater range of retouched flakes from prepared cores seen in the MSA).

Throughout the full time range of the Acheulean, biface plan forms generally vary from site to site; however, within sites one or another form will often recur or predominate. In the Acheulean of the Middle Awash, some sites exhibit remarkable uniformity among many of the bifaces present in terms of typological, morphological, and technological characteristics (i.e., with rules apparently governing both the technological process and the product). This uniformity is at times so profound as to indicate possible adherence to rather rigid rules of technological procedures by the hominids responsible.

Conclusion

Some of the notable features of the Acheulean archaeology of the Middle Awash would include the following:

- A substantial Acheulean sequence, with the record of the evolving Acheulean Industrial Complex in the Early and Middle Pleistocene from the Middle Awash study area providing the longest and most complete sequence from any African region
- Co-occurrence of Mode 1- and Mode 2-dominated assemblages throughout this sequence, possibly indicative of Acheulean activity variation
- Repeated association of artifacts with large animal, particularly hippopotamus, carcasses, strongly suggesting processing of these carcasses with stone tool-kits
- Often remarkably strong intra-assemblage uniformity in stylistic and technological conventions of biface manufacture, suggesting the operation of strong rules or conventions in technological operations

Acheulean sites in the Middle Awash provide important evidence regarding hominid technologies and behaviors during a long and important phase of human evolution. The evolving Acheulean technology is well documented, supported by radiometric dating, and found with a very rich mammalian fauna and associated hominids. The Acheulean record here preserves evidence of hominid occupation within a long span of time in the Early and Middle Pleistocene, and thus provides important evidence of adaptive and technological patterns during this important phase of hominid evolution.

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References

- Asfaw, B., T. Assebework, Y. Beyene, J. D. Clark, G. Curtis, J. de Heinzelin, Y. Haile-Selassie, P. Renne, K. Schick, T. Suwa, E. Vrba, T. D. White, G. WoldeGabriel, and Y. Zeleke
1997 Fossil Hominids, Fauna and Artifacts from Bouri, Middle Awash, Ethiopia.
American Journal of Physical Anthropology Supplement 24:69.
- Chavaillon, J.
1979 Un Site Acheuléen près du Lac Langano (Éthiopie). *Extrait de la Revue Abbey*
N. 10. Paris: Centre Nationale de la Recherche Scientifique (CNRS).
- Clark, G.
1961 *World Prehistory: In New Perspective*. Cambridge: Cambridge University Press.
- Clark, J. D.
1987 Transitions: *Homo Erectus* and the Acheulian: The Ethiopian Sites of Gadeb and the Middle Awash. *Journal of Human Evolution* 16:809-26.

Clark, J. D., and M. R. Kleindienst

- 1974 The Stone Age Cultural Sequence: Terminology, Typology and Raw Material. In *Kalambo Falls Prehistoric Site II: The Later Prehistoric Cultures*. J. D. Clark, ed. Pp. 71–106. Cambridge: Cambridge University Press.

Clark, J. D., and H. Kurashina

- 1979 An Analysis of Earlier Stone Age Bifaces from Gadeb (Locality 8E), Northern Bale Highlands, Ethiopia. *South African Archaeological Bulletin* 34:93–109.

Clark, J. D., B. Asfaw, G. Assefa, J. W. K. Harris, H. Kurashina, R. C. Walter, T. D. White, and M. A. J. Williams

- 1983 Paleoanthropological Discoveries in the Middle Awash Valley, Ethiopia. *Nature* 307:423–28.

Clark, J. D., B. Asfaw, R. Blumenschine, J. W. K. Harris, H. Kurashina, C. Sussman, and M. Williams

- 1993 Archaeological Studies in the Middle Awash, Ethiopia: The 1981 Field Season. Pp. 135–45. *Proceedings of the 9th Congress of the Pan-African Association of Pre-history and Related Studies*. Ibadan, Nigeria: Rex Charles Publications.

Clark, J. D., J. de Heinzelin, K. Schick, W. Hart, T. D. White, G. WoldeGabriel, R. C. Walter, G. Suwa, B. Asfaw, E. Vrba, and Y. Haile-Selassie

- 1994 African *Homo Erectus*: Old Radiometric Ages and Young Oldowan Assemblages in the Middle Awash Valley, Ethiopia. *Science* 264:1907–10.

Conroy, G. C., C. J. Jolly, D. Cramer, and J. E. Kalb

- 1978 Newly Discovered Fossil Hominid Skull from the Afar Depression, Ethiopia. *Nature* 275:67–70.

de Heinzelin, J., J. D. Clark, T. White, W. Hart, P. Renne, G. WoldeGabriel, Y. Beyene, and E. Vrba

- 1999 Environment and Behavior of 2.5-million-year-old Bouri Hominids. *Science* 284:625–29.

de Heinzelin, J., J. D. Clark, K. D. Schick, and W. H. Gilbert, eds.

- 2000 The Acheulean and the Plio-Pleistocene Deposits of the Middle Awash Valley, Ethiopia. *Annales—Science Geologiques* 104. Tervuren: Musee Royal de l'Afrique Centrale.

Kalb, J. E.

- 1978 Miocene to Pleistocene Deposits in the Afar Depression, Ethiopia. *Sinet (Ethiopian Journal of Science)* 1:87–98.

- Kalb, J. E., C. B. Wood, C. Smart, E. B. Oswald, A. Mebrate, S. Tebedge, and P. F. Whitehead
1980 Preliminary Geology and Paleontology of the Bodo D'Ar Hominid Site, Afar, Ethiopia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 30:107-20.
- Kalb, J. E., C. J. Jolly, A. Mebrate, S. Tebedge, C. Smart, E. B. Oswald, D. Cramer, P. F. Whitehead, C. B. Wood, G. C. Conroy, T. Adefris, L. Sperling, and B. Kana
1982a Fossil Mammals and Artifacts from the Middle Awash Valley, Ethiopia. *Nature* 298:25-29.
- Kalb, J. E., E. B. Oswald, S. Tebedge, A. Mebrate, E. Tola, and D. Peak
1982b Geology and Stratigraphy of Neogene Deposits, Middle Awash Valley, Ethiopia. *Nature* 298:17-25.
- Kalb, J. E., M. Jaegar, C. J. Jolly, and B. Kana
1982c Preliminary Geology, Paleontology and Paleoecology of a Sangoan Site at Andalee, Middle Awash Valley, Ethiopia. *Journal of Archaeological Science* 9:349-63.
- Kalb, J. E., E. B. Oswald, A. Mebrate, S. Tebedge, and C. Jolly
1982d Stratigraphy of the Awash Group, Middle Awash Valley, Afar, Ethiopia. *Newsletter on Stratigraphy* 11:95-127.
- Kalb, J. E., C. J. Jolly, S. Tebedge, A. Mebrate, C. Smart, E. B. Oswald, P. F. Whitehead, C. Wood, T. Adefris, and V. Rawn-Schatzinger
1982e Vertebrate Faunas from the Awash Group, Middle Awash Valley, Afar, Ethiopia. *Journal of Vertebrate Paleontology* 2:237-58.
- Leakey, M. D.
1971 *Olduvai Gorge: Excavations in Beds I and II, 1960-1963*. Cambridge: Cambridge University Press.
- Leakey, M. D., and D. Roe
1994 *Olduvai Gorge: Excavations in Beds III, IV, and the Masek Beds, 1968-1971*. Cambridge: Cambridge University Press.
- Schick, K. D.
1992 Geoarchaeological Analysis of an Acheulean Site at Kalambo Falls, Zambia. *Geoarchaeology* 7:1-26.
- Taieb, M.
1974 Évolution Quaternaire du Bassin de l'Awash. Ph.D. dissertation, University of Paris VI.

Toth, N.

- 1985 The Oldowan Reassessed: A Close Look at Early Stone Artifacts. *Journal of Archaeological Science* 12:101–20.

White, T. D.

- 1984 Pliocene Hominids from the Middle Awash, Ethiopia. *Courier Forschungsinstitut Senckenberg* 69:57–68.
- 1985 Acheulian Man in Ethiopia's Middle Awash Valley: The Implications of Cutmarks on the Bodo Cranium. *Kroon Memorial Lecture, 1985*. Albert Egges van Giffen Instituut voor Prae-en Protohistorie van de Universiteit van Amsterdam. Haarlem, The Netherlands: Enschede en Zonen.
- 1986 Cutmarks on the Bodo Cranium: A Case of Prehistoric Defleshing. *American Journal of Physical Anthropology* 69:503–09.



2

ACHEULEAN BIFACES AND EARLY HUMAN BEHAVIORAL PATTERNS IN EAST AFRICA AND SOUTH INDIA

Michael P. Noll and Michael D. Petraglia

The Acheulean Industrial Complex has conventionally been defined by the presence of characteristic tool types—cleavers and handaxes. Acheulean sites occur over a considerable time depth and are distributed across a large geographic area of the Old World. The statistical similarity of Acheulean bifaces between assemblages has been attributed to various factors, including: cultural conventions, tool function, raw material restrictions, and reduction intensity. This study used primary data to systematically compare Acheulean assemblages from Olorgesailie, Kenya and the Hunsgi-Baichbal Valleys, India. The intent was to explore general characteristics of biface morphology and hominid raw material exploitation patterns. Bifaces from both regions overlap in size and shape attributes. Results indicate that stone-knappers in both regions targeted specific raw material outcrops for biface manufacture, leading to some variations in biface parameters. While certain assemblages showed evidence for rejuvenation, the level of curation, transport, and reduction of bifaces appears negligible. Our general conclusion is that the Olorgesailie and Hunsgi-Baichbal lithic assemblages display similarities with respect to hominid raw material exploitation patterns, biface manufacturing strategies, and landscape transport behaviors.

The transition from archaic to modern human life-ways is a prominent topic in Paleolithic archaeology. Paleoanthropologists once considered the lifeways of Acheulean hominids to be similar to modern hunter-gatherers (Deacon 1970; Howell and Clark 1963); however, subsequent research demonstrated that Acheulean lithic assemblage variation had no modern behavioral analogs (Binford 1977, 1987; Isaac 1972a, b, 1977). The degree to which early hominids behaved like modern humans is typically investigated by analysis of archaeological faunas and land-use patterns (e.g., Blumenschine 1986; Blumenschine and Cavallo 1992; Bunn and Kroll 1986; Monahan 1996; Potts 1983, 1987, 1988; Rose and Marshall 1996). Despite the abundance of Acheulean lithic assemblages, there have been few advances in our understanding of Middle Pleistocene hominid behaviors on the basis of such materials. Additional research using available lithic assemblages is therefore necessary to enhance our understanding of Acheulean hominid behavior.

The Acheulean Industrial Complex is found first in Africa, and later in western Asia, Europe, and the Indian subcontinent. The Acheulean appeared in East Africa about 1.5 million years ago and continued until approximately 0.3 million years ago, and is associ-

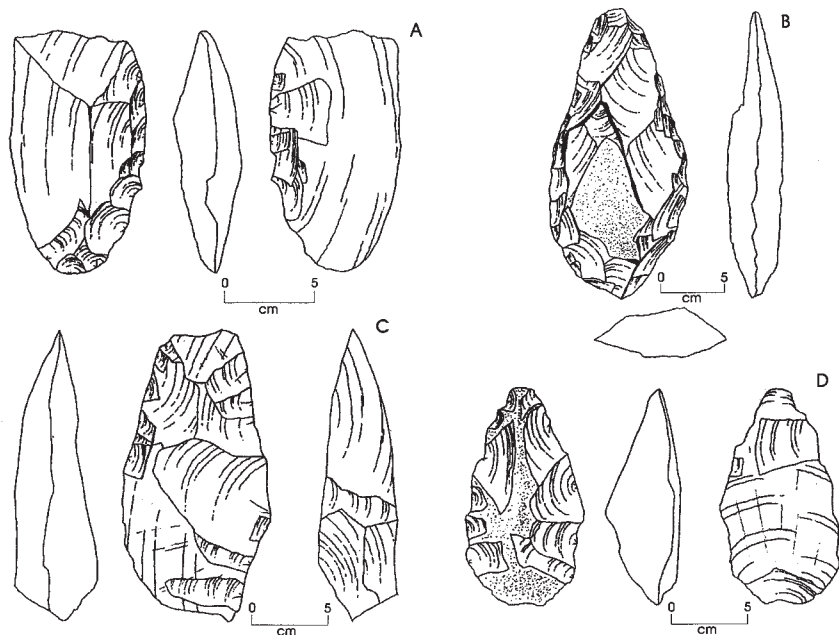


Figure 2.1 Examples of Acheulean bifaces: A. cleaver; B. handaxe, C. knife D. pick.

ated with the genus *Homo* (Asfaw et al. 1992; Manega 1993; Petraglia and Korisettar 1998; Tallon 1978; Tchernov 1992). The Acheulean has been defined conventionally by the presence of handaxes, which are teardrop shaped in outline, biconvex in cross-section, and commonly manufactured on large (more than 10 cm) unifacially or bifacially flaked cobbles, flakes, and slabs (Isaac 1969; Kleindienst 1961, 1962; Leakey 1971, 1975). Acheulean assemblages may also include tools known as cleavers, knives, and picks, which are similar in size to handaxes but differ in aspects of shape and edge attributes. Handaxes, cleavers, knives, and picks are collectively termed bifaces (Figure 2.1). Acheulean bifaces, which possess plan view and cross-sectional symmetry, represent a technological innovation over earlier nonsymmetrical Oldowan stone tools (Gowlett 1986).

Acheulean bifaces are standardized in morphology over a considerable time depth and geographic range, leading archaeologists to discuss conservative trends in stone tool conventions as products of learned behavior (Clark 1994; Gowlett and Crompton 1994; Roe 1964; 1968; Schick 1994). Although bifaces are standardized at a general level, assemblages often have unexplained regional and temporal differences in size, shape, and refinement (Isaac 1968, 1972a, b, 1977; Wynn and Tierson 1990). Studies have indicated that biface variability results from multiple factors including tool function, resharpening, and raw material properties (Ashton and McNabb 1994; Jones 1979, 1981, 1994; McPherron 2000; Noll 2000; White 1995, 1998).

Reconstruction of early hominid ranging patterns is based on distances between sources of lithic raw material and sites in which stone tools are found (site-to-source distance) (Blumenschine and Masao 1991; Bunn 1994; Hay 1976; Potts 1988; Rogers et al. 1994). Oldowan hominids were dependent on locally available raw materials. For example, site-to-source distances at Olduvai were usually less than 10 km (Hay 1976). In the



Figure 2.2 Old World Map with Olorgesailie and Hunsgi-Baichbal Valleys identified.

Acheulean, hominids transported raw materials greater distances than earlier Oldowan hominids. In the Early Acheulean at Olduvai, maximum site-to-source distances increased to 10 to 20 km, and a small proportion came from sources outside of the paleo-basin (Hay 1976). Acheulean hominid transport distances could be greater than 20 km, but few examples have been identified (Clark and Kurishina 1979).

The aim of the present study was to explore the relationship between Acheulean technologies and human behavior by comparing behavioral patterns associated with two geographically separated Acheulean contexts. Assemblages from Olorgesailie in East Africa and the Hunsgi-Baichbal Valleys in South India were selected for comparison (Figure 2.2) based on the availability of documented proveniences from scientifically controlled excavations at both sites (Isaac 1977; Paddayya 1982a). In the first part of the study, an analysis of biface size and morphology was carried out on both assemblages in order to determine the degree of similarity between the Acheulean tools in the two regions. Subsequently, evidence for patterns of raw material selection, biface morphology and lithic transport and discard behaviors was examined in order to compare behavioural attributes in the two geographical contexts. The findings of these analyses will be addressed below, after a brief introduction of the geological and archaeological context of the Olorgesailie Basin and the Hunsgi-Baichbal Valleys.

Geological and Archaeological Context of Sites

Olorgesailie

Olorgesailie is a Pleistocene sedimentary basin located in the southern Kenya Rift Valley at an elevation of approximately 940 to 1040 meters (1°35'S 36°27'E) (Isaac 1977; Leakey 1952). Basin history has involved intermittent local faulting, volcanism, and sedimentation associated with the development of the Gregory Rift Valley, and the creation of a series of lakes with oscillating water levels. The Olorgesailie Formation comprises a long sequence of terrestrial, volcanic tephra, and fluvio-lacustrine beds in a paleo-basin that formed when tectonics and/or lava flows blocked south-flowing streams (Isaac 1977;

Shackleton 1978). The chronostratigraphic framework for the formation spans a time period between approximately 0.49 to 0.99 million years ago (Deino and Potts 1990). Member 1, the basal unit of the Olorgesailie Formation, dates to 0.99 million years ago, using the $^{40}\text{Ar}/^{39}\text{Ar}$ dating technique. Member 6/7, which comprises a single stratigraphic unit, is rich in artifact occurrences and has an age of 0.75 to 0.97 million years ago (Potts et al. 1999). Excavations at Olorgesailie have focused on specific research questions related to hominid behavior. Systematic excavations of paleolandscapes in Members 1 and 6/7, and detailed work on the artifacts, fauna, and paleo-environments of the Olorgesailie Formation, have been conducted from 1985 to the present (Potts 1989, 1994; Potts et al. 1999). The current study uses four lithic assemblages: Isaac Site 3 (I3) in Member 1, and DE89B, H9A, and Mid, in Member 6/7 (Figure 2.3). These four assemblages were chosen for comparison because they are representative of biface size and shape diversity at Olorgesailie (Noll 2000).

Olorgesailie stone-knappers had to leave the basin floor to acquire suitable raw material for stone artifact production from in situ outcrops, especially for biface manufacture. Site-to-source distances are 0.1 to 7.5 km from excavated sites to raw material (Noll 2000). Raw material acquisition was focused on the Mt. Olorgesailie highlands with subsequent lithic transport into the basin. Several different types of raw material were used. Outcrop clast shapes differ for each raw material source. Basalt occurs as angular spalls and sub-rounded boulders; nephelinite occurs as angular blocks; phonolite and trachybasalt occur as boulders; phonolitic trachyte as tabular slabs; and trachyte as large tabular slabs.

The Olorgesailie volcanics (2.7 to 2.2 million years ago), partially buried by younger lava flows, were the principal lavas used in artifact manufacture within the region (Baker 1958; Baker et al. 1972; Fairhead et al. 1972). Mt. Olorgesailie raw material types include basalt (Ob), phonolite (Oph), and trachyte (Otp), all of which outcrop in the foothills and slopes of Mt. Olorgesailie (Shackleton 1978). Ol Keju Nyiro basalt (Kb), an olivine basalt, dates to 1.8 to 1.6 million years ago. These basalts crop out in the Ol Keju Nyiro River at the northern foot of Mt. Olorgesailie (Baker 1958). Flood lavas of quartz trachyte composition cover the central floor of the southern rift valley, including the Olorgesailie region (Baker 1958). The lavas are locally known as the Magadi trachytes (Mtr), dating to 1.25 to 0.66 million years ago (Baker et al. 1972). Magadi trachytes occur as small kopjes and larger ridges within the Olorgesailie Formation (i.e., Lava Peninsula and Lava Hump) and as ridges and escarpments on the western and eastern margins of the basin. Porphyritic rock (Pp) outcrops occur within the foothills and on the slopes of Mt. Olorgesailie, whereas tabular trachyte (Tt) occurs approximately 5 km southeast of the Main Site compound on lava flows and at several kopjes on the southern margin of Oltepesi Plain.

Hunsgi-Baichbal Valleys

The Hunsgi and Baichbal Valleys are located in the Gulbarga District of Karnataka, south-central India ($16^{\circ}30'N$ $76^{\circ}33'E$) (Paddayya 1982a). The 500 km² area represents a Tertiary basin, at an elevation of approximately 400 to 580 m. Shallow, but perennial, water bodies occur in the area due to the seep springs emanating from the junction of shales and limestones. The occurrence of thick and extensive travertine deposits indicates seep spring activity. Samples of travertine and teeth date the sites to the Middle to

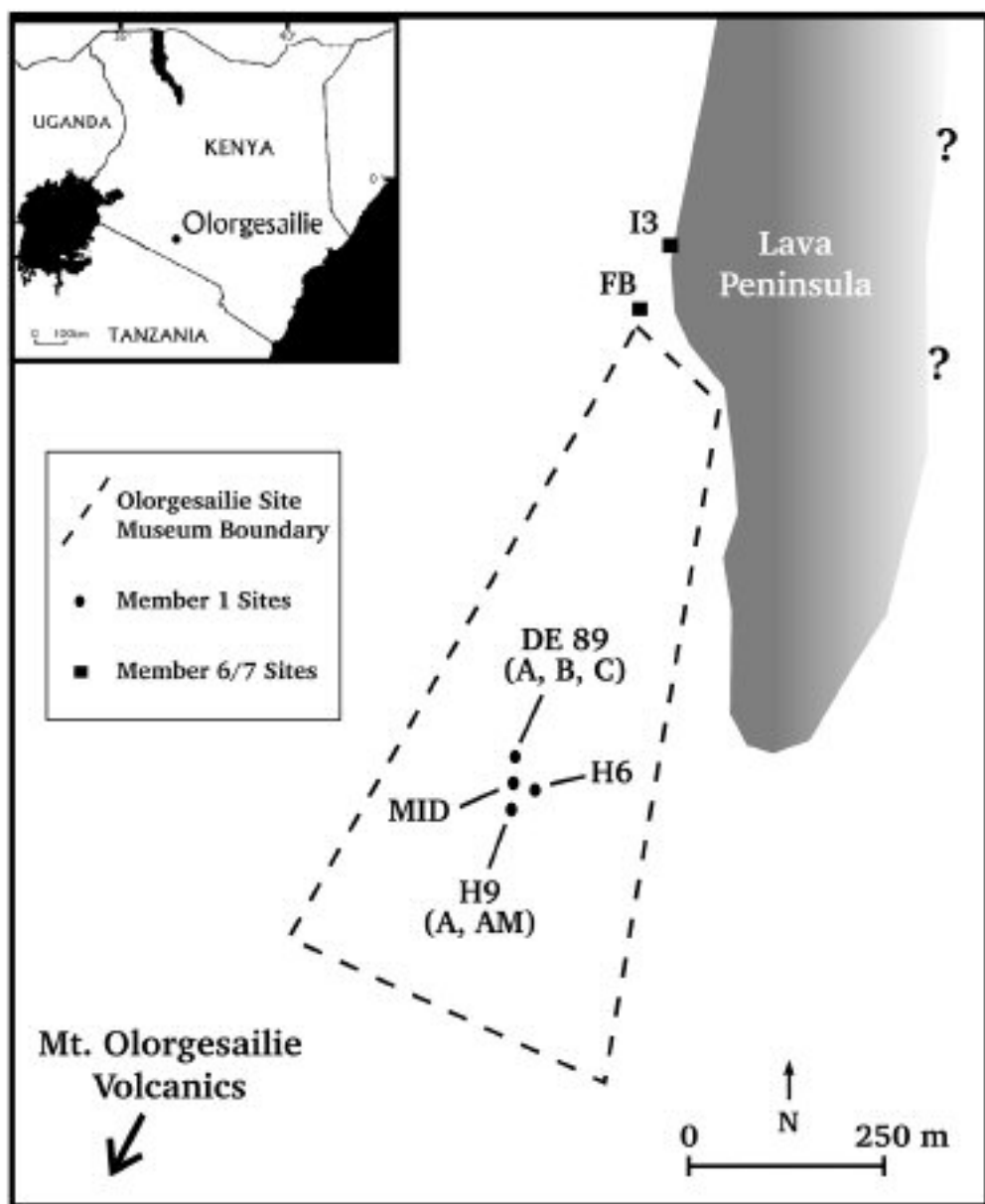


Figure 2.3 Site map of Olorgesailie region.

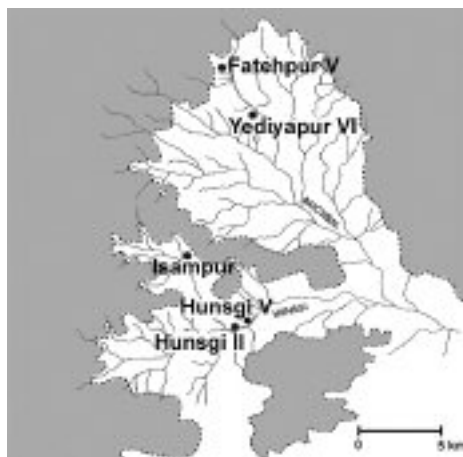


Figure 2.4 Site map of Hunsgi and Baichbal Valleys.

Late Pleistocene, from more than 350,000 years to 166,000 years ago (Szabo et al. 1990). The early dates represent the reliable utility of the $^{230}\text{Th}/^{234}\text{U}$ technique thereby indicating an older age. The youngest dates represent the last phase of drying of ponded environments and the terminus of Acheulean occupation. Preliminary ESR dates at Isampur place the site to about 1 million years ago (Blackwell et al. 2001). The Hunsgi Valley and the Baichbal Valley are separated by a narrow remnant of a shale-limestone plateau. The valleys are composed of geological rock groups (3,300 to 65 million years), the units of which show variable structure and outcropping between the basins (Jhaldiyal 1997; Radhakrishna and Vaidyanathan 1994).

Archaeological investigations have been carried out in the Hunsgi and Baichbal Valleys through surface survey and excavations, revealing the presence of more than 200 Acheulean occurrences and site complexes (Paddayya 1982a, 1982b, 1989). The recovery of abundant Acheulean occurrences is consistent with finds in other parts of the Indian subcontinent (Misra 1987; Petraglia 1998, 2001). Site formation research in the Hunsgi-Baichbal Valleys has demonstrated variability in preservation contexts. These studies have indicated that a number of Acheulean sites are in their original depositional contexts (Jhaldiyal 1997; Paddayya and Petraglia 1993; Petraglia et al. 1999). The current study uses five of these non-transported lithic assemblages: three in the Hunsgi Valley (Hunsgi II; Hunsgi V; Isampur) and two in the Baichbal Valley (Fatehpur V; Yediyapur VI) (Figure 2.4).

Bifaces in the Hunsgi Valley are predominately made on limestone, whereas in the Baichbal Valley bifaces are made on limestone, granite, schist, and dolerite. In most cases, materials typically outcrop within a 2-km radius of sites. The raw material outcrops have different spatial patterns. Limestone and granite are ubiquitous and occur on the valley floors and plateaus. In contrast, schist is spatially confined in the Baichbal Valley and dolerites occur in restricted areas in the two valleys. Size and shape of clasts vary for each raw material type. Two forms of limestone occur in the Hunsgi Valley: the first occurs as a primary bed at Isampur, and the second as rounded slabs and cobbles in fluvial and colluvial contexts (i.e., Hunsgi II, Hunsgi V) (Jhaldiyal 1997; Paddayya and Petraglia 1993; Petraglia et al. 1999). The granite occurs as small hillocks that weather as round hummocky boulders and spalls. The schist bedrock weathers into blocks and spalls. Intrusive

and isolated dykes of dolerite weather as boulders. Hammerstones in the Hunsgi and Baichbal Valleys are typically made of basalt, chert, and quartzite. Basalt occurs as volcanic flows and weathers as boulders and cobbles, whereas chert and quartzite occur as cobbles and pebbles in conglomerates and gravel beds.

Biface Data Analysis

Olorgesailie Bifaces

Biface linear measurements (length, breadth, and thickness) differ significantly between Olorgesailie assemblages using ANOVA tests with Tukey pairwise comparisons (Table 2.1; Figure 2.5). The most consistent differences occur between the three Member 6/7 biface assemblages and I3 bifaces. The longest bifaces occur at Mid (176.6 ± 37.9 mm) and the shortest bifaces at I3 (100.6 ± 37.7 mm). An ANOVA test indicates that all Member 6/7 assemblages have significantly (longer bifaces than the I3 assemblage (all statistically significant differences are $p < 0.01$ unless otherwise noted). Breadth also varies with the largest mean biface tool breadth at DE89B (98.9 ± 16.0 mm) and the smallest mean biface breadth at I3 (63.7 ± 18.2 mm) (Table 2.1; Figure 2.5). ANOVA tests of breadth and thickness indicate that Member 6/7 assemblages have significantly broader and thicker bifaces than I3. Differences in linear measurements occur between Member 6/7 biface assemblages, but these differences are not as systematic as the differences between Member 6/7 bifaces and I3 bifaces. DE89B bifaces are significantly larger than H9A bifaces in length, breadth, and thickness measurements, and significantly larger than Mid bifaces in thickness, whereas H9A bifaces are significantly smaller than Mid bifaces in breadth.

Frequencies of biface raw material types were tabulated for Olorgesailie assemblages (Table 2.2). The most common raw material types are Mt. Olorgesailie phonolite, Ol Keju Nyiro basalt, tabular trachyte, and Mt. Olorgesailie basalt. Mt. Olorgesailie phonolite bifaces occur in all assemblages. DE89B (45.3%), and Mid (44.1%) have high frequencies of Mt. Olorgesailie phonolite bifaces, whereas I3 (20.9%), and H9A (3.3%) have lower frequencies. Ol Keju Nyiro basalt bifaces are most common in I3 (25.4%) and H9A (23.3%), whereas Mid (6.9%) has a low frequency of Ol Keju Nyiro basalt. H9A (33.3%) and Mid (17.9%) have high frequencies of tabular trachyte bifaces. I3 has a high frequency of Mt.

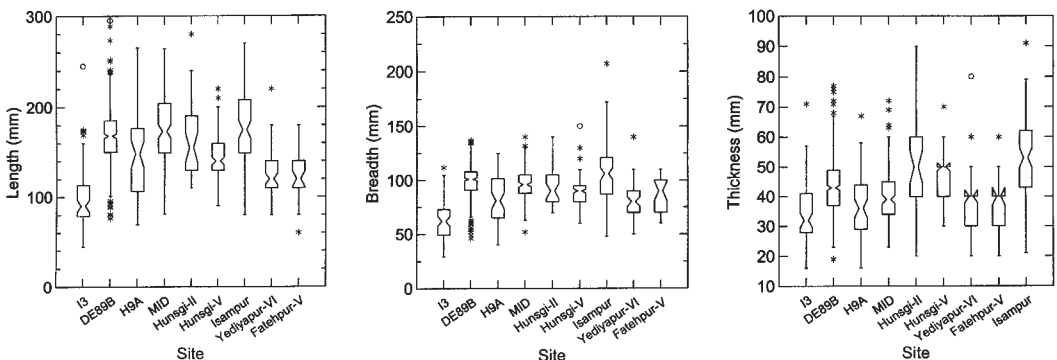


Figure 2.5 Boxplot of length, breadth, and thickness of Olorgesailie and Hunsgi-Baichbal Valley bifaces.

Table 2.1 Biface Linear Measurements by Locality and Site

Locality	Site (n)	Length (L)			Breadth (B)			Thickness (T)		
		Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Olorgesailie	I3 (67)	100.55	37.73	0.38	63.73	18.17	0.28	34.96	10.59	0.31
	DE89B (426)	168.37	33.17	0.20	98.89	16.00	0.16	43.72	9.54	0.23
	H9A (60)	146.78	49.04	0.34	82.90	21.58	0.27	37.18	11.41	0.30
	Mid (145)	176.64	37.91	0.22	96.77	14.30	0.14	40.15	8.92	0.23
	All Olorg. (697)	161.46	41.87	0.26	93.67	19.59	0.21	41.56	10.13	0.24
Hunsgi-Baichbal	Hunsgi-II (30)	162.50	41.27	0.25	96.56	18.77	0.19	50.00	13.44	0.27
	Hunsgi-V (143)	143.20	25.37	0.18	87.35	14.45	0.17	46.33	8.53	0.18
	Isampur (89)	175.22	44.13	0.25	106.54	28.46	0.27	52.70	14.00	0.27
	Fatehpur-V (27)	123.79	24.84	0.20	84.14	14.27	0.17	37.59	9.88	0.26
	Yediyapur-VI (52)	127.45	26.96	0.21	82.00	15.56	0.19	39.09	10.23	0.26
	All Hgi.-Bl.(352)	148.99	37.39	0.25	91.94	21.44	0.23	44.30	10.53	0.24
All bifaces (1049)		157.28	40.83	0.26	93.09	20.24	0.21	46.42	12.05	0.26

Table 2.2 Raw Material Number and Percentage (Olorgesailie)

Raw Mat. (abbrev.)	M 1	M 6/7			Total
	13	DE89B	H9A	Mid	
Mt. Olog basalt (Ob)	10 (14.9)	34 (8.0)	6 (10.0)	2 (1.4)	52
Mt. Olog phonolite (Oph)	14 (20.9)	193 (45.3)	2 (3.3)	64 (44.1)	273
Mt. Olog phonolitic trachyte (Otp)	2 (3.0)	7 (1.6)	5 (8.3)	13 (9.0)	27
OI Keju Nyiro basalt (Kb)	17 (25.4)	90 (21.1)	14 (23.3)	10 (6.9)	131
Magadi trachyte (Mtr)	0 (0.0)	6 (1.4)	3 (5.0)	2 (1.4)	11
Pyroxene porphyry (Pp)	3 (4.5)	24 (5.6)	2 (3.3)	2 (1.4)	31
Tabular trachyte (Tt)	8 (11.9)	14 (3.3)	20 (33.3)	26 (17.9)	68
Other	15 (16.4)	58 (13.6)	8 (13.4)	24 (16.6)	105

Olorgesailie basalt (14.9%) and Mid (1.4%) has a low frequency relative to the two other assemblages.

Few differences occur in linear measures when Olorgesailie bifaces are broken down by raw material (Table 2.3; Figure 2.6). Magadi trachyte (184.2 ± 48.7 mm) has the longest bifaces; Mt. Olorgesailie basalt (153.4 ± 49.3 mm) has the smallest length. Mean breadth varies between raw material types—Magadi trachyte bifaces (99.9 ± 16.1 mm) have the widest breadths, whereas Mt. Olorgesailie basalt bifaces (90.0 ± 26.3 mm) have the narrowest breadths. Biface thickness is the most variable of all the measurements and the only measure that has significant ($p < 0.05$) differences between raw materials. Pyroxene porphyry (47.7 ± 11.2 mm) and OI Keju Nyiro bifaces (46.3 ± 11.9 mm) are significantly thicker than all Mt. Olorgesailie raw materials, whereas tabular trachyte bifaces (36.5 ± 9.1 mm) are significantly thinner than all raw materials except Mt. Olorgesailie phonolitic trachyte.

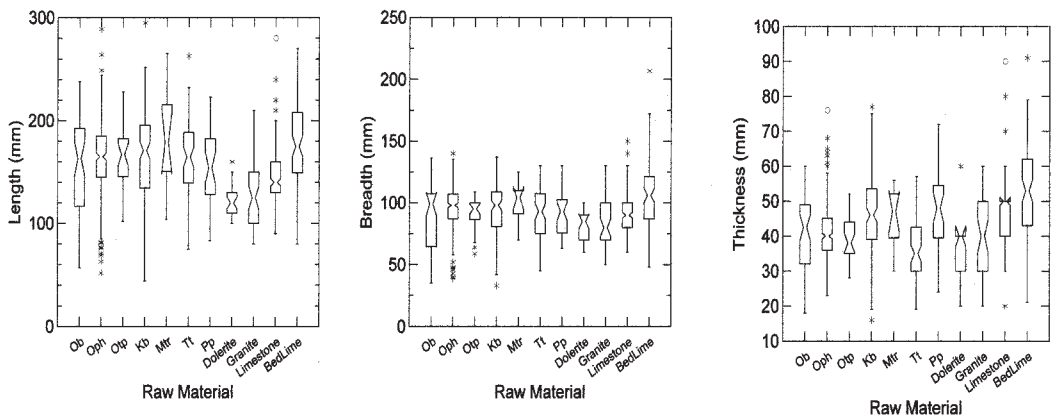


Figure 2.6 Boxplots of length, breadth, and thickness for raw materials at Olorgesailie and the Hunsgi and Baichbal Valleys.

Table 2.3 Biface Linear Measurements by Locality and Raw Material Type

Locality	Raw Material (n)	Length (L)			Breadth (B)			Thickness (T)		
		Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Olorgesalilie	Mt. Olorg basalt (Ob) (52)	153.35	49.29	0.32	90.02	26.30	0.29	41.04	10.69	0.26
	Mt. Olorg phonolite (Oph) (273)	164.66	36.48	0.22	96.21	17.17	0.18	41.00	8.43	0.21
	Mt. Olorg phonolitic trachyte (Otp) (27)	162.48	33.83	0.21	91.37	12.93	0.14	38.81	6.78	0.17
	Ol Keju Nyiro basalt (Kb) (131)	164.89	46.18	0.28	94.79	21.31	0.22	46.34	11.99	0.26
	Magadi trachyte (Mtr) (11)	184.18	48.73	0.26	99.91	16.07	0.16	45.36	7.83	0.17
	Tabular trachyte (Tt) (68)	162.44	42.86	0.26	91.49	20.29	0.22	36.47	9.12	0.25
	Pyroxene porphyry (Pp) (31)	154.90	39.01	0.25	92.48	18.32	0.20	47.74	11.21	0.23
	Others (116)	149.15	43.94	0.29	88.14	19.64	0.22	39.06	9.44	0.24
	Dolerite (28)	123.57	13.93	0.11	82.14	12.28	0.15	37.86	8.33	0.22
Hunggi-Baichbal	Granite (46)	128.91	30.86	0.24	83.04	16.04	0.19	38.91	9.71	0.25
	Limestone (177)	146.38	30.14	0.21	89.32	16.01	0.18	47.06	10.08	0.21
	Bedded Limestone (89)	175.22	44.13	0.25	106.54	28.46	0.27	52.70	14.00	0.27

The most obvious pattern in the Olorgesailie biface data is the systematic differences between I3 bifaces when compared with Member 6/7 bifaces. I3 bifaces are smaller in all linear measurements relative to Member 6/7 biface assemblages. Conversely, few significant differences in linear measurements were observed when Olorgesailie bifaces were broken down by raw material type. Raw material is not a significant component of biface linear measurement variability between I3 and Member 6/7 assemblages.

Hunsgi-Baichbal Bifaces

Biface linear measurements (length, breadth, and thickness) differ significantly between Hunsgi-Baichbal assemblages using ANOVA tests (Table 2.1; Figure 2.5). Hunsgi-Baichbal biface lengths vary considerably—with the longest bifaces at Isampur (175.2 ± 44.1 mm) and shortest bifaces at Fatehpur V (123.8 ± 24.8 mm). An ANOVA test indicated that Isampur bifaces are significantly longer than all other biface assemblages, except Hunsgi II. Hunsgi II bifaces are longer than Hunsgi V ($p = 0.02$), Fatehpur V, and Yediyapur VI. Hunsgi V bifaces are longer than Fatehpur V ($p = 0.03$) and Yediyapur VI ($p = 0.02$) bifaces. Fatehpur V and Yediyapur VI bifaces are significantly equivalent in length. An ANOVA test indicated that Isampur bifaces are significantly broader than all other biface assemblages, except Hunsgi II ($p = 0.09$). The only other significant difference in breadth ($p = 0.01$) occurs between the broader Hunsgi II bifaces relative to the narrower Yediyapur VI bifaces. Thickness differences are significant between the thinner Baichbal biface assemblages (Fatehpur V and Yediyapur VI) relative to the thicker Hunsgi biface assemblages (Hunsgi II, Hunsgi V, and Isampur). The only other significant difference in biface thickness occurs between the thinner Hunsgi V bifaces relative to Isampur bifaces.

Frequencies of biface raw material types were tabulated for the Hunsgi and Baichbal Valley assemblages (Table 2.4). The Hunsgi Valley biface assemblages are predominately made on limestone (97% to 100%). At Hunsgi II, a single biface is made on granite, which is found locally. In strong contrast to the Hunsgi Valley, no particular raw material dominates in the Baichbal Valley. Thus, sites vary in their individual composition, apparently reflecting general proximity to particular raw material sources. Raw materials used in Baichbal Valley biface assemblages commonly crop out within 1 to 2 km of sites and only in rare circumstances is longer distance transport indicated. For example, at Yediyapur VI granite occurs on-site, limestone is 2 km to the south-southwest, and dolerite is 5 km to the north.

Table 2.4 Raw Material Number and Percentage (Hunsgi and Baichal Valleys)

Raw Material	Hunsgi Valley			Baichbal Valley		Total
	Hunsgi-II	Hunsgi-V	Isampur	Fatehpur-V	Yediyapur-VI	
Dolerite	0 (0.0)	0 (0.0)	0 (0.0)	6 (22.2)	22 (42.3)	28
Granite	1 (3.3)	0 (0.0)	0 (0.0)	20 (74.17)	25 (48.1)	46
Bedded Limestone	0 (0.0)	0 (0.0)	89 (100.0)	0 (0.0)	0 (0.0)	89
Limestone	29 (96.7)	143 (100.0)	0 (0.0)	1 (3.7)	5 (9.6)	178

Mean length varies between Hunsgi-Baichbal raw material types. An ANOVA test indicated that significantly longer bifaces are made on bedded limestone (175.2 ± 44.1 mm) than any other Hunsgi-Baichbal material type, whereas the non-bedded limestone bifaces (146 ± 30.1 mm) are significantly shorter than the bedded limestones but longer than the dolerite (123.6 ± 13.9 mm) and granite (128.9 ± 30.9 mm) bifaces (Table 2.3, Figure 2.6). Granite and dolerite bifaces do not differ significantly in length. Mean breadth also varies between raw material types—bedded limestone bifaces (106.5 ± 28.5 mm) are significantly broader than the other raw materials, whereas the remaining raw materials have no significant differences in breadth. Bedded limestone bifaces (52.7 ± 14.0 mm) are significantly thicker than all other raw material, whereas the non-bedded limestone bifaces (47.1 ± 10.1 mm) are statistically thinner than the bedded limestones but thicker than the dolerite (37.9 ± 8.3 mm) and granite (38.9 ± 9.7 mm) bifaces.

The most obvious difference in linear measurements for the South Indian assemblages is that between the larger Hunsgi biface assemblages (Hunsgi II, Hunsgi V, and Isampur) relative to the smaller Baichbal biface assemblages (Fatehpur V and Yediapur VI). Hunsgi-Baichbal differences are correlated with raw materials. Hunsgi Valley bifaces are made on limestone, whereas the smaller Baichbal Valley bifaces are made on both granite and dolerite. The correlation of size and raw material indicates that raw material cannot be excluded as a component of biface variability within and between Hunsgi-Baichbal assemblages.

Inter-regional Comparison

Represented by the scatter plot of length versus breadth, linear measurements identify the range of biface sizes and shapes for the two regions (Figure 2.7). Biface length varies between 50 to 300 mm with a mean (157.3 mm) and median (157.3 mm), indicating a normal distribution (Figure 2.8). The majority of bifaces ($n = 545$, 56.7%) occur between 150 to 160 mm in length, whereas bifaces smaller than 100 mm ($n = 72$, 7.5%) and larger than 200 mm ($n = 118$, 12.3%) are rare.

Biface linear measurements differ significantly between Olorgesailie and Hunsgi-Baichbal assemblages using ANOVA tests. DE89B, Mid, Hunsgi II, and Isampur bifaces have significantly similar lengths, and all four assemblages have longer bifaces than H9A, I3, Hunsgi V, Fatehpur V, and Yediapur VI. Bifaces from H9A, Hunsgi V, Fatehpur V, and Yediapur VI have significantly equivalent lengths. I3 bifaces are shorter than all other bifaces assemblages except Fatehpur V. Mid, Hunsgi II, and Isampur bifaces are significantly similar in breadth and significantly broader than other assemblages. DE89B, H9A, Fatehpur V, Hunsgi V, and Yediapur VI have narrower bifaces. I3 bifaces are significantly narrower than all other biface assemblages. Biface thickness clearly reflects raw material variability, with limestone bifaces from the Hunsgi Valley being thicker than most other biface assemblages. Hunsgi II and Isampur bifaces are significantly thicker than all assemblages except Hunsgi V bifaces. Hunsgi V bifaces are statistically equivalent to Hunsgi II bifaces. DE89B, H9A, Mid, I3, Fatehpur V, and Yediapur VI bifaces have significantly similar thicknesses.

Biface size variability is expressed to the highest degree in three assemblages—I3, Mid, and Isampur. The I3 biface assemblage is small in all linear measurements, and has been interpreted to represent a large amount of rejuvenation through flaking (Noll 2000). In contrast, Isampur and Mid bifaces are larger in length and breadth measurements than most other bifaces assemblages. Isampur bifaces are consistent with a quar-

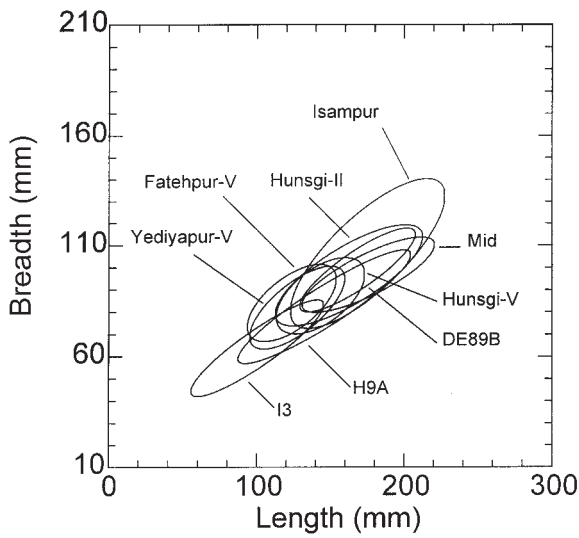


Figure 2.7 A plot of elliptical confidence intervals ($p=0.50$) for LCT length and breadth from Olorgesailie and Hunsgi-Baichbal. Intra-assemblage variability is represented by the elongated ellipses for individual sites.

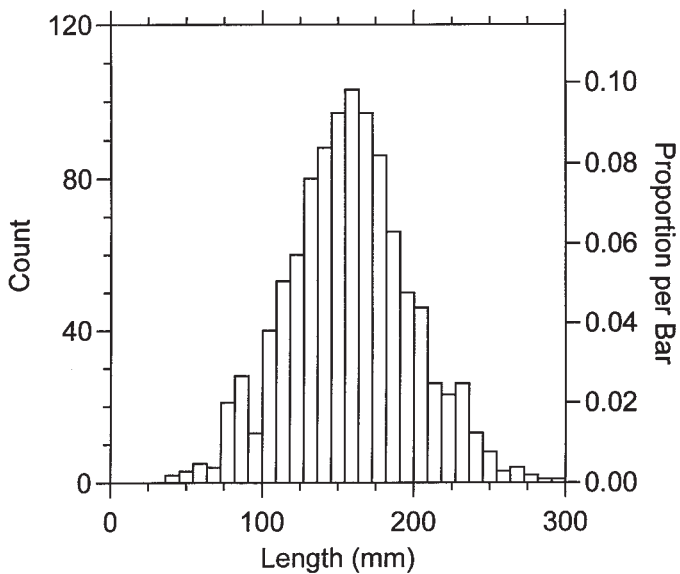


Figure 2.8 Bar graph of LCT length for all LCTs.

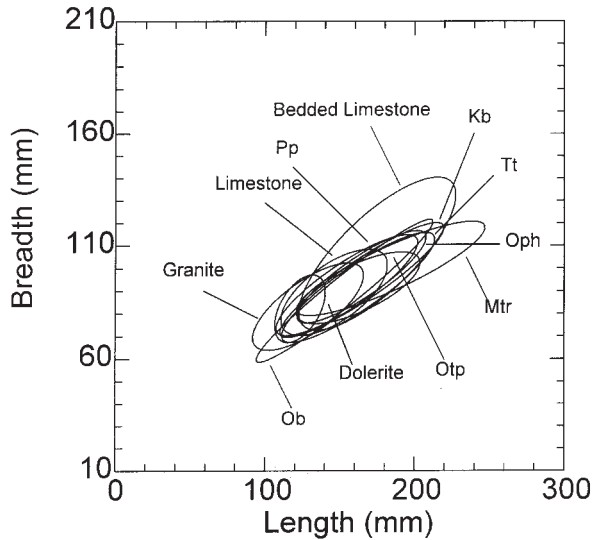


Figure 2.9 Elliptical confidence intervals ($p=0.50$) for bifaces length versus breadth between raw material types.

ry site, where initial stages of biface manufacture were occurring (Petraglia et al. 1999). However, the significantly longer Mid bifaces, which are more than 5 km from many raw material outcrops, are ambiguous. Mid bifaces are large relative to their location on the landscape.

Raw material variability appears to explain aspects of biface assemblage variation, especially in the Hunsgi-Baichbal Valleys (Figure 2.9). At Olorgesailie, lengths and breadths broken down by raw material are consistent with the exception of Magadi trachyte, where both measurements are larger. However, this raw material is infrequently used. Hunsgi-Baichbal has greater raw material variability when compared with Olorgesailie. Limestone is similar in size to Olorgesailie raw materials; bedded limestone falls within the larger size range of Mtr. Dolerite; and granite bifaces are significantly smaller in both length and breadth than the majority of Olorgesailie raw materials, indicating that these raw materials could account for the smaller bifaces at both Fatehpur-V and Yediyapur-VI. The factor generating the increased variability in Hunsgi-Baichbal bifaces most likely relates to raw material clast size and form. Non-bedded limestone and bedded limestone bifaces are manufactured on large flakes and tabular slabs, whereas granite and dolerite bifaces produced on smaller and irregularly shaped clasts.

Discussion

A comparative study of the Acheulean Industrial Complex from Olorgesailie and the Hunsgi-Baichbal Valleys was initiated to characterize behaviors of Middle Pleistocene hominids. Behavior was explored through inter-regional comparison of raw material selection and biface morphology, transport, and discard.

Several observations that are important for understanding Acheulean procurement and transport patterns can be made for the two regions. Raw materials chosen for stone tool manufacture are ubiquitous but not necessarily evenly distributed across the basins. Outcrops have large spatial boundaries and occurred at numerous locations on the paleo-landscape. Raw materials used in biface manufacture were primarily selected from local raw material sources (less than 5 km) and, more rarely, regionally (5-20 km). Distant (more than 30 km) sources—obsidian and quartz/quartzite—were rarely accessed at Olorgesailie. The Hunsgi-Baichbal assemblages show no evidence for long-distance transport. Overall, stone-knappers in both regions appear to have restricted themselves to raw materials from the basin in which they were active, with little transport of non-basin materials. Although the maximum ranging difference of Acheulean lithics is greater than typically found in Oldowan assemblages, it appears that the majority of the bifaces are produced and discarded locally. The raw material procurement and transport situation changes entirely in later assemblages, such as in the Middle Stone Age of Africa, where sources of stone tools are more distant from sites, often times reaching more than 100 kms away (McBrearty and Brooks 2000). Greater site-to-source distances are considered to be a product of increased foraging territory as well as the possible exchange of materials between groups.

In comparing the Olorgesailie and the Hunsgi-Baichbal Valleys, we can observe that there is a general tendency for overlap in biface size and shape linear measurements regardless of the differences in raw material type. Bifaces are large (approximately 150-160 mm) in both regions, which indicates that tools were acquired from large-clasted outcrops. This selection and manufacturing pattern appears to be a deliberate preference of Acheulean hominids in both regions.

Inter-assemblage comparison of Olorgesailie bifaces revealed that significant differences in linear measurements occur between I3 bifaces and all Member 6/7 biface assemblages, indicating the role of other activity patterns. I3 bifaces are smaller in linear measurements relative to Member 6/7 biface assemblages. Previous analysis suggests that the smaller I3 bifaces may be a product of rejuvenation through flaking, whereas larger Member 6/7 assemblages are less rejuvenated (Noll 2000). If rejuvenation of stone tools was more intense at I3, this could account for the small size of bifaces in the assemblage. In this instance, it appears that a level of curation is involved in forming the biface assemblage.

Interestingly, few differences in linear measurements occurred when Olorgesailie bifaces were broken down by raw material type. Raw material is not a significant component of biface linear measurement variability at Olorgesailie. Unlike Olorgesailie assemblages, Hunsgi-Baichbal raw material types cannot be excluded as a factor generating significant biface variability, thus differences between Hunsgi-Baichbal biface assemblages are more closely correlated with raw material frequencies. For instance, limestone bifaces from the Hunsgi Valley are larger in linear measurements when compared with granite and dolerite bifaces from the Baichbal Valley. This signals that in some cases, raw material can structure the formation of Acheulean biface assemblages.

Although raw materials are often local and ubiquitously found on the landscape, hominids in both regions transported large bifaces (150-160 mm in length), implying the use of raw materials with large clast sizes (greater than 256 mm), over what appear to be short distances. This ranging pattern is in contrast to what might be anticipated from study of the post-cranial anatomy of hominids of this time period. The post-cranial anat-

my of Middle Pleistocene hominids suggests adaptation for long distance, high-endurance bipedal locomotion (Ruff 1991; Walker and Leakey 1993). Hence, the combined lithic and anatomical evidence implies that either Acheulean hominids had small home ranges and only used locally available raw materials, or they had larger home ranges but did not transport bifaces long distances. If small home ranges were a common behavioral pattern, then the anatomy of Acheulean hominids contradicts the artifact distribution evidence. New hypotheses need to be constructed in order to explore the relationship between anatomy, Acheulean land-use patterns and tool manufacture, use, and discard behaviors.

Exploration of technological and behavioral variables implies that a number of parallels transcend time and widely separated geographic areas during the Acheulean. Our study indicates that Acheulean stone-knappers had an intimate knowledge of local landscapes, targeting specific raw material outcrops for biface manufacture; however, curation, transport, and intense reduction of bifaces was negligible in both of the regions studied. The recovery of Acheulean bifaces of a restricted size range and shape, and the observation of similar patterns of biface manufacture, transport, and discard, in both East Africa and South India, conveys information about geographic continuity in hominid design choices and learned behaviors. The combination of local production, use and short distance transport argues for Acheulean stone-knappers having high biface discard rates and low levels of curation.

Our study is a first attempt to examine Acheulean biface assemblages from controlled archaeological proveniences in East Africa and South India. Although most paleoanthropologists have assumed that there is similarity in Acheulean assemblages from these two continents, our study has attempted to firmly establish the validity of this observation. In the end, the result of our analyses reaffirmed and supported the general notion that there were indeed convergences in technology and size parameters sought by Acheulean hominids. Similarities in biface attributes implies that the procedures for stone tool manufacture were a learned strategy in which relatively little experimentation and deviation from the norm occurred. The similarity of Acheulean assemblages in different latitudes and environmental settings supports observations for a generic skills model (Gamble 1998, 1999). While there appears to be general similarity in biface manufacturing strategies and production of particular sized artifacts, our study also shows that local situations and various behavioral factors (e.g., raw material, rejuvenation) can also account for the final forms of bifaces, and that no single variable satisfactorily explains the formation of lithic assemblages. This further implies that hominids were able to adjust to the particular conditions with which they were faced, and that we should anticipate some degree of divergence in Acheulean technology and tool types. In the current examples, some level of biface variability can be viewed as a consequence of the use of variable raw material and clast types. Additionally, hominids appear to apply some degree of flexibility in the use and maintenance of their toolkits, as shown by assemblages displaying high discard rates and those with some level of curation.

Today, paleoanthropologists appear to accept the fact that Acheulean hominids were engaging in behaviors for which there are no modern analogs in human foraging societies or primate groups. The study of Acheulean assemblages from East Africa and South Asia indicates that, in fact, a certain type of behavioral system was in place that we do not fully understand. There certainly appears to be some level of learning ability and forethought among Acheulean hominids, as demonstrated by the way in which raw materials were sought, used, and manufactured. However, our study also shows that there are other fea-

tures, strikingly similar in East Africa and South Asia, that do not indicate a high degree of strategic planning depth. The overall lack of long distance transport in both regions and the high level of biface discard may be taken as the sign of a behavioral repertoire or a cognitive level that does not fully anticipate long term, future requirements.

The ability of *Homo erectus* and later hominids to occupy different geographic regions and ecological settings is clearly a novel behavior, and certainly the anatomy of these early humans suggests an adaptation for long-distance locomotion. While this reflects a general biogeographic and behavioral break-through for these hominids in an evolutionary framework, examination of our particular study areas shows that the lives of these hominids were nevertheless tethered to local resources and acted out over highly localized landscapes. While hominids may have been ranging further distances than is shown by the lithic transport information, the data tends to indicate that many activities, from tool manufacture to discard, occurred in close spatial proximity and as responses to immediate needs.

Our initial study of East African and South Asian assemblages shows that future research on the Acheulean Industrial Complex should be directed toward studies of biface size, form, and frequency, as well as behavioral patterns associated with Acheulean hominid mobility (tool manufacture, transport, use, and discard) and responses to ecological settings and environmental changes. A more holistic approach to Acheulean lithic technology, which includes consideration of raw material mechanical properties, site-to-source distances, manufacturing techniques, curation, transport, use, maintenance, and discard, needs to be adopted if we are to move beyond gross generalizations about a period lasting more than one million years.

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References

- Ashton, N. M., and J. McNabb
 1994 Bifaces in Perspective. In *Stories in Stone: Lithic Studies Society Occasional Papers*, 40. M. Ashton, and A. David, eds. Pp. 182–91. London: Lithic Studies Society.

- Asfaw, B., Y. Beyene, G. Suwa, R. C. Walter, T. D. White, G. WoldeGabriel, and T. Yemane
1992 The Earliest Acheulean from Konso-Gardula. *Nature* 360:732-35.
- Baker, B. H.
1958 *Geology of the Magadi Area*. Report 42. Nairobi: Geological Survey of Kenya.
- Baker, B. H., P. A. Mohr, and L. A. J. Williams.
1972 *Geology of the Eastern Rift System of Africa*. Special Paper 136, Geological Society of America.
- Binford, L. R.
1977 Olorgesailie Deserves More than the Usual Book Review. *Journal of Anthropological Research* 33:493-502.
1987 Searching for Camps and Missing the Evidence: Another Look at the Lower Palaeolithic. In *The Pleistocene Old World*. O. Soffer, ed. Pp. 17-31. New York: Plenum Press.
- Blackwell, B. A. B., S. Fevrier, J. I. B. Blickstein, K. Paddayya, M. Petraglia, R. Jhaldiyal, and A. R. Skinner
2001 ESR Dating of an Acheulean Quarry Site at Isampur, India. *Journal of Human Evolution* 40.
- Blumenschine, R. J.
1986 *Early Hominid Scavenging Opportunities: Implications of Carcass Availability in the Serengeti and Ngorongoro Ecosystems*. BAR International Series, 283. Oxford: British Archaeological Reports.
- Blumenschine, R. J., and J. A. Cavallo
1992 Scavenging and Human Evolution. *Scientific American* 267:90-96.
- Blumenschine, R. J., and F. T. Masao
1991 Living Sites at Olduvai Gorge, Tanzania? Preliminary Landscape Archaeology Results in the Basal Bed II Lake Margin Zone. *Journal of Human Evolution* 21:451-62.
- Bunn, H. T.
1994 Early Pleistocene Hominid Foraging Strategies along the Ancestral Omo River at Koobi Fora, Kenya. *Journal of Human Evolution* 27:247-66.
- Bunn, H. T., and E. M. Kroll
1986 Systematic Butchery by Plio-Pleistocene Hominids at Olduvai Gorge, Tanzania. *Current Anthropology* 27:431-451.
- Clark, J. D.
1994 The Acheulian Industrial Complex in Africa and Elsewhere. In *Integrative Paths to the Past: Paleoanthropological Advances in Honor of F. Clark Howell*. R. S. Corruccini, and R. L. Ciochon, eds. Pp. 451-69. Englewood Cliffs, NJ: Prentice-Hall.

Clark, J. D., and H. Kurashina

- 1979 Hominid Occupation of the East-Central Highlands of Ethiopia in the Plio-Pleistocene. *Nature* 282:33–39.

Deacon, H. J.

- 1970 The Acheulean Occupation at Amanzi Springs, Uitenhage District, Cape Province. *Annals Cape Provincial Museums* 8:89–189.

Deino, A., and R. Potts

- 1990 Single Crystal $^{40}\text{Ar}/^{39}\text{Ar}$ Dating of the Olorgesailie Formation, Southern Kenya Rift. *Journal of Geophysical Research* 95:8453–70.

Fairhead, J. D., J. G. Mitchell, and L. A. J. Williams

- 1972 New K/Ar Determinations on Rift Volcanics of Southern Kenya and Their Bearing on the Age of Rift Faulting. *Nature* 238:66–69.

Gamble, C.

- 1998 Concluding Remarks: Archaeology's Fifth Big Question. In *Early Human Behaviour in Global Context: the Rise and Diversity of the Lower Paleolithic Record*. M. D. Petraglia, and R. Korisettar, eds. Pp. 451–468. New York: Routledge.
- 1999 *The Palaeolithic Societies of Europe*. Cambridge: Cambridge University Press.

Gowlett, J. A. J.

- 1986 Culture and Conceptualisation—The Oldowan-Acheulean Gradient. In *Stone Age Prehistory: Studies in Memory of Charles McBurney*. G. N. Bailey, and P. Callow, eds. Pp. 243–60. Cambridge: Cambridge University Press.

Gowlett, J. A. J., and R. H. Crompton

- 1994 Kariandusi: Acheulean Morphology and the Question of Allometry. *African Archaeological Review* 12:1–40.

Hay, R. L.

- 1976 *Geology of the Olduvai Gorge: A Study of Sedimentation in a Semiarid Basin*. Berkeley: University of California Press.

Howell, F. C., and J. D. Clark

- 1963 Acheulean Hunter-Gatherers of Sub-Saharan Africa. In *African Ecology and Human Evolution*. F. C. Clark and F. Bourliere, eds. Pp. 458–533. Chicago: Aldine de Gruyter.

Isaac, G. L.

- 1968 The Acheulean Site Complex at Olorgesailie, Kenya: A Contribution to the Interpretation of Middle Pleistocene Culture in East Africa. Ph.D. dissertation, Department of History, Cambridge University.
- 1969 Studies of Early Culture in East Africa. *World Archaeology* 1:1–27.
- 1972a Chronology and Tempo of Cultural Change During the Pleistocene. In *Calibration of Hominid Evolution*. W. W. Bishop and J. Miller, eds. Pp. 381–430. Edinburgh: Scottish Academic Press.

- 1972b Early Phases of Human Behavior: Lower Paleolithic Archaeology. In *Models in Archaeology*. D. L. Clarke, ed. Pp. 167-99. London: Methuen.
- 1977 *Olorgesailie: Archaeological Studies of a Middle Pleistocene Lake Basin in Kenya*. Chicago: University of Chicago Press.
- Jhaldiyal, R.
- 1997 Formation Processes of the Prehistoric Sites in the Hunsgi and Baichbal Basins, Gulbarga District, Karnataka. Ph.D. dissertation, Department of History, Deccan College.
- Jones, P.
- 1979 Effects of Raw Material on Biface Manufacture. *Science* 204:835-36.
- 1981 Experimental Implement Manufacture and Use: A Case Study from Olduvai Gorge, Tanzania. *Philosophical Transactions of the Royal Society of London* 292:189-95.
- 1994 Results of Experimental Work in Relation to the Stone Industries of Olduvai Gorge. In *Olduvai Gorge*, vol. 5: *Excavations in Beds III, IV, and the Masek Beds 1968-1971*. M. D. Leakey and D.A. Roe, eds. Pp. 254-98. Cambridge: Cambridge University Press.
- Kleindienst, M. R.
- 1961 Variability within the Late Acheulian Assemblage in East Africa. *South African Archaeological Bulletin* 16:35-52.
- 1962 Components of the East African Acheulian Assemblage: An Analytical Approach. In *Actes du IVe Congrès Panafricain de Préhistoire (Tervuren, Belgium)*. G. Mortelmans and J. Nenquin, eds. Pp. 81-105. Panafrican Association of Prehistory and Related Studies.
- Leakey, L.S.B.
- 1952 The Olorgesailie Prehistoric Site. In *Proceedings of the First Pan-African Congress on Prehistory, 1947, Nairobi*. L. S. B. Leakey and S. Cole, eds. P. 209.
- Leakey, M. D.
- 1971 *Olduvai Gorge*, vol. 3. Cambridge: Cambridge University Press.
- 1975 Cultural Patterns in the Olduvai Sequence. In *After the Australopithecines: Stratigraphy, Ecology, and Culture Change in the Middle Pleistocene*. K. W. Butzer, and G. L. Isaac, eds. Pp. 477-490. The Hague: Mouton.
- Manega, P. C.
- 1993 Geochronology, Geochemistry, and Isotopic Study of the Plio-Pleistocene Hominid Sites and the Ngorongoro Volcanic Highlands in Northern Tanzania. Ph. D. dissertation, Department of Geology, University of Colorado, Boulder.
- McBrearty, S., and A.S. Brooks
- 2000 The Revolution that Wasn't: A New Interpretation of the Origin of Modern Human Behavior. *Journal of Human Evolution* 39:453-563.

McPherron, S. P.

- 2000 Handaxes as a Measure of the Mental Capabilities of Early Hominids. *Journal of Archaeological Sciences* 27:655–63.

Misra, V. N.

1987. Middle Pleistocene Adaptations in India. In *The Pleistocene Old World*. O. Soffer, ed. Pp. 99–119. New York: Plenum Press.

Monahan, C. M.

- 1996 New Zooarchaeological Data from Bed II, Olduvai Gorge, Tanzania: Implications for Hominid Behavior in the Early Pleistocene. *Journal of Human Evolution* 31:93–128.

Noll, M. P.

- 2000 Components of Acheulean Lithic Assemblage Variability at Olorgesailie, Kenya. Ph.D. dissertation, Department of Anthropology, University of Illinois, Urbana.

Paddayya, K.

- 1982a *The Acheulian Culture of the Hunsgi Valley (Peninsular India): A Settlement System Perspective*. Poona: Deccan College Postgraduate and Research Institute.
- 1982b The Lower/Middle Palaeolithic Transition in the Hunsgi Valley, Peninsular India. In *The Transition from Lower to Middle Palaeolithic and the Origin of Modern Man*. A. Ronen, ed. Pp. 257–64. Oxford: British Archaeological Reports.
- 1989 The Acheulian Culture Localities Along the Fatehpur Nullah, Baichbal Valley, Karnataka (Peninsular India). In *Old Problems and New Perspectives in the Archaeology of South Asia*. J. M. Kenoyer, ed. Pp. 21–28. Madison, WI: University of Wisconsin Press.

Paddayya, K., and M. D. Petraglia

- 1993 Formation Processes of Acheulean Localities in the Hunsgi and Baichbal Valleys, Peninsular India. In *Formation Processes in Archaeological Context*. P. Goldberg, D. T. Nash, and M. D. Petraglia, eds. Pp. 61–82. Madison, WI: Prehistory Press.

Petraglia, M. D.

- 1998 The Lower Paleolithic of India and Its Bearing on the Asian Record. In *Early Human Behaviour in Global Context: The Rise and Diversity of the Lower Paleolithic Record*. M. D. Petraglia and R. Korisettar, eds. Pp. 343–90. New York: Routledge.
- 2001 The Lower Palaeolithic of India and Its Behavioural Significance. In *Human Roots: Africa and Asia in the Middle Pleistocene*. L. Barham and K. Robson-Brown, eds. Pp. 217–33. Bristol: Western Academic & Specialist Press.

Petraglia, M. D., and R. Korisettar, eds.

- 1998 *Early Human Behaviour in Global Context: The Rise and Diversity of the Lower Paleolithic Record*. New York: Routledge.

Petraglia, M. D., P. LaPorta, and K. Paddayya

- 1999 The First Acheulian Quarry in India: Stone Tool Manufacture, Biface Morphology, and Behaviors. *Journal of Anthropological Research* 55:39-70.

Potts, R.

- 1983 Foraging for Faunal Resources by Early Hominids at Olduvai Gorge, Tanzania. In *Animals and Archaeology*, vol. 1. *Hunters and Their Prey*. J. Clutton-Brock, and C. Grigson, eds. Pp. 51-62. Oxford: British Archaeological Reports.
- 1987 On Butchery by Plio-Pleistocene Hominids. *Current Anthropology* 28:95-96.
- 1988 *Early Hominid Activity at Olduvai Gorge*. New York: Aldine de Gruyter.
- 1989 Olorgesailie: New Excavations and Findings in Early and Middle Pleistocene Contexts, Southern Kenya Rift Valley. *Journal of Human Evolution* 18:477-84.
- 1994 Variables Versus Models of Early Pleistocene Hominid Land Use. *Journal of Human Evolution* 27:7-24.

Potts, R., A. K. Behrensmeyer, and P. Ditchfield

- 1999 Paleolandscape Variation in Early Pleistocene Hominid Activities: Member 1 and Member 7, Olorgesailie Formation, Kenya. *Journal of Human Evolution* 37:747-88.

Radhakrishna, B. P., and R. Vaidyanathan

- 1994 *Geology of Karnataka*. Bangalore: Geological Survey of India.

Roe, D. A.

- 1964 The British Lower and Middle Paleolithic: Some Problems, Methods of Study and Preliminary Results. *Proceedings of the Prehistoric Society* 30:245-67.
- 1968 British Lower and Middle Paleolithic Handaxe Groups. *Proceedings of the Prehistoric Society* 34:1-82.

Rogers, M. J., J. W. K. Harris, and C. S. Feibel

1994. Changing Patterns of Land Use by Plio-Pleistocene Hominids in the Lake Turkana Basin. *Journal of Human Evolution* 27:139-58.

Rose, L., and F. Marshall

1996. Meat Eating, Hominid Sociality, and Home Bases Revisited. *Current Anthropology* 37:307-38.

Ruff, C. B.

- 1991 Climate and Body Shape in Hominid Evolution. *Journal of Human Evolution* 21:81-105.

Schick, K. D.

- 1994 The Movius Line Reconsidered. In *Integrative Paths to the Past: Paleoanthropological Advances in Honor of F. Clark Howell*. R. S. Corruccini and R. L. Ciochon, eds. Pp. 569-96. Englewood Cliffs, NJ: Prentice-Hall.

Shackleton, R. M.

- 1978 A 1:10,000 Geological Map of the Olorgesailie Area. In *Geological Background to Fossil Man: Recent Research in the Gregory Rift Valley, East Africa*. W. W. Bishop, ed. Edinburgh: Scottish Academic Press.

Szabo, B. J., C. McKinney, T. S. Dalbey, and K. Paddayya

- 1990 On the Age of the Acheulian Culture of the Hunsgi Baichbal Valleys, Peninsular India. *Bulletin of the Deccan College Post Graduate and Research Institute* 50:317-21.

Tallon, P. W. J.

- 1978 Geological Setting of the Hominid Fossils and Acheulian Artifacts from the Kapthurin Formation, Baringo District, Kenya. In *Geological Background to Fossil Man: Recent Research in the Gregory Rift Valley, East Africa*. W. W. Bishop, ed. Pp. 361-73. Edinburgh: Scottish Academic Press.

Tchernov, E.

- 1992 Biochronology, Paleoecology, and Dispersal Events of Hominids in the Southern Levant. In *The Evolution and Dispersal of Modern Humans in Asia*. T. Akazawa, K. Aoki, and T. Kimura, eds. Pp. 149-88. Tokyo: Hokusen-sha.

Walker, A., and R. E. Leakey, eds.

- 1993 *The Nariokotome Homo Erectus Skeleton*. Cambridge, MA: Harvard University Press.

White, M. J.

- 1995 Raw Materials and Biface Variability in Southern Britain: A Preliminary Examination. *Lithics* 14/15:1-20.
- 1998 On the Significance of Acheulean Biface Variability in Southern Britain. *Proceedings of the Prehistoric Society* 64:15-40.

Wynn, T., and F. Tierson

- 1990 Regional Comparisons of the Shapes of Later Acheulean Handaxes. *American Anthropologist* 92:73-84.



3

TECHNOLOGICAL AND TYPOLOGICAL VARIABILITY IN THE BIFACES FROM TABUN CAVE, ISRAEL

Shannon P. McPherron

Jelinek's 1967-72 excavations of Tabun Cave yielded more than 2,000 complete and partial bifaces. These bifaces come from a series of beds, but the bulk of the assemblage can be attributed to the Late Acheulian and Yabrudian industries. This chapter builds on a detailed morphometric analysis of the Tabun bifaces published by Rollefson in 1978, in which he identified several patterns in biface shape throughout the sequence. In particular, it applies a reuse and resharpening reduction model to the morphological variability within several stratigraphic units. Variability between stratigraphic units is examined from this same perspective, and relationships between patterning in the bifaces and variability in the flake tool components of the assemblages is sought. The focus is to achieve some level of understanding of the relationships between technology, raw materials, reduction intensity, and typology and to how these variables changed through time in the Tabun sequence.

Elsewhere I have put forth a reduction model to explain the variability in biface shape (McPherron 1994, 1995, 1999, 2000). The model links the intensity of bifacial reduction with variability in biface shape. It is based on the simple assumption that a biface, once made, will be resharpened or periodically reworked before it is discarded into the archaeological record for the last time. With each resharpening event, the size of the biface, whether measured by the length, width or thickness, is reduced. The question is whether shape is altered in the process as well. If a particular shape, as we measure it, was important to these hominids, then we would expect the shape to remain relatively constant despite the diminishing size of the biface. On the other hand, if factors other than shape were more important, then we might expect shape to gradually change as the biface diminished in size. In fact, when I examined several Acheulian assemblages from northern France, I found a consistent and predictable relationship between size and shape (McPherron 1994, 1999). There are several ways to measure size; in my work I have focused on length of the tip (measured from the point of maximum width to the tip). I selected tip length because it seemed like a safe assumption that the tip is the primary focus of bifacial reduction, and in reworking or resharpening the tip the length will almost certainly be effected. Thus, tip length can be said to be a measure of the intensity of bifacial reduction. When looking at previously published data on biface shape, in the absence of data on tip length, I substituted length with identical results. In the assemblages that I have examined, length and tip length are always very highly correlated.

Length (or any measure of size) is effected by the size of the nodule or flake blank one begins with, and this can be highly variable. Unlike reduced flakes in which the size of the original flake blank can be estimated from measurements on the preserved platforms (Dibble 1997), there is very little that can be done with bifaces to consistently estimate the size of the original blank from which it was made. Thus, I have made the simplifying assumption that hominids consistently sought the largest nodules available, and that these nodules would have been roughly the same size for a particular assemblage of bifaces. Thus, size reflects intensity of reduction. This is an assumption commonly made with cores for instance. Smaller cores are regularly interpreted as more heavily reduced than larger cores in the same assemblage. In some assemblages I have been able to test the relationship between raw material variability and size using the percentage cortex remaining on the pieces. If all the nodules start out roughly the same size, then as reduction intensity increases and as size decreases, the amount of cortex remaining on the piece should decrease. On the other hand, if the nodules start with varying sizes, then there should be no relationship between cortex and size.

Such a cavalier attitude towards raw material variability certainly invites disaster. Raw materials obviously varied to a great extent and certainly played a role in bifacial reduction. White (1998) has worked on just this problem using some of the English biface assemblages that Roe (1964, 1968) had previously analyzed. In a set of 38 assemblages, Roe found a clear distinction between assemblages characterized by pointed forms and assemblages characterized by rounded or ovate forms; this pattern has been repeatedly confirmed (Doran and Hodson 1975; Callow 1976). It is important to note that each assemblage contains a mixture of both forms. Although to at the assemblage level, the distinction is clear between the two kinds of biface assemblages, at least for the British 38, the same distinction has never been demonstrated within an assemblage. Assemblages are characterized by a modal shape around which there is typically substantial variability and a gradual or continuous transition from one form to another.

White examined the British bifaces and noted the type of raw material from which they were made. He found a consistent pattern that led him to suggest that variability in raw material size, shape, and quality is behind the shape patterning in these assemblages; something that Ashton and McNabb (1994) had also noted. Pointed forms tend to be made on smaller, poorer quality raw materials obtained from secondary deposits on river terraces. In these instances, the shape of the nodules often placed constraints on the type of form that could be manufactured. Conversely, rounded forms were generally made on larger, high-quality raw materials obtained from primary sources. Because pointed or ovate forms could have been manufactured in these instances, White (1998:22) takes the analysis a step further, arguing that ovate forms were in fact the preferred form of Britain's hominids and that pointed forms were simply an accommodation to inferior raw materials.

Arguing preferences from the trash hominids left behind is a tricky business in a reductive technology like stone (Frison 1968; Jelinek 1976, 1977; Davidson 1991; Davidson and Noble 1993). In my own analysis of Roe's assemblages (1995), I noted the exact same patterning that I found in the northern French assemblages and had attributed to reduction intensity. Although there is naturally a great deal of variability in the British bifaces, size and shape are still statistically significantly correlated. The average length of the bifaces in Roe's pointed assemblages is greater than in the rounded assemblages. Moreover, other measures of shape, not just whether the edge is pointed or round-

ed, also vary between these assemblages in the exact same way the reduction model shows them to work elsewhere.

Which model is correct? As Ashton and White indicate, both models lack information about the process of bifacial reduction. My own approach has been to argue that the bifaces of an assemblage represent different stages of the reduction process. Some will be in the earlier stages of reduction when they enter the archaeological record and others will be nearly exhausted. By looking at the whole collection, the process can be thereby reconstructed. What is more, if the reduction model is correct, it also allows the average reduction intensity in an assemblage to be assessed and quantified and then compared with other factors (i.e., distance from raw materials, environmental changes) just as it has been done with the flake tool component of Mousterian assemblages (Rolland and Dibble 1990). This is, in fact, exactly what I try to do with Tabun and have attempted elsewhere (McPherron 1999:14).

To a very large extent, however, both models are likely correct. The two models work very well together. Raw materials certainly play a role in determining the reduction strategy. In particular, if they follow the kinds of patterns documented elsewhere for other kinds of stone tools, large, high-quality raw materials should see extended use-lives and enter the archaeological record in a more intensively reworked and reduced form. I have argued that this is exactly what White has documented (McPherron 1999:14). In my reduction model, pointed forms represent an early stage of reduction and rounded forms a later stage. It makes good sense that the bifaces made of poor-quality material are being discarded into the archaeological record at an early stage of reduction and that the large, high-quality material bifaces are being curated and more intensively reduced before they enter the record as rounded forms. White (1998:20) seems to agree. He repeatedly offers that ovate bifaces show signs of being more intensively reduced than pointed forms.

Where I disagree with White is in the attribution of preference to the rounded form. My own data from northern France (McPherron 1994, 1999), the British assemblages (1994, 1995), and even comparisons of assemblages at the level of continents (2000), show the same recurrent patterns in which pointed and rounded forms are simply stages along a single trajectory. Factors like raw-material quality affect when a biface falls from this trajectory into the archaeological record. It is the trajectory, therefore, and not the stage along the trajectory that is preferred.

Ashton and White attempt to address the question of process, but their methods are so different from my own that we may be talking past each other at this point. There is a way to bring the two together. It would be interesting to take an assemblage, divide the bifaces into raw material types, and apply the tests of the reduction model, as I have outlined them, to each. Regardless of whether pointed and ovate bifaces are points along a single trajectory or two separate trajectories, I would expect them each to show a reduction sequence. If not, we can stop there. On the other hand, if they show reduction trajectories, then how are they different? The two could be plotted on the same graph. If they are right, then the reduction trajectories should look distinctly different despite the fact that pointed and round forms grade into one another. One trajectory, for instance, might emphasize the removal of material from the tip with each resharpening reduction episode, whereas the other may not. These differences should be evident when the shape ratios are plotted against the reduction intensity.

That said, I will take a difference approach here with the Tabun data. Tabun offers an excellent opportunity to pursue this question of the roles of reduction intensity and raw

Table 3.1 Biface Counts for Jelinek's Excavations of Tabun

Garrod	Jelinek		Bifaces	Complete
Layer	Unit	Bed		Bifaces
C	III	35	1	1
C	V	41	4	3
C	VI	45	1	1
C	VI	49	1	1
C	VII	58	1	1
C	VIII	59	2	1
C	VIII	61	1	1
D	IX	63	2	1
D	IX	64	1	0
D	IX	66	4	4
D	IX	67	2	1
D	IX	68	1	1
D	X	70	8	7
D	X	71	31	13
D	X	72	97	72
Ea	XI	73	65	40
Ea	XI	74	80	61
Ea	XI	75	135	100
Ea	XI	76	541	365
Ea	XI	77	53	33
Eb	XII	78	3	2
Eb	XII	79	260	174
Eb	XII	80	149	97
Ec	XIII	81	18	11
Ec	XIII	82	62	39
Ec	XIII	83	187	108
Ec	XIII	84	72	47
Ec	XIII	85	11	8
G	XIV	90	289	190
Total			2082	1383

Garrod's layers are based on Jelinek's stratigraphic correlations. Bifaces from boxed beds were examined by the author as part of this study.

material variability for several reasons. First, Tabun is unusual among biface sites in that it has a deep sequence of bifacial levels. Not only can patterns within assemblages be examined, but also any changes in these patterns through time. Second, the sample size from many of these levels is large enough to be amenable to the kinds of statistical analysis on which the reduction model relies. Third and most importantly in the context of the debate between Ashton and White and myself, some aspects of raw-material variability in the Tabun sequence are thought to be constant. In particular, the raw material source is likely constant, meaning that the quality and the shape of the nodules are less variable. It is possible, however, that the quantity of available nodules varied with environmental changes and with the rate at which they were being used. Tabun therefore, offers an opportunity to examine the relationship between bifacial reduction intensity and shape through time with some control over raw-material variability.

Tabun

Tabun Cave is located in Israel near the mouth of the Wadi Mughara, on the western margin of Mount Carmel, approximately 20 kilometers south of Haifa and between 3 and 3.5 km inland from the Mediterranean Sea. The site is 45 m above sea level and faces northwest overlooking the Mediterranean coastal plain. The cave itself consists of a large outer chamber open to the sky, a smaller inner chamber open to the sky due to a large chimney that opened during the prehistoric occupation of the site, and an intermediate and smaller chamber that communicates with the other two (Jelinek 1982; Mercier et al. 1995; Rollefson 1978).

The archaeology of the cave is known principally from two excavations. First, Garrod excavated a large portion of the site, as well as the nearby caves of Skhul and el Wad, between 1929 and 1934. Second, more recently, Jelinek re-excavated a portion of the site from 1967 to 1972 and produced a more detailed stratigraphic sequence along with an artifact assemblage of approximately 45,000 pieces. Whereas Garrod recognized seven principal Layers A-G, Jelinek organized the stratigraphy into fourteen Units I-XIV, which are further subdivided into approximately 90 beds, many of which are further subdivided into smaller groups of associated materials. For the most part, Garrod's and Jelinek's sequences can be correlated (Jelinek 1982), although some of Garrod's sequence was not sampled by Jelinek and vice versa.

More than 2000 bifaces come from Jelinek's excavations (Table 3.1). Most of these come from the lower part of the sequence in Jelinek's Late Acheulian (Layer G), Mugharan (Layer E), and early Lower Mousterian (Layer D). Bifaces occur only sporadically through the Middle Mousterian (Layer C) and are absent thereafter. The Tabun bifaces are best known from Rollefson's 1978 dissertation in which he completed a detailed morphometric, typological, and technological analysis using multivariate and PCA statistical techniques. The observations on the material presented here are based on Rollefson's publication, a reanalysis of his published data, and my own observations of the material from the three Beds with the largest samples: 76, 79, 90.

Some of the finds to date with regard to the reduction model are presented; however, the work is still in progress. The long-term goal is to update Rollefson's work, principally in terms of the stratigraphic information, which is now out of date in Rollefson's original publication (Rollefson 1978:68-69), and to reexamine the patterning in these collections in light of two decades of work into the kinds of factors which can affect the structure of variability in biface assemblages.

Table 3.2 Regression Analysis of the Relationship Between Tip Length and Shape

	Level 76 (N=333)		Level 79 (N=134)		Level 90 (N=125)	
	R	P	R	P	R	P
Tip length to Elongation	0.4280	0.0000	0.4804	0.0000	0.2702	0.0001
Tip length to Refinement	0.0985	0.0725	-0.0308	0.7243	-0.0316	0.7263
Tip length to Bordes' Edge	0.6017	0.0000	0.6076	0.0000	0.5568	0.0000
Tip length to Roe's Edge	0.4479	0.0000	0.5498	0.0000	0.4785	0.0000

Statistically significant relationships are set in boldface type.

Tabun's Bifaces

In terms of typology, following Bordes' (1961) terminology, the Tabun bifaces tend to be relatively thick, broad, and more rounded than pointed. Amygdaloid, thick ovate, and thick disc shapes are quite common (Table 3.2). There are also a fairly substantial number of cleaver types. These pieces have a relatively straight distal edge usually formed by some combination of tranchet removals and retouch from the distal end. In some instances, the distal end is formed by two tranchet blows from opposite sides. It can also be formed by bifacial retouch directly from the distal end, and sometimes it is a combination of tranchet on one side and retouch on the other. Unsystematic data collected on whether the tranchet preceded or followed the retouch revealed no consistent pattern; although it did seem that most instances in which it could be determined, the end was retouched following a tranchet removal. As Rollefson (1978) notes, there is also a fairly high percentage of bifaces that have to be classified as diverse or miscellaneous. A couple of examples that resemble prodniks from central Europe are particularly interesting.

Similarly, using Roe's typological approach wherein bifaces are placed in either the cleaver, ovate, or pointed category based on the ratio of the base length to the length (Figure 3.1), ovate types are relatively more common than pointed forms. In Roe's system, to characterize an assemblage, at least 60% of the bifaces must be of one type or another. In the Tabun sequence, when we consider beds with at least double digit frequencies, pointed bifaces never predominate (Table 3.2). The assemblages are most often indeterminant, meaning that neither type exceeds 60% of the assemblage, or ovate. Interestingly, two of the three largest assemblages, are ovate.

Most of the bifaces retained some cortex, often in the form of a cortical base. Raw-material data are not available, but it appears that the vast majority of bifaces are made on locally available flint. Roughly 20% of the bifaces could be positively identified as having been manufactured on flake blanks. This figure undoubtedly underestimates the true proportion of bifaces made on flakes because the type of support could not be determined in most instances. In some instances it could be determined that the bifaces were made on thin, flat nodules of flint or thin tabular pieces of flint.

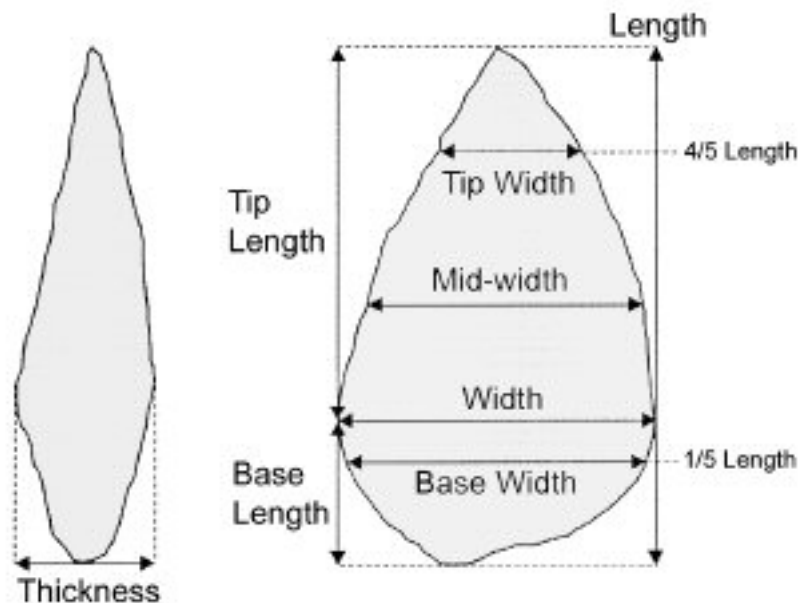


Figure 3.1 The biface measurements referred to in this article. All of these measurements are drawn from the combined systems outlined by Bordes (1961) and Roe (1964).

Within Assemblage Variability

From the tables and descriptions presented, it is clear that whereas some modalities in shape exist, there is also a great deal of variability. At a most basic level, for instance, there are both ovate and pointed forms. Whereas White found that in the British data pointed forms tended to be manufactured on poorer quality raw materials, there is absolutely no indication at Tabun that raw-material quality varied. The general assumption has been that raw materials were of high-quality throughout. In my own observations of the material, I saw some instances in which nodule shape seemed to have influenced to some extent the final form of the biface; this is difficult to quantify because it is only obvious if the biface enters the archaeological record at an early stage of reduction when traces of the original nodule are still present on the piece. On more reduced bifaces, there is no way of knowing what the original form might have been like.

Variability in the Tabun bifaces does seem, however, to follow the reduction model. The model predicts a correlation between size, which is a function of the intensity of reduction when raw materials are constant, and shape. In nearly all studies of patterning in biface shape, size is explicitly removed from the analysis, presumably because it represents “noise” or unintended variability related to factors outside the control of the knappers; namely, the size of the original raw materials. The idea is that once the effects of size

are removed from the analysis, we can see the true intentions of the knapper. Indeed, as a most basic level, this is one of the basic reasons why we calculate shape ratios that have the effect of standardizing one measure relative to another. We compare elongation ratios (length/width) rather than directly comparing absolute length and width.

Until size is removed from the analysis, multivariate studies of biface shape have found that size explains or predicts most of the variability. Particularly interesting in this regard is Wynn and Tierson's (1990) study of bifaces from several continents. They found that size explained more than 90% of the variability in their 22 radial measurements of biface shape, and then attempted to discarded this from their analysis so that they could look at the remaining variability (I have argued that they were not successful in removing size from their analysis [McPherron 2000]). The significance of their finding is that size plays such an important role. It is especially significant if we acknowledge that size is more than variability in raw materials. Size also has a behavioral component, namely the intensity of bifacial reduction.

At about the same time that I first published my reduction model, Gowlett and Crompton (1994; Crompton and Gowlett 1993) also directly tackled the issue of size-related variability from a different perspective. They analyzed assemblages from East Africa and found significant relationships between size and shape. For them, it is the very relationship between size and shape that has behavioral significance. I agree completely with this assessment, but I disagree with their interpretation of the behavior behind this pattern. The important point of agreement, however, is that size must be included in an analysis of biface shape.

Whereas Gowlett and Crompton use allometric statistics, I have focused on correlations between size and shape. To test the reduction model, regression analysis is applied and correlation coefficients calculated between tip length and various measures of shape that existing typologies and multivariate analyses have already identified as significant areas of morphological variability in bifaces. If maintaining a biface of a particular shape was important to prehistoric knappers despite multiple resharpening reduction episodes and variability in raw material size, then there should be no correlation between tip length and shape. If, on the other hand, shape varies as the tip is reduced in length, then there will be a statistically significant correlation.

By and large, the patterns that I have found elsewhere hold at Tabun (Figures 3.2–3.4, Table 3.3). In the three beds with the largest samples (Beds 76, 79, and 90), there is a strong correlation between edge shape, as defined by both Bordes and Roe, elongation, and tip length. As tip length decreases, the bifaces become broader and rounder. In other words, during bifacial reduction, length-related variables decrease more quickly than width, particularly near the base. As a result, the width gradually becomes larger relative to the length (elongation) and the width near the tip becomes larger relative to the width at the base (edge shape). It is important to emphasize that Tabun is similar to other bifaces sites not only for having a statistically significant correlation between size and shape, but the direction of this relationship is also the same. In other words, there is a shared bifacial reduction strategy. Refinement (width / thickness), on the other hand, does not correlate with tip length. In fact, refinement is fairly constant in the Tabun assemblages regardless of changes in size, shape, or blank type (flake or nodule).

With other assemblages that I have examined, I have found supporting evidence for the relationship between size, shape, and reduction intensity in the percentage of cortex left on the pieces. If nodules of roughly the same size are worked into bifaces, then the

Table 3.3 The Relationship Between Size,
as Measured by Length, and Percentage Cortex

Bed	Small	Large	t-statistic	p
76	23.9 s.d.= 19.81 (N=149)	19.4 s.d.= 16.13 (N=136)	2.066	0.040
79	22.9 s.d.= 14.47 (N=66)	22.9 s.d.= 18.88 (N=47)	0.009	0.993
90	16.0 s.d.= 14.50 (N=60)	13.6 s.d.= 12.96 (N=47)	0.869	0.387

The groups small and large are based on the mean length in the respective beds.

expectation is that as the nodules are more intensively worked, the size and the percentage of the cortex remaining on the nodule will decrease together. This model works if at some point in the reduction sequence cortex at the base is removed and the bifacial edge eventually extends around the entire periphery of the biface. On the other hand, if a cortical base is retained, then the *percentage* of cortex remaining on the piece will actually increase with decreasing size. The Tabun data show that cortex either remains the same or increases with changes in size (Table 3.4). In Bed 76, smaller bifaces, on average, have more cortex as a percentage than larger bifaces. In Bed 79, cortex remains constant with changes in size, and Bed 90 follows the Bed 76 pattern, although in this case the difference is not statistically significant. One of the bifacial reduction strategies employed at Tabun involved leaving cortex on the pieces, typically as a cortical base, which led towards small, fairly cortical, broad, rounded bifaces. Interestingly, typologically these bifaces can look like small chopping tools. In looking through the material, I did come across several instances in which pieces I would have classified as bifaces had been classified as chopping tools or vice versa.

This reduction strategy may also explain why refinement, measured as the ratio of the width to the thickness, remains fairly constant throughout and is not correlated with reduction intensity. I have argued previously that in the early stages of bifacial reduction, the biface will have a refinement equal to that of the nodule or flake blank from which it is being made. As the bifacial thinning technology expands to include the entire periphery of the biface and as the technology penetrates across the surfaces of the biface, the refinement will begin to reflect this technology rather than the original blank. As bifacial reduction progresses, however, it reaches a limit in which the piece can no longer be thinned. At this point, if bifacial reduction continues, the piece may actually become relatively thicker or less refined. As a result, the direction and strength of the correlation between reduction intensity and refinement will vary with the stage of reduction. In the early stages, refinement increases as reduction increases (tip length decreases). In the middle stages, refinement remains fairly constant despite increased reduction. And in the later stages, refinement decreases as reduction increases.

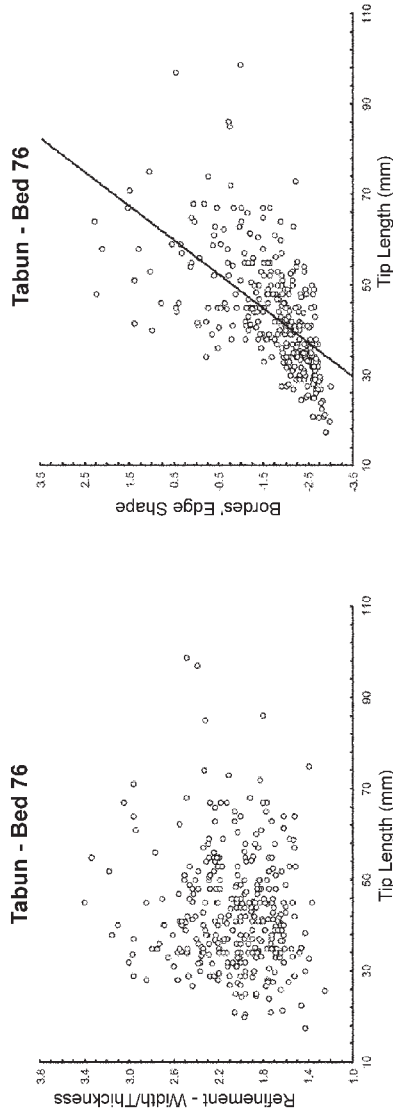
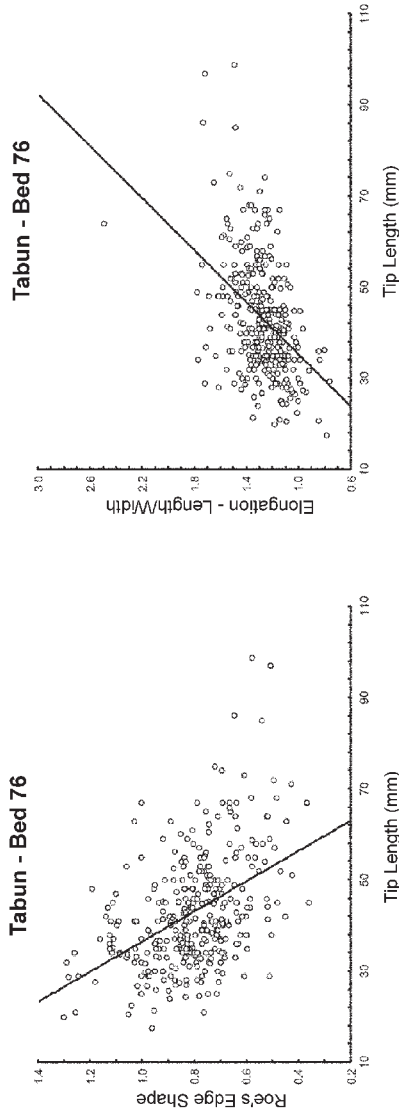


Figure 3.2 Bed 76. The relationships between tip length and elongation (length / width), refinement (width / thickness), Bordes' calculation of edge shape, and Roe's calculation of edge shape. Bordes' edge shape is a combination of midwidth, width, length and base length following the formula (length / base length) - $(4.575 * (\text{midwidth} / \text{width}))$ (Bordes 1961). As a result, pointed forms have high values and rounded forms have low values. Roe's edge shape is based on the ratio of the width near the tip to the width near the base (Roe 1964). In this system, rounded forms have high values and pointed forms have low values. The graphs with regressions lines have a statistically significant correlation between the two variables.

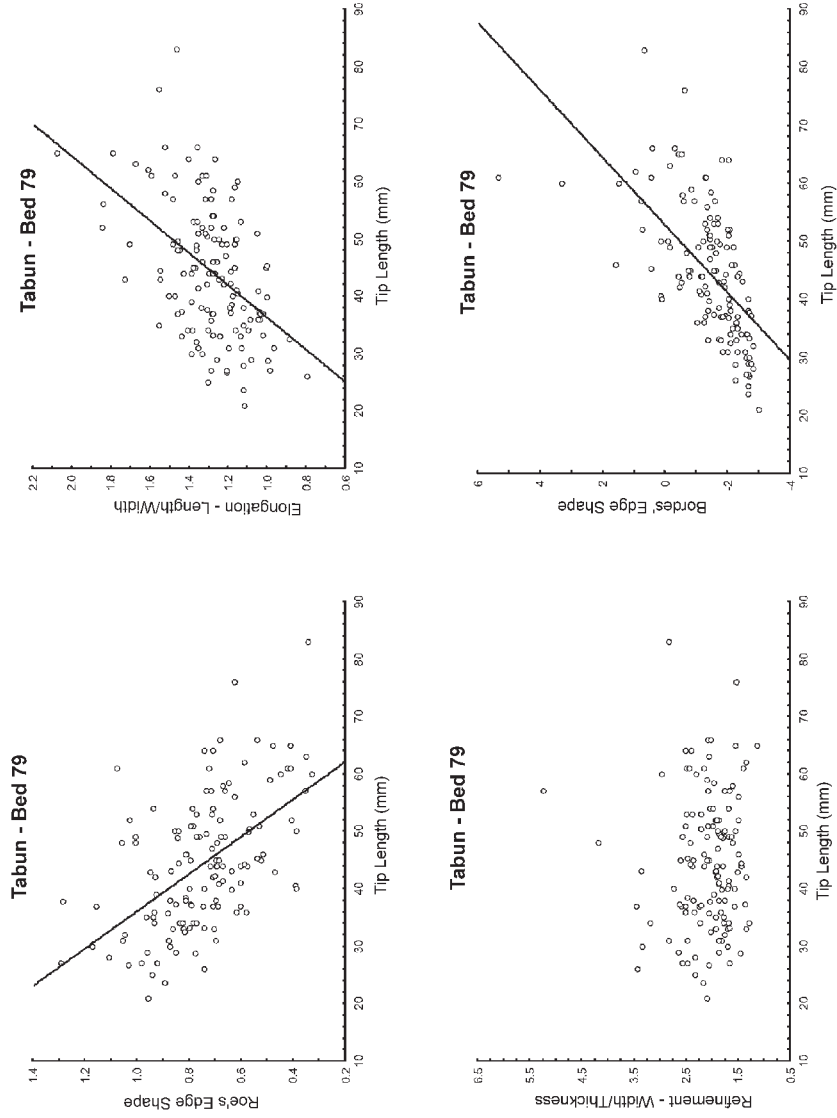


Figure 3.3 Bed 79. See Figure 3.2 for a description of the graphs.

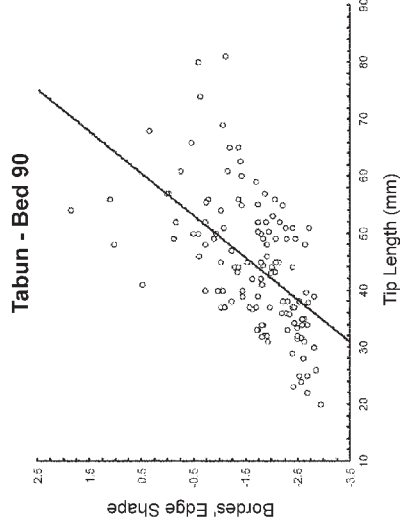
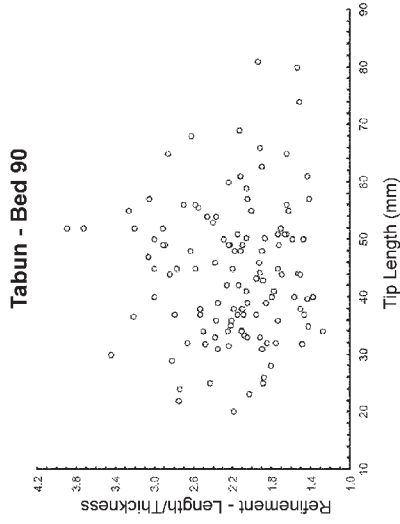
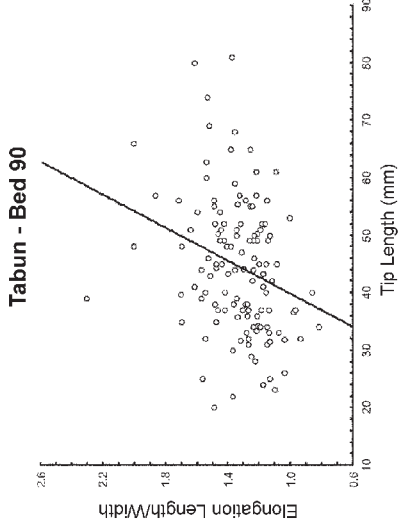
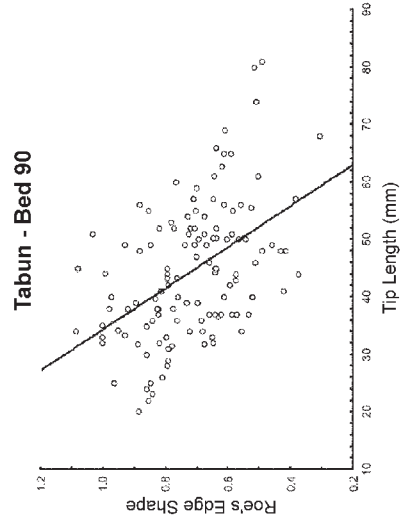


Figure 3.4 Bed 90. See Figure 3.2 for a description of the graphs.

Table 3.4 Comparison of Basic Size Measurements Between Beds with ANOVA Test of Significance

Bed	N	Length		Tip Length		Width		Thickness		Weight	
		Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.
72	50	84.54	15.21	55.08	14.40	56.66	9.88	28.56	7.41	121.10	60.57
73	35	80.77	18.86	52.23	20.52	56.46	11.40	27.83	8.02	129.63	93.28
74	46	79.17	15.88	50.17	14.60	56.13	10.53	25.61	8.30	112.57	68.79
75	75	85.09	20.72	52.16	17.05	59.56	12.38	28.95	9.72	152.31	105.37
76	333	72.65	15.19	43.08	12.47	57.27	10.02	28.64	6.39	120.37	64.80
77	18	68.39	16.99	42.22	12.51	54.83	11.27	27.83	6.90	110.00	61.48
79	134	72.07	13.53	44.36	11.52	56.41	9.31	28.68	6.77	111.82	55.95
80	66	69.39	13.32	42.80	13.37	55.09	9.11	26.26	5.78	98.80	45.79
82	21	77.43	21.39	48.29	19.79	55.14	12.59	29.62	10.31	165.43	150.81
83	61	83.05	22.04	55.21	16.85	57.13	13.35	28.82	10.05	125.75	86.31
84	32	85.81	21.02	54.53	15.65	60.34	11.93	28.03	9.14	147.25	113.32
90	125	74.05	15.40	44.53	11.80	56.48	12.06	27.28	8.44	116.54	76.58
ANOVA	F	9.238		9.864		1.098		1.374		3.102	
	P	0.000		0.000		0.359		0.179		0.000	

Table 3.5 Comparison of Basic Shape Ratios Between
Beds with ANOVA Test of Significance

		Elongation		Refinement		Bordes' Edge Shape		Roe's Edge Shape	
Bed	N	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.
72	50	1.51	0.23	2.06	0.42	-1.04	1.21	0.67	0.20
73	35	1.45	0.30	2.12	0.44	-1.04	1.83	0.67	0.16
74	46	1.42	0.17	2.34	0.63	-1.09	1.54	0.69	0.18
75	75	1.43	0.21	2.21	0.65	-1.49	1.10	0.79	0.22
76	333	1.27	0.19	2.05	0.38	-1.72	0.99	0.80	0.17
77	18	1.25	0.19	2.02	0.42	-1.65	0.76	0.75	0.14
79	134	1.29	0.20	2.06	0.56	-1.45	1.20	0.74	0.19
80	66	1.28	0.24	2.18	0.52	-1.31	1.68	0.76	0.21
82	21	1.42	0.30	1.98	0.56	-1.35	1.23	0.67	0.16
83	61	1.49	0.37	2.15	0.72	-0.59	1.82	0.61	0.18
84	32	1.43	0.23	2.28	0.54	-1.20	1.06	0.61	0.20
90	125	1.33	0.22	2.17	0.52	-1.65	0.89	0.71	0.16
ANOVA	F	12.428		2.410		6.122		10.295	
	P	0.000		0.006		0.000		0.000	

If the reduction strategy leaves a cortical base, then regardless of how thin the tip may become as a result of the bifacial thinning technology, the maximum width and thickness will likely be measured at the base where the cortex preserves the original shape of the nodule from which it was made. In this case, refinement is unlikely to change much with reduction intensity.

Between Assemblage Variability

One of the more interesting aspects of the Tabun data set, in contrast to so many other Acheulian sites, is that it contains a deep sequence of bifacial industries, making it possible to examine patterns through time. In addition, it is already clear that in the Tabun sequence there are several chronological patterns in the retouched tools, flakes, and core reduction strategies (Jelinek 1982). Thus not only can changes in bifacial technologies be examined through time at a single occupation locus, but these changes can also be correlated with changes in the rest of the industry.

There are a number of very clear chronological changes in the Tabun bifaces. Like Jelinek's (1982) scraper to biface ratio these changes are cyclical rather than directional. Consider, for instance, changes in biface size through time as measured by length, tip length, width, and thickness (Figure 3.5, Table 3.5). Only length and tip length are significantly different between beds. Although some time trends are visible in width, statisti-

cally these changes are indistinguishable. Thickness shows the least variability through the section.

With regard to shape, using the basic shape ratios of both Roe (1964) and Bordes (1961), the patterns are nearly identical. All of the ratios show cyclical patterning that results in statistically different shape ratios between various groups of beds (Figure 3.6, Table 3.6). It can also be seen from this graph that changes in the shape ratios tend to follow one another. At the bottom of the sequence in Bed 90 and moving through time to Bed 83, the bifaces are becoming more elongated, more pointed, and more refined. Then each of these aspects of shape start to move in the opposite direction, particularly from Beds 80 through Bed 76. Lastly, the shape ratios switch back again towards the same type of configuration seen in the lower beds.

Given that there is a relationship in each bed between size and shape (based on the data presented here for Beds 76, 79, and 90), and that size varies cyclically through the sequence, it is no surprise that shape also varies in much the same way. If my model is correct and reduction intensity is controlling the size and shape of bifaces within each level, it appears that reduction intensity also varies in a cyclical way through the sequence. The interesting thing at Tabun is that these patterns can be tested against the rest of the assemblage.

Figure 3.7 shows the relationship between Jelinek's (1982) scrapers to bifaces ratio along side the two measures of size that best show reduction intensity: length and tip length. All measures have been standardized to a scale of 0 to 1 based on their range for the beds under consideration in the figure. The two measures co-vary in a manner such that when bifaces are few relative to scrapers, the bifaces are longer, and when bifaces are many relative to scrapers, bifaces are shorter. It is also interesting that in the lower beds, changes in size seem to precede changes in the relative importance. As the bifaces become smaller on average, they also gain in importance relative to scrapers.

Figure 3.8 shows Jelinek's scraper to biface ratio; however, this time against the shape ratios. The patterns are predictably the same. As shape changes, so too does the relative frequency of bifaces and scrapers. In this case, when bifaces are a larger proportion relative to scrapers, they are broader and more rounded. Conversely, when scrapers dominate over bifaces, the bifaces are more elongated and more pointed. To some extent refinement seems to follow the same cyclical pattern, although it is less clear in this case. The changes in refinement are not pronounced throughout the sequence.

Discussion

When the Tabun hominids made more bifaces, in relative proportion to scrapers, they also worked them more intensively before discarding them. Because shape is a function of the reduction intensity, this too varies with the relative importance of bifaces in the assemblage.

The question then becomes why were they making proportionately more bifaces in some levels and more scrapers in others? Eventually, of course, they stopped making bifaces altogether in the Tabun sequence. This basic pattern underlies Lower and Middle Paleolithic variability throughout the Old World, but relatively few sites have it so well represented in a single sequence.

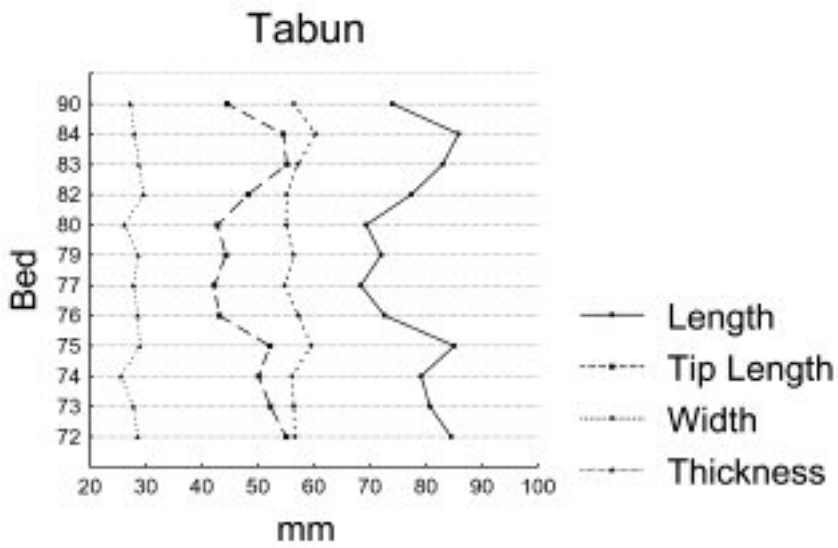


Figure 3.5 Basic measures of size for each bed.

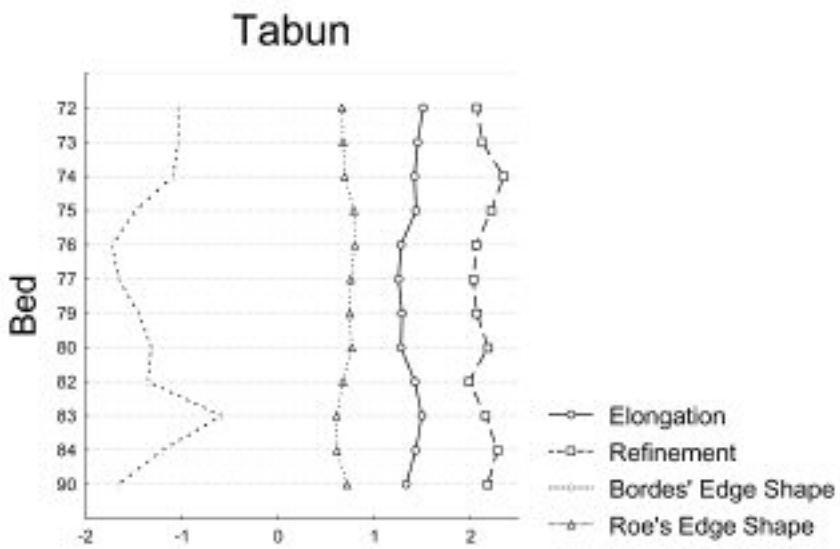


Figure 3.6 Basic measures of shape for each bed.

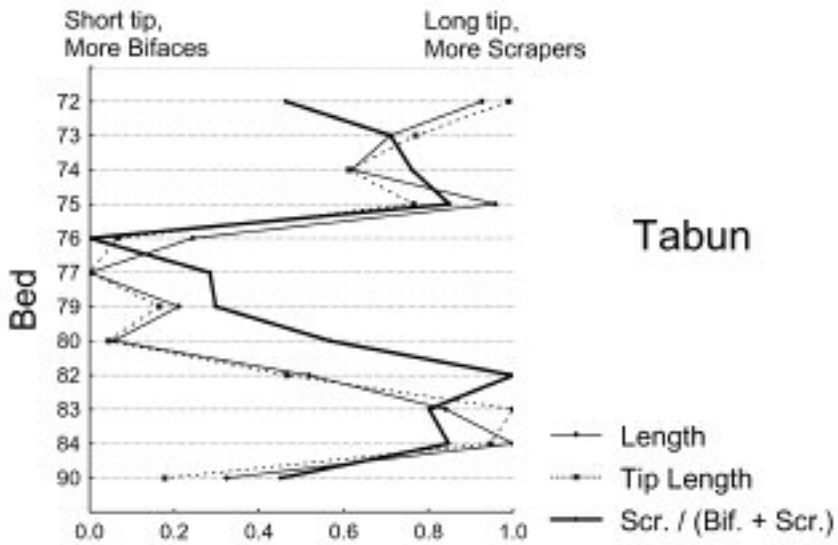


Figure 3.7 Basic measures of size and Jelinek's (1982) biface to scraper ratio (scrapers / (bifaces + scrapers)). All measures have been standardized to a scale of 0 to 1 based on the actual range for each.

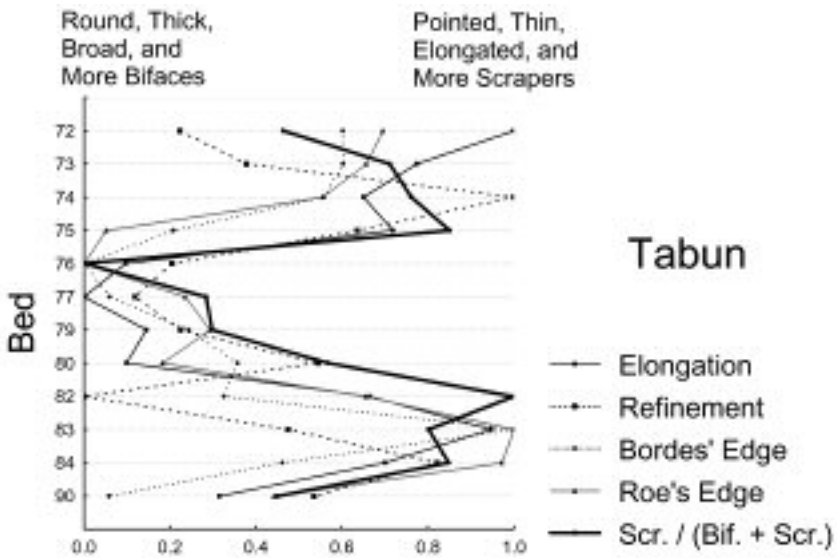


Figure 3.8 Basic measures of shape and Jelinek's ratio (see Figure 3. 6). Roe's edge shape ratio has been reversed to make the associated shapes parallel Bordes' edge shape ratio. All measures have been standardized to a scale of 0 to 1 based on the actual range for each.

Table 3.6 The Tabun Bifaces as Classified According to Roe's System

Bed	Cleaver	Ovate	Pointed	N	Roe's Type
35	0.0	100.0	0.0	1	
41	0.0	0.0	100.0	1	
45	0.0	0.0	100.0	1	
49	0.0	100.0	0.0	1	
59	0.0	0.0	100.0	1	
63	0.0	0.0	100.0	1	
66	0.0	50.0	50.0	2	
67	0.0	0.0	100.0	1	
68	100.0	0.0	0.0	1	
70	0.0	0.0	100.0	3	
71	0.0	45.5	54.5	11	Indeterminant
72	0.0	52.0	48.0	50	Indeterminant
73	8.6	48.6	42.9	35	Indeterminant
74	4.3	52.2	43.5	46	Indeterminant
75	9.3	52.0	38.7	75	Indeterminant
76	6.8	65.2	28.0	339	Ovate
77	0.0	72.2	27.8	18	Ovate
78	0.0	100.0	0.0	1	
79	10.1	51.4	38.5	148	Indeterminant
80	10.6	51.5	37.9	66	Indeterminant
81	0.0	87.5	12.5	8	
82	4.8	52.4	42.9	21	Indeterminant
83	3.3	41.0	55.7	61	Indeterminant
84	3.1	50.0	46.9	32	Indeterminant
85	0.0	100.0	0.0	6	
90	5.0	64.0	30.9	139	Ovate
Totals	6.5	57.3	36.2	1069	Indeterminant

For an assemblage to be classified as one type or another, the type needs to comprise at least 60% of the assemblage. A classification is given here only for assemblage with double-digit biface frequencies.

The fact that we really only have a limited idea of what these tools might have been used for makes it all the more difficult to answer this question. We do not even know for certain whether the bifaces were manufactured primarily as tools with a bifacial edge or as cores for a source of small sharp, flakes or both. In other words, we do not even know what it means to compare scrapers to bifaces. Are we comparing the equivalent of Philips screwdrivers to flat-head screwdrivers or a box of nails to a screwdriver?

To some extent further analyses of Rollefson's data set may help answer some of these questions. Rollefson, for instance, recorded detailed observations on the shape and type of retouch on each edge of the biface and has already shown that some of these data are amenable to this kind of change through time analysis. It may be possible to formulate predictions as to how many and what kinds of edges should predominate under what kinds of conditions in the bifacial and non-bifacial components of the assemblages. It will be interesting to see whether these kinds of bifacial attributes vary as well through the sequence, similarly.

It will also be interesting to see what other kinds of patterns are apparent in the flake tool component of the assemblages and the relative importance of other core technologies. There are numerous other possibilities. The important point is that at Tabun changes in the intensity of bifacial reduction, shape, and their importance relative to flake tools can all be linked together. This means that it may be possible to link bifacial variability into existing models of the kinds of factors, such as availability and access to raw materials and mobility, that are known to structure variability in the flake tool component of other Lower and Middle Paleolithic stone tool assemblages.

Finally, to return to White's suggestion that pointed and ovate forms are the result of two different bifacial reduction strategies applied to different raw materials, the Tabun data do not support such an approach. There are pointed and ovate bifaces in each of the levels considered here. They are all part of a single bifacial reduction strategy applied to an apparently homogenous raw material. The pointed forms are early in the reduction sequence and the rounded forms are late. This is the exact same pattern I found in my own analysis of the British assemblages (McPherron 1995). Likewise, it follows that, in the Tabun assemblages, one cannot say that ovates are the preferred form. Rather, the extent to which ovates occur more frequently than pointed forms is a function of the intensity of bifacial reduction in the assemblage.

It is possible that the Tabun hominids were behaving differently in this regard than the British hominids, but it seems unlikely given that the Tabun patterns match those in the northern French and British data. Ashton, McNabb, and White have demonstrated that raw material is playing an important role in the British assemblages that it does not seem to play at Tabun. Raw material quality, form, and abundance all have the potential to affect how intensively the material will be worked before it is discarded. Together the two lines of explanation have the power to explain the morphological variability we see in bifaces much more satisfactorily than has been previously possible.

Acknowledgments

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References

Ashton, N., and J. McNabb

- 1994 Bifaces in Perspective. In *Stories in Stone: Lithic Studies Society Occasional Papers No. 4*. N. Ashton and A. David, eds. Pp. 182–91. London: Lithic Studies Society.

Bordes, F.

- 1961 *Typologie du Paléolithique Ancien et Moyen*. Paris: Centre National de la Recherche Scientifique.

Callow, P.

- 1976 The Lower and Middle Palaeolithic of Britain and Adjacent Areas of Europe. Ph.D. dissertation, Cambridge University.

Davidson, I.

- 1991 The Archaeology of Language Origins—A Review. *Antiquity* 65:39–48.

Davidson, I., and W. Noble

- 1993 Tools and Language in Human Evolution. In *Tools, Language and Cognition in Human Evolution*. K. Gibson and T. Ingold, eds. Pp. 363–88. Cambridge: Cambridge University Press.

Dibble, Harold

- 1997 Platform Variability and Flake Morphology: A Comparison of Experimental and Archaeologic Data and Implications for Interpreting Prehistoric Lithic Technological Strategies. *Lithic Technology* 22(2):150–70.

Doran, J., and F. R. Hodson

- 1975 *Mathematics and Computers in Archaeology*. Cambridge, MA: Harvard University Press.

Frison, G. C.

- 1968 A Functional Analysis of Certain Chipped Stone Tools. *American Antiquity* 33:149–55.

Gowlett, J. A. J., and R. H. Crompton

- 1994 Kariandusi: Acheulean Morphology and the Question of Allometry. *The African Archaeological Review* 12:3–42.

Jelinek, A. J.

- 1976 Form, Function and Style in Lithic Analysis. In *Cultural Change and Continuity: Essays in Honor of James Bennett Griffin*. C. E. Cleland, ed. Pp. 19–33. New York: Academic Press.

- 1977 The Lower Paleolithic: Current Evidence and Interpretations. *Annual Review of Anthropology* 6:11-32.
- 1982 The Tabun Cave and Paleolithic Man in the Levant. *Science* 216(4553):1369-75.
- McPherron, S. P.
- 1994 A Reduction Model for Variability in Acheulian Biface Morphology. Ph.D. dissertation, University of Pennsylvania.
- 1995 A Re-examination of the British Biface Data. *Lithics* 16:47-63.
- 1999 Ovate and Pointed Handaxe Assemblages: Two Points Make a Line. *Préhistoire Européenne* 14:9-32.
- 2000 Handaxes as a Measure of the Mental Capabilities of Early Hominids. *Journal of Archaeological Science* 27:655-663.
- Mercier, N., H. Valladas, G. Valladas, J. L. Reyss, A. J. Jelinek, L. Megnen, and J. Joron
- 1995 TL Dates of Burnt Flints from Jelinek's Excavations at Tabun and Their Implications. *Journal of Archaeological Science* 22:495-509.
- Roe, D.
- 1964 The British Lower and Middle Palaeolithic: Some Problems, Methods of Study and Preliminary Results. *Proceedings of the Prehistoric Society* 30:245-67.
- 1968 British Lower and Middle Palaeolithic Handaxe Groups. *Proceedings of the Prehistoric Society* 34:1-82.
- Rolland, N., and H. L. Dibble
- 1990 A New Synthesis of Middle Paleolithic Assemblage Variability. *American Antiquity* 55(3):480-99.
- Rollefson, G. O.
- 1978 *A Quantitative and Qualitative Typological Analysis of Bifaces from the Tabun Excavations, 1967-1972*. Ann Arbor: University of Michigan.
- White, M. J.
- 1998 On the Significance of Acheulian Biface Variability in Southern Britain. *Proceedings of the Prehistoric Society* 64:15-44.
- Wynn, T., and Tierson, F.
- 1990 Regional Comparison of Shapes of Later Acheulean Handaxes. *American Anthropologist* 92:73-84.



4

BIFACIAL TOOLS IN THE LOWER AND MIDDLE PALEOLITHIC OF THE CAUCASUS AND THEIR CONTEXTS

Vladimir Doronichev and Lubov Golovanova

It is currently believed that bifacial techniques first appeared in the Caucasus during the Mindel-Riss Interglacial. In this region, pointed bifaces dominated in assemblages during the Lower Paleolithic, whereas classic biface types became rare near the beginning of the Upper Acheulian. The majority of Acheulian sites here are Upper Acheulian, many of which, especially in the Transcaucasus, are dominated by partial bifaces, often made on flakes. Middle Paleolithic sites in the northwestern Caucasus are characterized by a wide spectrum of bifacial and partial-bifacial tools, including bifacial backed knives typically found in the Micoquian industries of Europe. In contrast, very few bifacial tools are found in the Mousterian sites in the Transcaucasus. It seems that the northern Caucasus and Transcaucasus were inhabited by different cultural groups during the Lower and Middle Paleolithic. What is typically found in the northern Caucasus are Lower Paleolithic industries with few or no bifaces, and eastern European Micoquian industries in the Middle Paleolithic. In contrast, the later Lower Paleolithic in the Transcaucasus is dominated by Acheulian industries with numerous bifaces and the Middle Paleolithic industries are similar to Zagros and Levantine Mousterian industries.

The earliest traces of human occupation in the Caucasus come from Dmanisi in southern Georgia, which has been dated to approximately 1.7 million years ago (Gabunia et al. 2000). Ubeidiya in Israel, which dates to between 1.4 and 1.0 million years ago (Bar-Yosef 1998:242) is the site that is environmentally and chronologically most similar to Dmanisi. However, the industry found at Ubeidiya is very dissimilar to that found at Dmanisi, containing macro-tools with bifacially trimmed surfaces. Bifacial macro-tools (i.e., axes, cleavers, picks), which can be assigned to a “Large Cutting Tools” group, are characteristic of the Acheulian techno-complex. Because they are absent from Dmanisi, we can attribute its industry to the Lower Paleolithic Oldowan (Gabunia et al. 2000:25), whereas the Ubeidiya industry can be attributed to the Lower Acheulian (Bar-Yosef 1998).

Early Middle Pleistocene Sites

There are no Acheulian sites contemporary with Ubeidiya in the Caucasus. The data that are currently available allows us to hypothesize that industries without bifaces preceded the appearance of the Acheulian complex in this area. After Dmanisi, the next oldest site is Amiranis-gora in southern Georgia. Approximately 20 artifacts (pebble cores,

Table 4.1 Proposed Chronological Correlations for
Lower Paleolithic Cave Sites in the Caucasus

Oxygen-isotopic stages	Ages of OIS stages (ka)	Sites			
7	195-246	Treugol'naya, 4a,4b,4c (up)	Kudaro I, 5a/VI-VII	Tcona	Azih, V (levels 6-7)
8	245-303	Treugol'naya, 4c (low)	Kudaro I, 5a/VIII 245-29; 252-51 ka (TL)	Kudaro III, 5	Azih, V (levels 8-9)
9	303-339		Kudaro I, 5b 350-70 ka (TL)	Kudaro III, 6-7	Azih, V (levels 10-11)
10	339-362	Treugol'naya, 5a	Kudaro I, 5c/Xa	Kudaro III, 8	Azih, VI ?
11	362-423	Treugol'naya, 5b 393-27 ka (ESR)	Kudaro I, 5c/X 360-90 ka (TL)		
12		Treugol'naya, 5c			Azih, VI ?
13					
14					
15	565-620	Treugol'naya, 6, 7a, 7b 583-25 ka (ESR)		Kudaro III, 8a 560-112 ka (TL)	

flakes, flake-tools) have been found here. Based on the faunal data, these lithics have been dated to between the end of the Lower Pleistocene and the beginning of the Middle Pleistocene (Gabunia 2000).

Sites from the beginning of the Middle Pleistocene (600-500 thousand years) are represented by finds in layer 7a at Treugol'naya cave (Doronichev 1998, 2000) and, perhaps, finds in layer 8a at Kudaro 3 cave (Liubin 1998a). These assemblages are correlated with a warm period at the end of the Günz-Mindel (Cromerian) Interglacial in Europe (stage 15 on the oxygen-isotope scale). Layer 7a at Treugol'naya cave has been dated to 583,000 $\pm$ 25,000 years ago by a series of six ESR dates, and the upper level of layer 8a at Kudaro 3 cave has been dated by thermoluminescence to 560,000 $\pm$ 112,000 years ago. Both these assemblages contain only a few artifacts (Treugol'naya layer 7a-15; Kudaro layer 3, 8a-11). The tools consist of single sidescrapers and other flake tools.

Sites dated to the Mindel Glaciation (oxygen-isotope stage 12-14) are unknown in the Caucasus. Closest in time are finds from layers 5a, 5b, and 5c in Treugol'naya cave, which have been dated to the beginning of the Mindel-Riss Interglaciation (Table 4.1). Layer 5b correlates with the first optimum of this interglaciation (oxygen-isotope stage 11), having been dated by two ESR dates to 393,000 $\pm$ 27,000 years ago. Because finds in these layers are very scarce (18 artifacts in total), they have been combined in one assemblage. It is characterized by a predominance of the "Other Flake Tools" category (endscrapers dominate over sidescrapers), and a lack of Acheulian bifaces.

Later Middle Pleistocene Acheulian Cave Sites

It is generally believed that the Caucasus (in particular, the Transcaucasus) is a region where Acheulian industries containing bifaces spread during the Lower Paleolithic

(Liubin, 1998a:172). The data presented above demonstrate that this view is incorrect. Lower Paleolithic industries without classical Acheulian bifaces are found in cave sites in the Caucasus during the second half of the Middle Pleistocene, for example in the assemblages from layers 4a, 4b, 4c, and 4d at Treugol'naya cave (more than 300 artifacts in total). An unusual series (for the Caucasus) of Paleolithic macro-tools made from limestone pebbles was found here: pointed proto-bifaces or chopping-tools and heavy pick-like unifacial tools (Figure 4.1:8,9). In the assemblages from layers 5 to 8 of Kudaro 3 cave (about 80 artifacts in total) only one biface was found, in layer 5, an atypical *lagéniforme* (Figure 4.1:7). The lower layer of Tcona cave (30 items) also lacks bifaces.

Layer VI at Azikh cave might possibly date to the middle of the Middle Pleistocene (Liubin 1998a:44). This assemblage contains 1890 artifacts, mainly made from slate. Among 427 tools identified in the layer, sidescrapers (207) and other flake tools (191) predominate. A series of more than 30 pebble tools includes types not usually found in Acheulian cave sites in the Caucasus. Bifacial tools are represented by an amigdaloid hand-axe (Figure 4.2:6), a possible biface fragment, and an atypical hachereau. The remaining eight bifacial tools recognized in the layer (Guseinov 1984) are amorphous and difficult to categorize. One hand-axe is similar to bifaces from the upper portion of level V, and intrusion of material from level V into level VI is quite likely (Liubin 1998a:29). The layer VI assemblage at Azikh cave cannot be unequivocally attributed to the Acheulian techno-complex because the bifacial tools are few in number and undiagnostic in contrast to the pebble tools, which are relatively numerous and identifiable.

It is likely that the earliest appearance of the Acheulian techno-complex in the Caucasus was during the Mindel-Riss Interglacial (Likhvin interglacial in eastern Europe). Level 5a in Kudaro 1 cave, where an oval slate biface was found (Liubin 1998a:58), has been TL dated to $360,000 \pm 90,000$ years ago, and correlates, based on palynological data, to the end of stage 11 – stage 10 of the oxygen-isotope scale. It would seem that the industries from upper levels 5a-5b at Kudaro 1 cave represent a specific variant of the Acheulian. This industry may also be represented in deposits from the second half of the Middle Pleistocene (oxygen-isotope stages 9–7 ?) in levels 5a and 5b at Kudaro 1, the upper level at Tcona, and at Azikh, level V (Table 4.1). Because of the high percentages of Charentian-type (convex and transverse) sidescrapers in the assemblages, these Acheulian industries were defined as “Proto-Charentian” (Liubin, 1981:13).

As far as it is possible to judge based on the small quantity of published data available, all of these industries have the following characteristics: (1) a non-Levallois flaking technology that allowed production of elongated blanks up to 20–25 cm in length, and in which massive flakes with high-angled striking platforms predominate; (2) frequent usage of steep elongated (*surélevées* type), scale and stepped (*Quina* type) retouch; (3) a predominance of sidescrapers (mostly single and transverse sidescrapers with convex edges); (4) high percentages of denticulates, notches, and endscrapers, with some typical Tayac points and limaces; (5) few large cutting tools—elongated partial bifaces made on flakes (Figure 4.3:1, 2, 5, 6), some *bachereaux sur éclats* (Figure 4.3:3, 4, 7, 8) and partially bifacially backed sidescrapers (*bifaces à dos*) (Figure 4.1:4-6) are the most common, with a very small number of classical Acheulian bifaces in the form of elongated pointed hand-axes (Figure 4.2); and (6) moderate percentages of chopper/chopping-tools.

A general description of the bifacial tools found in these assemblages is provided. In level V of Azikh, out of a total of 289 tools, only 7 bifaces manufactured from slate were found, half of which were made on flakes (Guseinov 1984). The largest biface is a 17-cm

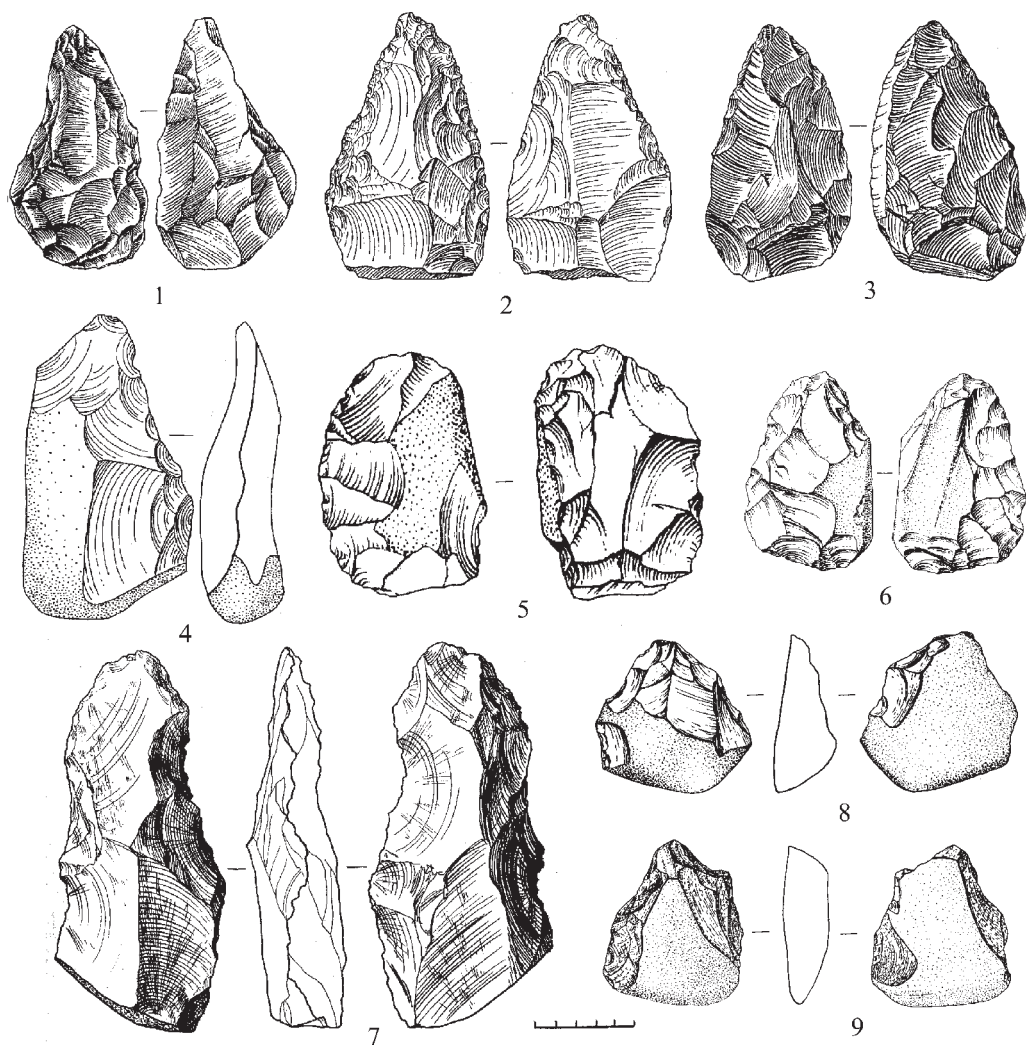


Figure 4.1 Bifaces from Tcona (1-3) and Kudaro 3 (7), backed bifaces from Tcona (4), Azikh (5), and Kudaro (6), and partial bifaces from Treugol'naya cave (8-9). (Sources: Doronichev, 2000; Kalandadze, 1969; Liubin, 1998a)

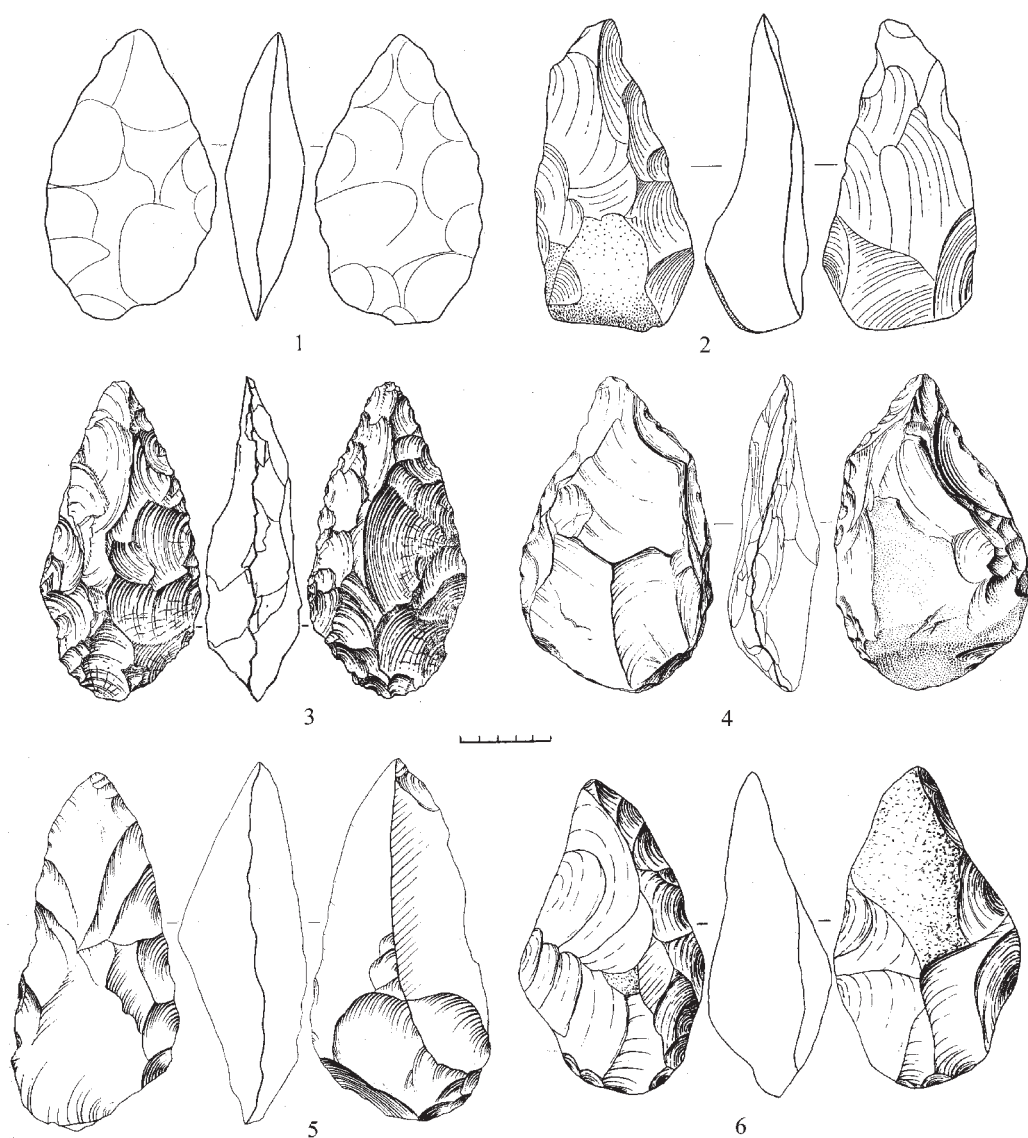


Figure 4.2 Bifaces from Acheulian cave sites: Tona (1, 2), Kudaro 1 (3, 4), and Azikh (5, 6). (Source: Liubin, 1998a)

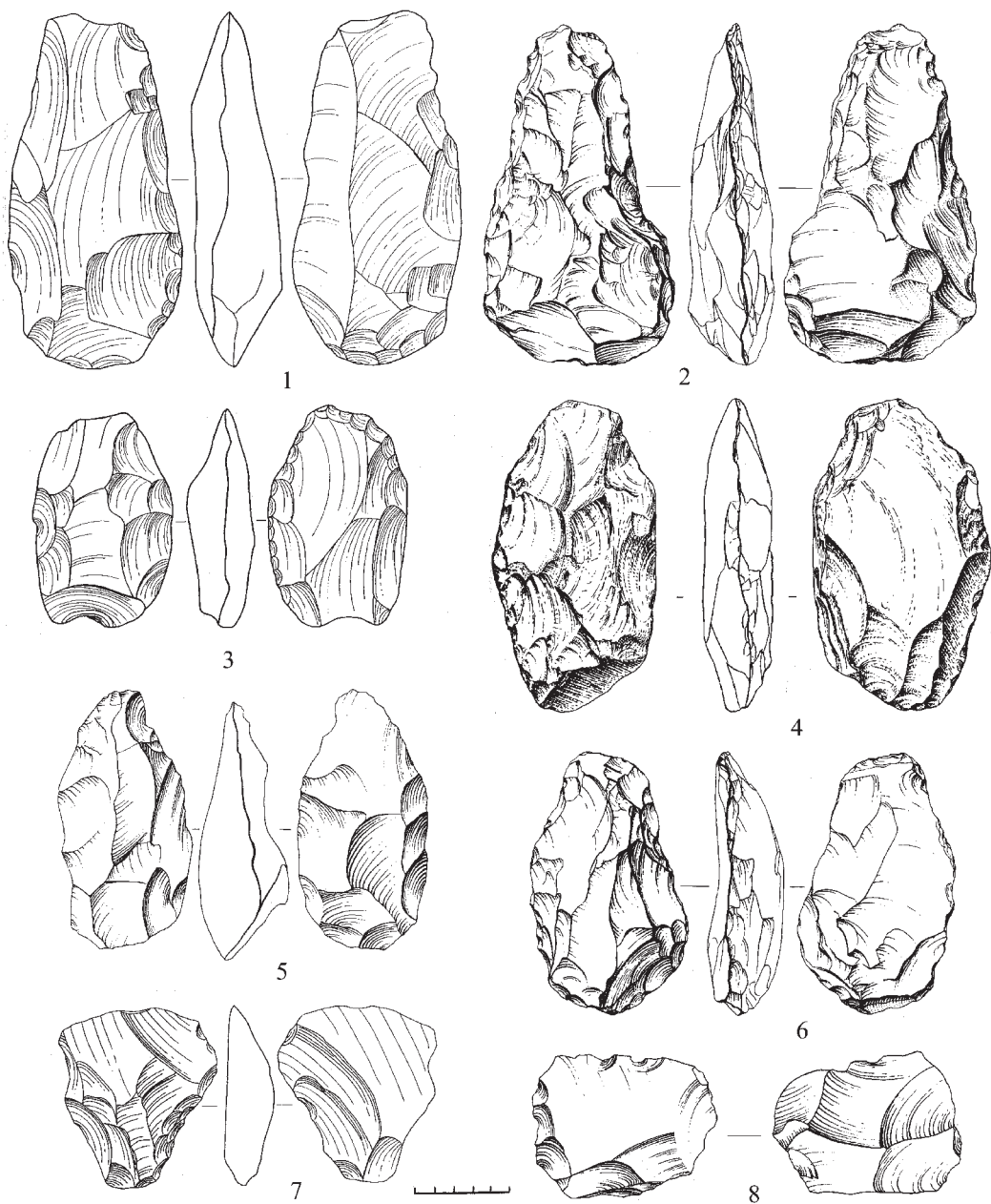


Figure 4.3 Bifaces on flakes and cleavers (*bachereau sur éclat*) from Acheulian cave sites: Tcona (1, 3, 7), Kudaro 1 (2, 4, 6), and Azikh (5, 8). (Source: Liubin, 1998a)

long lanceolate. There are two other elongated partial bifaces, 14.4- and 12-cm long, both with heavily thinned bases (Figure 4.2:5). There are also some backed bifaces (Figure 4.1:5) and *bachereaux sur éclats* (Figure 4.3:8). At Kudaro 1, levels 5a, 5b and 5c produced more than 5000 artifacts. Two lanceolate hand-axes manufactured from sandstone (Figure 4.2:3) and an amygdaloid biface (Figure 4.2:4) are the most skillfully made. The other bifaces found at this site are small, mainly manufactured on flakes, and are often atypical (Liubin 1998). The most noteworthy examples are two elongated bifaces on flakes (Figure 4.2:2, 6), an *bachereau sur éclat* (Figure 4.3:4), and a partially bifacially worked sidescraper (Figure 4.1:6).

The bifaces found in the upper level of Tcona, the largest Acheulian cave site in the Caucasus, are also worth noting (Kalandadze & Tushabramishvili 1978). Forty-seven of 104 artifacts found here are bifaces (Liubin 1998a: 96). Slate was the main raw material utilized for tool production. Bifaces were made from cobbles or from large flakes. They are predominantly large (12–18 cm), elongated (one greater than 1.5m), with flat profiles (index of refitting no greater than 2.35), straight or slightly curved edges, and pointed or rounded tips. Many of these bifaces exhibit plano-convex retouch, and were made on elongated flakes (Figure 4.3:1). Some are similar in size and manufacturing technique to Upper Acheulian leaf-like bifaces (Figure 4.1:1–3). There are only a few typical pointed Acheulian bifaces (Figure 4.2:1, 2) and backed bifaces (Figure 4.1:4). Tcona has the largest collection of *bachereaux sur éclats* in the Caucasus (Figure 4.3:3, 7), with the majority being 8 to 12 cm long.

Unfortunately, the Lower Paleolithic materials from cave sites in the Caucasus are almost completely unpublished, which prevents us from developing a comprehensive framework of how Lower Paleolithic cave industries developed in this region. From the data that are available, it is possible to suggest that cave industries with Acheulian bifaces (Kudaro 1, 5a–5b; Tcona, upper level; Azikh, V) were a local variant of the Acheulian, which existed only in part of the Transcaucasus and for only a limited period of time. Its chronological range can be tentatively set at from ca. 200,000 BP throughout ca. 350,000 BP (oxygen-isotope stages 7–9/10). Its relationship to the other Acheulian industries in the Caucasus, as well as to those of the Near East, remains unclear.

Acheulian Locations in the Transcaucasus

From an examination of the geographic distribution of Acheulian sites in the Caucasus two concentrations, which appear to be independent of each other, can be noted. These industries appear mainly in the highlands of the central Transcaucasus. This area is rich in sources of obsidian, as well as having lesser quantities of andesite and basalt, which were used for the production of bifaces and other tools. The largest group of Acheulian sites in the Caucasus, which includes Satani-dar, Atis and Djaber, is located here and has yielded more than 700 Acheulian bifaces. Another small group of Acheulian sites, where just under 70 bifaces manufactured from siliciferous rocks have been found, is located on the south slope of the Greater Caucasus ridge in the Central Transcaucasus. Acheulian bifaces made from flint are very rare in the western Transcaucasus, northwestern Caucasus, along the Black Sea coast, and in the eastern Transcaucasus. There are Upper Acheulian sites located in the northwestern Caucasus, where there are sources of high quality flint. While sites exist in the Transcaucasus which are rich in Acheulian bifaces, in the majority of cases, only surface gathering of material was performed. The collections remain almost completely unstudied, and publications are sparse. In some cases, all that

Table 4.2 Statistical Data on Acheulian Locations in the Transcaucasus

Locations	Total number	Number (percent) of bifaces
Satani-dar	about 800	185 (23.0)
Arzni	250	25 (10.0)
Djraber	3,000	50 (1.7)
Atis	2,000	420 (21.0)
Lashe-Balta, Kaleti, Tigva, Goristavi	?	about 70
Yashtukh	?	8

is known is the total number of finds, with sometimes the number of bifaces listed (Table 4.2).

Even that limited data, when available, shows that in many cases we are dealing with sites which are isochronic although, perhaps, facially different. According to Panichkina (1950), at Satani-dar, which is one of the best studied locations, the material comes from isochronic sites which no longer exist. The sites of Djrabber, Fontan, and Kendarasi are huge workshops, several square kilometers in area, located on sources of raw material (Liubin 1998a). Atis 1 is also situated on a source of raw material (Kazarian 1986), but the percentage of bifaces here is much higher. Yashtukh consists of more than 50 isochronical find-spots (Korobkov, 1971). The Acheulian materials in those collections were identified typologically. In some cases several distinct industries were identified: early and late Acheulian at Satani-dar, Upper and Final Acheulian at Atis 1, and Late Acheulian and Mousterian at Arzni.

It is obvious that new, more sophisticated studies need to be undertaken on all these assemblages. First, an analysis of the technological processes (*chaîne opératoire*) involved in biface production needs to be performed. At many locations workshops for stone flaking and biface production were found which were located on raw material sources. This means that most bifaces at these sites were abandoned at various stages of production. Nonetheless, most bifaces have been identified as finished forms, and their typological characteristics have been used as a basis for dating. A complex technological analysis was performed only at Satani-dar (Matiuhin 1981; Golovanova 1984) which demonstrated that the majority of bifaces, although ranging typologically from coarse amorphous bifaces to well made Upper Acheulian ones, could be considered to all belong to one manufacturing process.

Unquestionably, these sites are also of considerable interest because they are the product of different aspects of human survival strategies than stratified cave sites. However, the finds require careful study and comparison with assemblages from cave sites using modern methodologies. At present, one can say no more than that in some locations biface types similar to those found in cave sites have been found. However, such analogies are not very enlightening, besides which obsidian industries from Acheulian sites in the Transcaucasus highlands differ from Acheulian cave assemblages in the Transcaucasus.

An assemblage from Satani-dar, in which pointed bifaces predominate and which can be typologically dated to the Upper Acheulian, seems to be one of the most recent (Figure 4.4:2, 4, 5, 7, 8). A majority of these bifaces have plano-convex cross-sections, and more than a third are partial bifaces. A series of sub-triangular bifaces, made on flakes, is the most striking (Figure 4.4:5, 7, 8). In contrast, at Djaber, much larger, predominantly elongated cordiform double-convex bifaces, manufactured mainly from blocks, are the most common (Figure 4.4:1, 3, 6). Thus, based on the materials recovered from Acheulian locations in the Transcaucasus several variants of the Acheulian industry existed in this region. However, because these assemblages have been poorly studied and published we cannot currently make any definitive statements about them.

Upper Acheulian Locations in the Northern Caucasus

A total of approximately 40 Acheulian sites (Autlev 1981; Formozov 1965; Golovanova 1986) are currently known from the northern Caucasus. The geomorphologic positions of the sites permit them to be dated from the later Middle Pleistocene to the Last Interglaciation (Golovanova 1986, 2000; Nesmeyanov 1999) or from oxygen isotope stages 6 throughout 5. Typologically they have been dated to the Upper Acheulian. The sites richest in finds are concentrated in the northwestern Caucasus, and can be grouped through technological and typological analysis into three local variants or groups—Abadzeh (sites at Abadzeh, Fortepyanka, and Kurdjips), Abin (sites at Abin and Khabl'), and Khadjoh (open air sites at Sredniy Khadjoh and Shahan, and a workshop at Shahan) (Golovanova 2000). These sites have been tentatively dated to oxygen-isotope stage 6 (Table 4.3).

All the Upper Acheulian sites in the region are characterized by pointed bifaces (Figure 4.5). The Khadjoh group contains small sub-triangular double-convex bifaces with wide deep scars (Figure 4.5:1, 2). Sub-triangular plano-convex bifaces (Figure 4.5:3, 5) are characteristic of the Abadzeh group. Isolated sub-cordiform double-convex, sub-triangular double-convex, and Micoquian type bifaces have been found in the Abadzeh area. They exhibit large elongated scars, often have leaf-like morphologies (Figure 4.5:4), and have been roughly shaped. A typological peculiarity of the Abin group is that tools make

Table 4.3 Proposed Chronological Positions for Upper Acheulian and Early Mousterian Sites in the Northern Caucasus

OIS Stage	Age (kyr)	Alpine scale	Sites
4			Matuzka, layer 5B ?
5	125	R-W	Matuzka, layer 6 Matuzka, layer 7
6	180	Late Riss	Sredniy Khadjoh, Shahan w. Abadzeh, Fortepyanka, Kurdjips Abin, Habl'

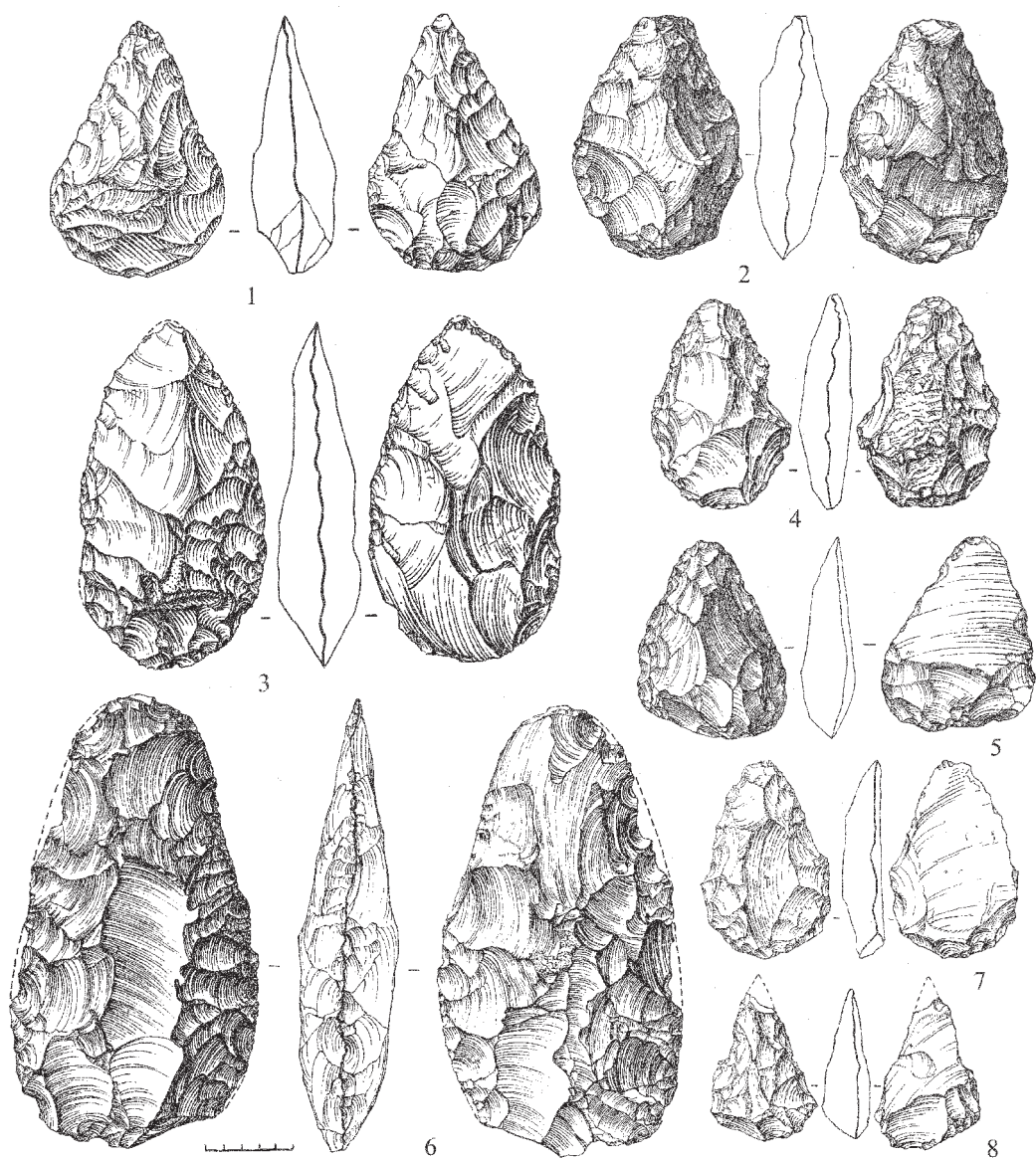


*Figure 4.4 Bifaces from Acheulian sites: Djraber (1, 3, 6) and Satani-dar (2, 4, 5, 7, 8).
(Sources: Liubin, 1989; 1998a)*

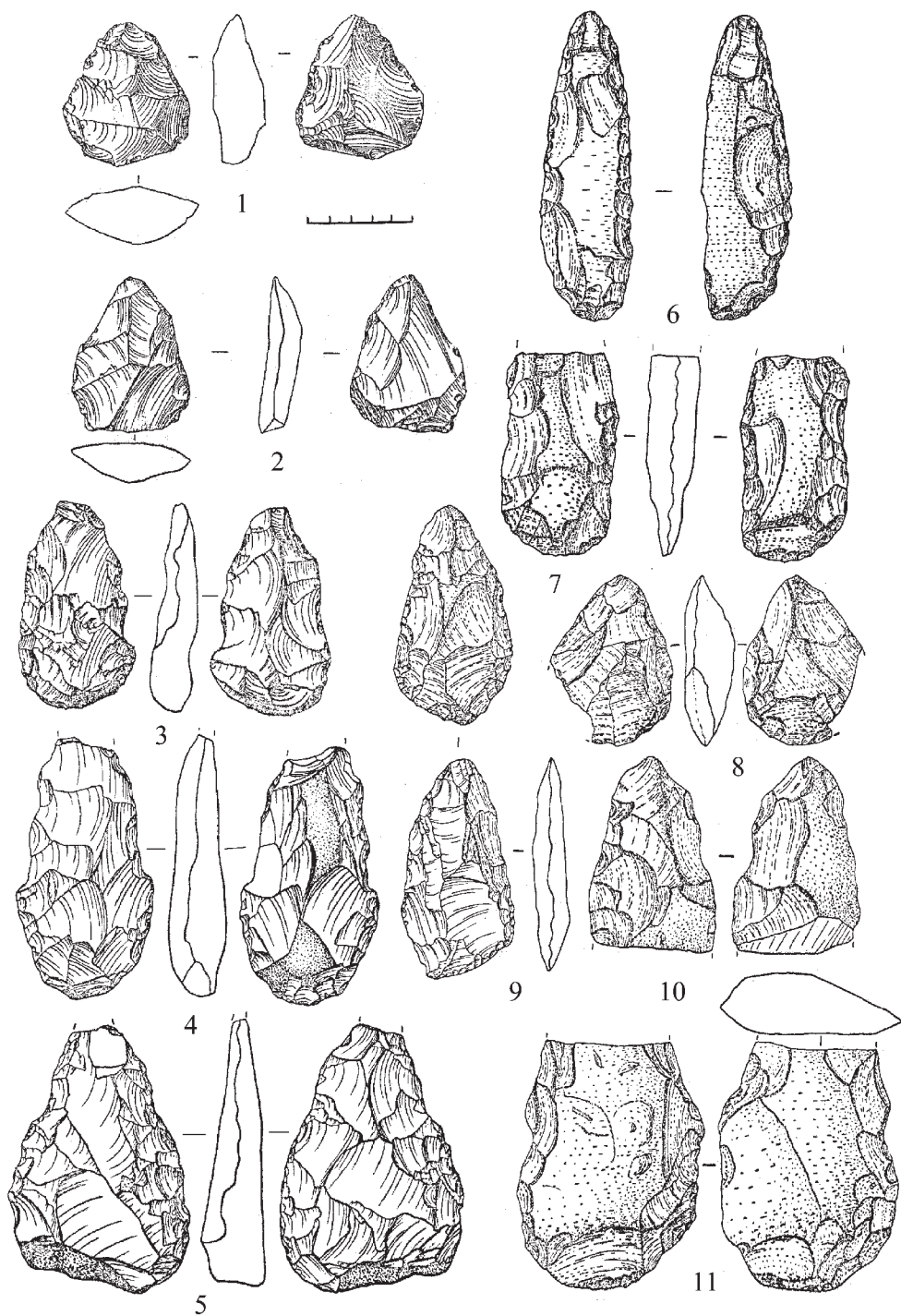


Figure 4.5 Bifaces from Upper Acheulian sites in the northwestern Caucasus: Sredniy Kbadzob (1, 2), Fortep'yanka (3), Abadzeb (4, 5), and Abin (6-11).

Table 4.4 Technological and Typological Indexes for Upper Acheulian Sites in the Northern Caucasus

Sites	Ilam	IFl	IFst	IR	IC	IDent	IUP	IB	Index Convergent Tools
Abadzeh	13.5	61.7	38.1	31.5	17.0	37.7	6.4	3.1	1.3
Fortepyanka	13.5	24.3	10.0	27.3	18.2	27.3	14.5	3.1	4.3
Kudjips	19.0	54.9	31.0	40.6	31.3	6.3	15.6	4.4	2.9
Sredniy Khadjoh	-	14.3	-	6.7	-	38.2	25.8	3.0	-
Shahan workshop	-	17.9	-	27.6	-	13.8	31.0	3.3	-
Abin	?	?	?	29.2	5.1	-	2.2	32.9	2.1

up to 28.2% of the total (216 items), with heavy-duty tools (37.5% or 81 items) and bifaces (32.9% or 71 items) predominating. Triangular, sub-triangular (Figure 4.5:8,9), sub-cordiform (Figure 4.5:11), oval, and elongated oval bifaces, as well as a series of partial biface leaf-like projectile points (Figure 4.5:6, 7, 10) are represented here.

At all the Upper Acheulian sites a method of parallel flaking on slightly convex surfaces was used. The principal differences lie in methods of core preparation and utilization (Table 4.4). Usage of former scars as striking platforms and an orthogonal technique of striking are characteristics of the Khadjoh group. In contrast, utilization of only one surface on a core is typical for the Abadzeh group. The flaking technique utilized in the Abadzeh group yielded more blades and elongated flakes: 13.5% at Abadzeh and Fortepyanka, and 19.0% at Kurdjips. At the Khadjoh group sites, blades are completely absent, whereas elongated flakes make up to between 4 and 4.3% of the assemblages at Sredniy Khadjoh and Shahan, and 8.8% at the Shahan workshop. Larger flakes were selected for tool production.

A comparison of these sites using Bordes' (1961) typology indicates that higher numbers of sidescrapers and Upper Paleolithic tools are characteristic of the Khadjoh group (Table 4.4). Bifaces are rare in both the Abadzeh and Khadjoh group assemblages, whereas they form up to 32.9% of those in the Abin group, which also contain 29.2% sidescrapers and choppers/chopping-tools (81 items).

The Upper Acheulian assemblages found in the northwestern Caucasus show some similarities to those from Near Eastern and European sites, but cannot be linked with any of them. The Abadzeh group industries seem to be similar to many Upper Acheulian sites in the Near East. The latter are characterized by the presence of the Levallois technique, a predominance of pointed bifaces (amygdaloid and cordiform bifaces outnumber ovates), and sometimes large numbers of flake tools (Bar-Yosef, 1998). The Abadzeh group sites are also characterized by what could be considered a Levallois technique, developed parallel flaking, cordiform and sub-triangular bifaces, and a high percentage of sidescrapers (up to 25.9%) and other flake tools. However, their biface indexes are very different: 36.0 at Kissufim, 40.0 at Evron, up to 32.0 at Tabun E (Jelinek 1975; Rollefson 1980), only 3.1 in the assemblages at Abadzeh, and Fortepyanka and 4.4 at Kurdjips. Moreover, there are high percentages of Yabrudian déjeté sidescrapers at some Near Eastern Upper Acheulian sites (up to 8.2% at Tabun E, 21.6% at Kissufim, and 28.3% at En-

el-Assad). These tools are almost completely absent from the Upper Acheulian assemblages of the northern Caucasus. In contrast to the Upper Acheulian industries of the northwestern Caucasus, the majority of the Upper Acheulian sites recognized in Northern France, Southern Germany (Salzgitter-Lebenstedt, Hannover-Dohren, Rethen, Herne, Balver Hohle), and Belgium (Grotte de l'Hermitage, Docteur) have yielded Mousterian points and convergent tools in significant numbers (Bosinski 1967; Ulrix-Closset 1975). An assemblage from Sredniy Khadjoh shows some interesting similarities to the industry from Muret in the Northern Alps (Malenfant 1976), namely in the primitive flaking techniques utilized, low blade indexes (6.9 at Muret and 4.4 at Sredniy Khadjoh), low faceting indexes, and low sidescraper indexes (Muret-9.85, Khadjoh-10.1). Both assemblages also contain endscrapers/burins, Quinson points, and partial bifaces.

There is no evidence that the Upper Acheulian industries of the Northern Caucasus evolved into the Mousterian industries that followed them. At the end of the Riss-Würm interglacial and beginning of the Würm glaciation, eastern European Micoquian assemblages appeared in the northwestern Caucasus. They were completely different from the earlier Upper Acheulian industries. Thus, a discontinuity is observable between the local Upper Acheulian and Mousterian industries in the Northern Caucasus (Golovanova 1994, 2000).

Micoquian Assemblages in the Northwestern Caucasus

There are eight known Middle Paleolithic sites in the Northern Caucasus which contain Micoquian industries: Il'skaya 1, Il'skaya 2, and Baranaha 4, which are open-air sites; Monasheskaya, Barakaevskaya, Mezmaiskaya, and Matouzka caves; and Gubskiy rockshelter 1. In total, they contain 27 layers of what are generally considered to be eastern European Micoquian industries (Bosinski 1967; Gabori 1976), although they have also been argued to be East-European Mousterian industries (Praslov 1984). Dates have been obtained for these industries that range from the beginning of the Riss-Würm interglacial through almost the entire Würm glaciation (Table 4.5).

Zamiatnin (1929; 1934), who excavated Il'skaya 1, was the first to recognize the presence of the Micoquian industry in the northern Caucasus. His point of view was later shared by Praslov (1970, 1984) and Formozov (1965), whereas Liubin (1977, 1984:63) identified this industry as a Charentian-type Mousterian, and only recently changed his mind (Liubin 1998b). However, all researchers linked the Il'skaya 1 industry to the Mousterian sites then known in the northwestern Caucasus (Monasheskaya cave and Gubskiy rockshelter 1). Moreover, Formozov (1977) noted that this industry is closer to the biface-rich East European Mousterian sites than to other Mousterian sites in the Caucasus. In a recently published comprehensive report, the industry of Il'skaya 2, an important site discovered in 1979 and excavated by Shelinskiy (1998), was studied in conjunction with the materials from Il'skaya 1.

Mezmaiskaya cave in the northwestern Caucasus was discovered in 1987. This site contains the most complete Micoquian succession in the region (seven Mousterian levels) and helped to clarify the dating of the earliest Micoquian industries in the northern Caucasus and to trace their development through the Würm glaciation. Based on the stratigraphy at Mezmaiskaya, it is possible now to associate Mousterian industries that were never before linked together. The degree of preservation of organic material at this site is unique for the Middle Paleolithic, enabling a series of carbon-14 dates (Golovanova

Table 4.5 Chronological Correlations for Micoquian Sites in the Transcaucasus

Age (kyr)	OIS Stage	SW/ NW France	I'skaya 2	Ilskaya I	Mezmayetskaya	Barakaevskaya	Monasheskaya	Gubskiy I	Matuzka	Baranaha 4
30,000		WIIIb			Layer 2 32,230 ± 740 (LE-4735)					
35,000	3	WIIIa			Layer 2A 35,760±400 (Beta-53896/ CAMS-2999) 36,280±540 (Beta-53897/ ETH-9817) ?		Layers 2-3	?		?
			?					Layers 5-7	Layer 4B 34,200 ±1,410 (LU-369) Layer 4C	Layer 2
45,000		W II-III			Layer 2B-1 Layer 2B-2 40,660±1600 (LE-3599)***	Layer 3	Layer 4	?		?
50,000		W I-II		?	Layer 2B-3 Layer 2B-4 Layer 3 >45000 (LE-3841) ?					
60,000			?	Upper Layer. ?						
75,000	4		Layers III-V	?						
118,000	5a-d		Layers VI-VIII	Lower Layer U-series*: 135,000±25,000 C14**: 37,200±1,800; 40,800±1,200 lo-date*: 47,000±2,000						
128,000	5e	R-W								

*Tcherdintcev 1969; **Ivanova 1982 (no data on what levels of I'skaya I these dates come from); ***C14 date for all of bed 2B.

et al. 1998a, 1998b, 1999) to be obtained which provide a framework for studying the chronological positions of other Mousterian sites in the northwestern Caucasus that are currently undated (Table 4.5).

New data from Il'skaya 2 (Shelinskiy 1998) provide a tentative relative chronology at this site. The lower alluvium deposits (layers VIII–VI) have been attributed to the last interglaciation (oxygen-isotope stage 5e) based on the geomorphologic position of this site on a river terrace. However, it is unclear why the higher deposits (layers V–II) were dated to OIS stages 5d throughout 5a. No absolute dates or comprehensive palynological spectrums are currently available. Moreover, both the stratigraphic and palynological data point to a complex and long history of deposits at this site, as well as to possible breaks in sedimentation.

The presence of certain types of bifacial tools is the main factor that links all these sites and distinguishes them from other Mousterian sites in the Caucasus. These include small, broad, triangular handaxes (*Breit dreieckige Faustkeilblätter*), laurel leaf-like projectile points, various bifacial and partially bifacially worked convergent tools, as well as various bifacial sidescrapers and knives similar to *Bocksteinmesser*, *Prondnikmesser* and *Wolgogradmesser* types (Bosinski, 1967). The earlier sites differ from the later ones not only in their higher percentages of bifacial tools, but in their greater diversity.

The Il'skaya 1 industry contains leaf-like projectile points (Figure 4.6:1), small triangular handaxes (Figure 4.6:3, 11), several types of convergent tools (Figure 4.6:2, 8), and fragments of triangular bifaces (Figure 4.6:7). Types of bifacial sidescrapers include partially bifacially worked *Keilmesser*-like sidescrapers with well-trimmed lateral sides and bases (Figure 4.6:4, 10, 12), and *Prondnikmesser*-like tools with distal backs thinned by elongated burin-like scars (Figure 4.6:6). There are also bifacial and partially bifacially worked sidescrapers similar to *Wolgogradmesser* types (Figure 4.6:9) in the Il'skaya 1 industry. Some bifacial tools have contours similar to unifacial Chokurcha triangular tools. Many convergent scrapers, sidescrapers, and endscrapers exhibit some bifacial retouch. Burdukiewicz (2000) stresses that the definition of *Prondnikmesser*-like knives includes having a back thinned by flat burin-like scars, although this definition has long been disputed.

In the lower levels, 3 and 2B, of Mezmaiskaya cave, leaf-like bifacial projectile points (Figure 4.7:1), small triangular handaxes (Figure 4.7:3, 4), and various bifacial sidescrapers have been found. Among the latter, bifacial and partially bifacially worked sidescrapers are the most numerous, some of them very similar to *Bocksteinmesser* types (Figure 4.7:5, 6, 8). The bases of these tools are unworked, and the backs are sometimes thinned (Figure 4.7:6). The plano-convex retouch seen on some sidescrapers, with one lateral side being more carefully retouched and accompanied by a shaped base (Figure 4.7:10), resembles that seen on *Keilmesser* tools. Among the Mezmaiskaya cave materials there are also bifacial and partially bifacially worked knives, which are similar to *Prondnikmesser* tools (Figure 4.7:9), bifacial and partially bifacially worked Chokurcha-type triangular bifaces (Figure 4.7:7), and partially bifacially worked convergent tools (Figure 4.7:2).

Shelinskiy (1998:157) believes that the Il'skaya 2 assemblages should be grouped with the Mousterian sites of the northwestern Caucasus. What is surprising is that in seven Mousterian layers at this site only about 200 tools were found. A total of 10 bifacial and partially bifacially worked tools were recovered as isolated finds within the various levels, except for the lowest level, 7, where three partially bifacially worked tools, out of a

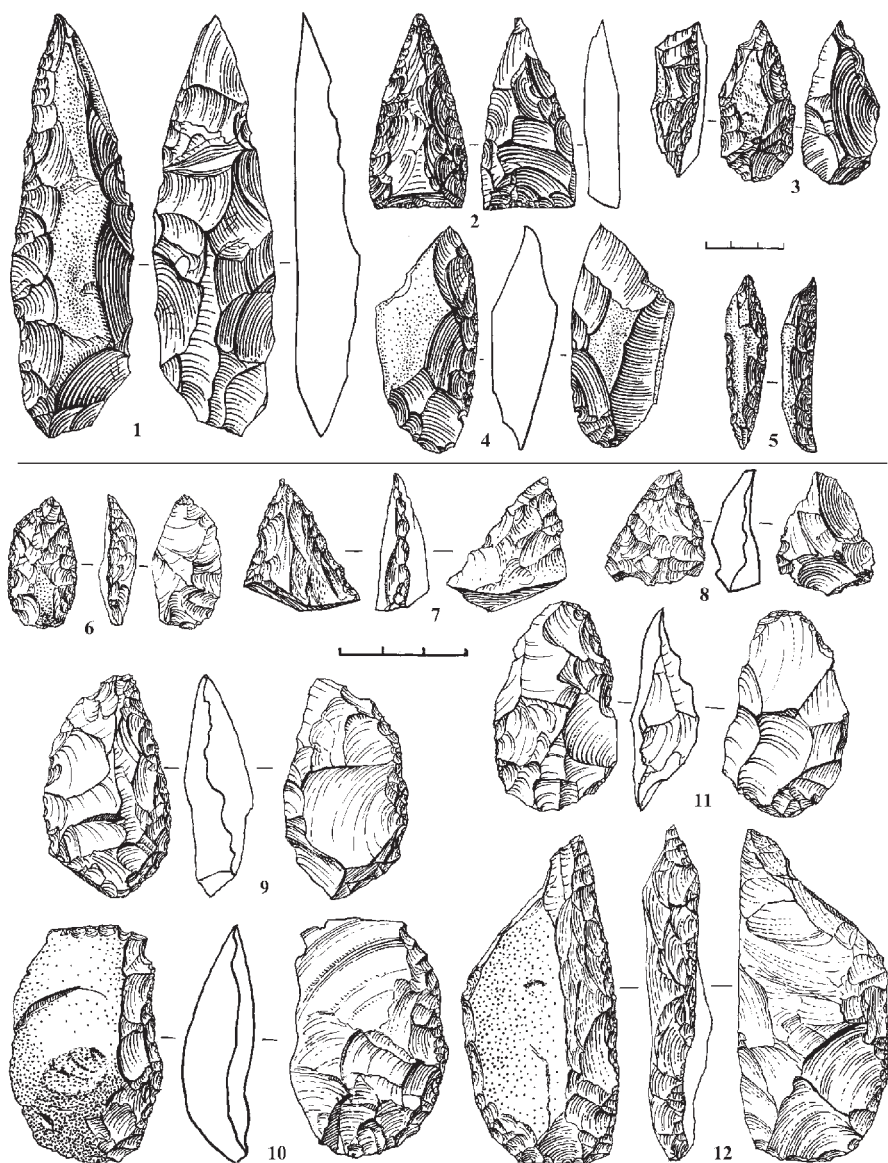


Figure 4.6 Bifacial tools from open air site at Il'skaya 1. (Sources: [1-5], Zamiatnin, 1961; [6-12] by L. Golovanova)

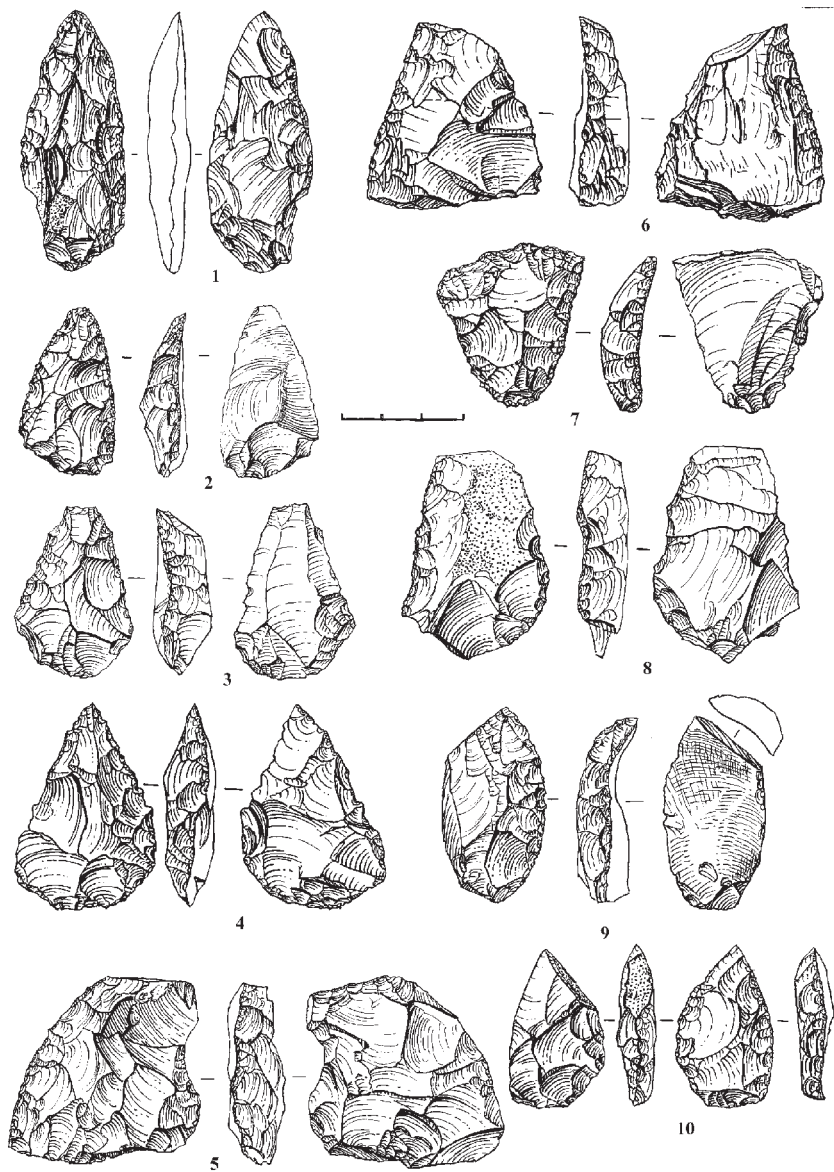


Figure 4.7 Bifacial and partially bifacially worked tools from Mezmaiskaya cave, layers 3-2B.

total of four tools, were found. They consist of three oval segmented knives (Figure 4.8:10), two bifacial and partially bifacially worked sidescrapers (Figure 4.8:11, 12), a triangular point, and some atypical tools. Unifacial tools include sidescrapers (single, transverse, double, and *déjeté*), points, and an endscraper. This preliminary data on Il'skaya 2 does not allow us at present to clarify its position relative to the other Mousterian sites of the region.

The later Micoquian industries found in the northwestern Caucasus differ from the earlier ones by their lower percentages of bifacial tools and by the more frequent use of bifacial retouch (Table 4.6). The Barakaevskaya cave material provides a good illustration of this (Liubin 1994; Liubin, 1998b). This assemblage contains convergent tools and *déjeté* sidescrapers with ventral and dorsal thinning (Figure 4.8:8), as well as single sidescrapers with thinned backs (Figure 4.8:9). The bifacial tools include small triangular handaxes (Figure 4.8:1, 3, 4), and a *Prondnikmesser*-like knife (Figure 4.8:5). One tool resembles a *Bocksteinmesser*, and several tools are similar to Chokurcha-type triangular bifaces.

In the last stage of development of the Micoquian industry bifacial tools are very rare. In the Gubskiy rockshelter 1 industry only one small sub-triangular handaxe has been found (Figure 4.8:2), and there are only a few bifaces and bifacial side-scrappers in a new assemblage from Belyaeva's excavation in Monasheskaya cave (Belyaeva 1999). In the upper levels at Mezmaiskaya cave, a bifacial backed side-scraper (Figure 4.8:7) and a small triangular handaxe were found in levels 2 and 2A. Some small triangular handaxes and partially bifacially worked sidescrapers (Figure 4.8:6) were found at Baranaha 4 (Golovanova & Doronichev 1997). In more recent assemblages ventral and/or dorsal thinning of tools appears frequently on convergent tools, *déjeté* and single sidescrapers, and some endscrapers from Monasheskaya cave, Gubskiy 1 rockshelter, and Mezmaiskaya cave. Ventral thinning of retouched edges on *déjeté* and transverse sidescrapers has also been noted, as well as thinning of backs on single sidescrapers.

Although bifacial tools are the most noteworthy feature of the Micoquian industries in the northwestern Caucasus, single sidescrapers and convergent tools together make up more than half of the tool counts at these sites (Table 4.6). There are no significant variations in the tool percentages from earlier to later assemblages. In general, the percentages of convergent tools fluctuate around 20%, whereas single sidescraper percentages vary between 20% and 30%.

Typological changes within the Micoquian industries in the northwestern Caucasus would seem to have been accompanied by transformations in flaking technology. In the assemblages from Il'skaya 1, Mezmaiskaya (the lower layers), Barakaevskaya, and Monasheskaya, there is a tendency for the blade and faceting indexes to increase over time (Table 4.6). This resulted in an increase in the number of tools made on blades: 5.3% in the lower level of Mezmaiskaya; 13.0% (calculation by Golovanova) at Barakaevskaya; 33.3% in the upper levels in Mezmaiskaya, and 25.9% at Monasheskaya (Belyaeva, 1999—data only on single sidescrapers). Thus, variation in the index of tools made on blades might provide a way to develop a relative chronology for these industries.

Micoquian assemblages in the northwestern Caucasus, especially the earliest ones (Il'skaya 1 and the lower levels at Mezmaiskaya) share similarities with many Micoquian sites in eastern and central Europe. Among the Micoquian sites in the Crimea, they are most similar to assemblages attributed to the Kiik-Koba culture (Kolosov et al. 1993) in

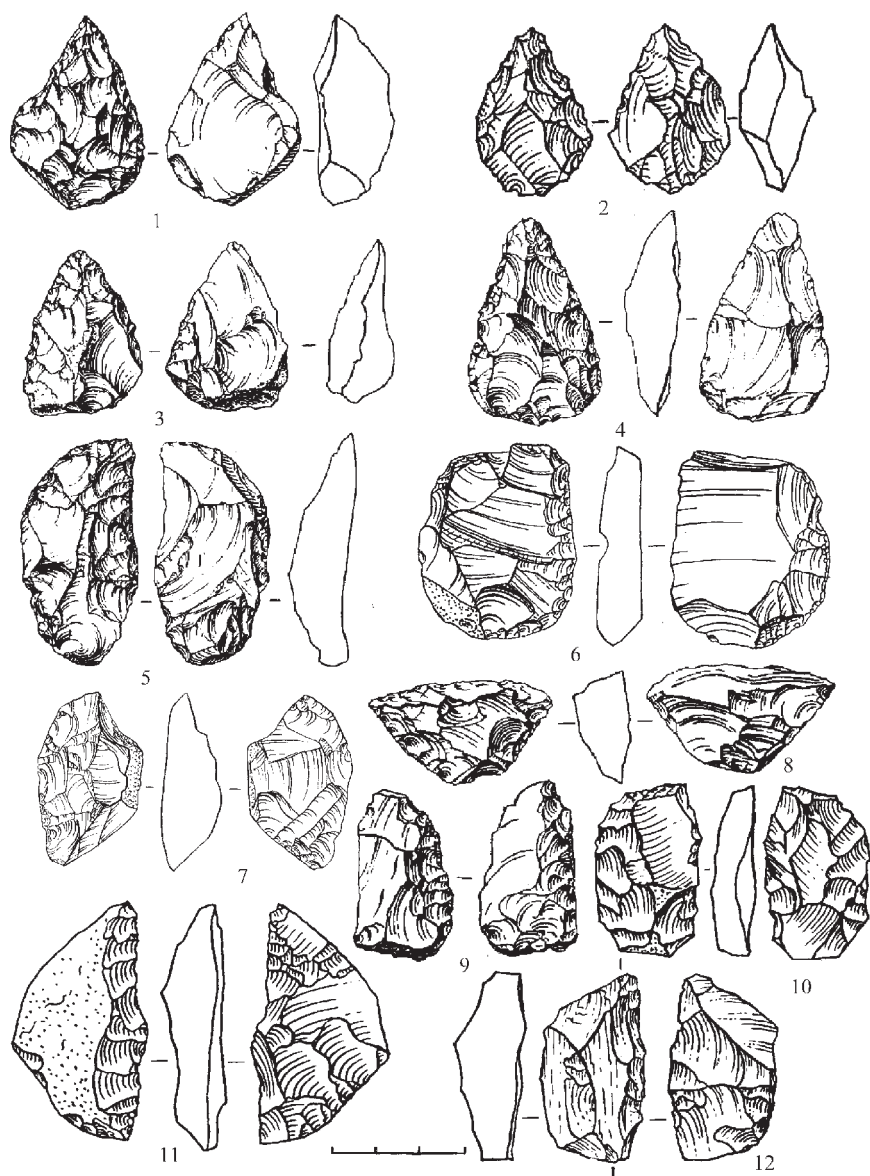


Figure 4.8 Bifacial and partially bifacially worked tools from Barakaevskaia cave (1, 3, 4, 5, 8, 9), Gubskiy rockshelter 1 (2), Baranaba 4 (6), Mezmaiskaya cave, layer 2 (7), and Il'skaya 2 (10-12). (Sources: [1-5, 8, 9], Liubin, 1977; 1994; [10-12], Shelinskiy, 1998; [6, 7], by Golovanova)

Table 4.6 Technological and Typological Indexes for
Micoquian Assemblages in the North Caucasus

Sites	ILam	IB	E-Scrapers & burins (%)	Convergent Tools (%)	Single sidescrapers (%)
Mezmaiskaya, Layer 3	23.9	12.6	0.5	20.1	36.3
Mezmaiskaya, Layers 2B-4	27.7	10.6	0.5	27.3	34.3
Il'skaya 1, Upper layer*	25.0	lower	14.2	21.0	?
Il'skaya 1, Lower layer*	15.4	higher	4.4	20.0	?
Barakaevskaya	17.5	1.0	6.2	20.4 (?)	24.7
Monasheskaya	21.4 (35.0)	isolated	18.4	22.4	23.0
Gubskiy Rockshelter 1	16.0 (35.1)	1.5	10.6	14.3	23.1
Mezmaiskaya, Layers 2 – 2A	27.5	1.5	8.6	18.6	45.7

percentages of bifacial tools (14–15%). It must be stressed, however, that the development of the Micoquian in the northern Caucasus has some unique features as the Micoquian industries do in other regions (Bosinski 1967; Valoch 1988; Allsworth-Jones 1990; Ulrix-Closset 1990; Koulakovskaya et al. 1993; Farizy 1995; Conard & Fischer 2000).

Based on currently available data, it would appear that the Micoquian industry first appeared in the northern Caucasus near the end of the Riss-Würm interglacial or the beginning of the Würm glaciation. Here, as in other regions, the Micoquian was preceded by UpperAcheulian industries containing few bifaces (excluding Abin, where bifaces make up to 32.9% of the assemblage). However, none of these UpperAcheulian industries contain any bifacial sidescrapers or knives, which are often considered to be Micoquian “index fossils,” and do not exhibit any retouch characteristic of the Micoquian. Moreover, the UpperAcheulian and Micoquian in the northern Caucasus differ from one another by the almost total absence of convergent tools in the former (Tables 4.4, 4.6). These tools usually number up to 25% of all tools found at Micoquian sites in the northern Caucasus, and many of them exhibit bifacial retouch or thinning. Some differences have also been noted in the development of flaking techniques. At the end of the Lower Paleolithic and beginning of the Middle Paleolithic, a tendency toward increased production of laminar flakes became apparent in the northern Caucasus. The earlier Micoquian industries from the upper level of Il'skaya 1 and levels 3–2B at Mezmaiskaya contain about 10% more blades than the UpperAcheulian ones (Tables 4.4, 4.6). There is a very strong discontinuity between the Micoquian and the UpperAcheulian in the Northern Caucasus, with no evidence for transformation of one industry into the other.

Bifaces in the Middle Paleolithic Industries in the Transcaucasus

Middle Paleolithic sites are numerous in the Transcaucasus and much variability exists in the industries found in them. However, they are all characterized by an almost total absence of fully bifacial tools. At the same time, partial biface shaping has been noted in some Mousterian industries.

The Mousterian assemblages belonging to the Kudaro group (Djruchula, Kudaro 1, Kudaro 3, and Tcona caves), which contain Mousterian points made on blades and elongated blades with thinned bases and tips (Figure 4.9:1-3) (Liubin 1977), are the earliest Mousterian industries in the Transcaucasus. The lowest levels (level 4 at Kudaro 1 and Kudaro 3, level 5 at Tcona, and levels IX-X at Djrchula) have been dated to the early Würmian interstadial. Layer 3 in Djrchula has been tentatively assigned to the middle of the Würm glaciation, and the uppermost layer 3 at Kudaro 1 has been dated to $44,150 \pm 400/1850$ BP. These industries have very high blade indexes (Kudaro 1—74.4; Djrchula, layer 1—68.5, layer 2—41.2; Tcona —64.2), and high faceting indexes (Kudaro 1—67.7/37.2; Djrchula, layer 1—62.5/30.0, layer 2—38.8/18.8). Tool counts are dominated by sidescrapers, Mousterian points, and denticulates.

There are several Mousterian sites in the Transcaucasus where industries with truncated-faceted points and sidescrapers have been found (Doronichev 1993) similar to the Mousterian industries from caves in the Zagros mountains (Dibble 1984; Dibble & Holdaway 1990). In the upper Mousterian levels at Taglar cave, a similar method was often used for thinning the bases of Mousterian points (Figure 4.9:5, 6). Only isolated truncated-faceted points have been found in the lower levels, but they increase in numbers in the upper levels, and rise as high as 50% of all points in the uppermost Mousterian level (Djafarov 1983:41). Single or double sidescrapers with truncated-faceted retouch on one or both ends (Figure 4.9:8) also appear in these industries, as well as single sidescrapers with truncated-faceted retouch on three edges (a type called “sidescraper with thinned body”) (Figure 4.9:13) (Djafarov 1983:53).

Truncated-faceted retouch was also used to sharpen the tips and thin the bases of Mousterian points (Figure 4.9:10, 11), sidescrapers (Figure 4.9:7), and endscrapers (Ertician 1970) in the Mousterian industries from Erevan cave. Isolated bifaces have also been found here. The biface index decreases from 3.0% in the lowest level to 0.8% in the uppermost level (Ertician 1970:24-26). These industries are similar to those from Zar and Lusakert caves (Figure 4.9:4).

Sidescrapers with thinned backs and points with thinned bases have been found at Ortvale-klde cave (Tushabramishvili 1994). Their numbers decrease over time; they are completely absent in level 2, the uppermost Mousterian level. Mousterian points with thinned bases (Figure 4.9:9) and sidescrapers with ventral thinning are noted from Bronzovaya cave (Figure 4.9:12), and a fragment of a bifacial leaf-like tool was also found here (Tushabramishvili 1978).

The excavators of these sites assigned the assemblages they found to several different industries: Taglar cave was argued to contain a typical Mousterian industry of Levallois facies (Djafarov, 1983), Erevan cave a typical Mousterian industry (Erticayn, 1970), Bronzovaya cave a typical Mousterian of non-Levallois facies (Tushabramishvili 1978), and Ortvale-klde predominantly a Typical Mousterian industry (Tushabramishvili et al.

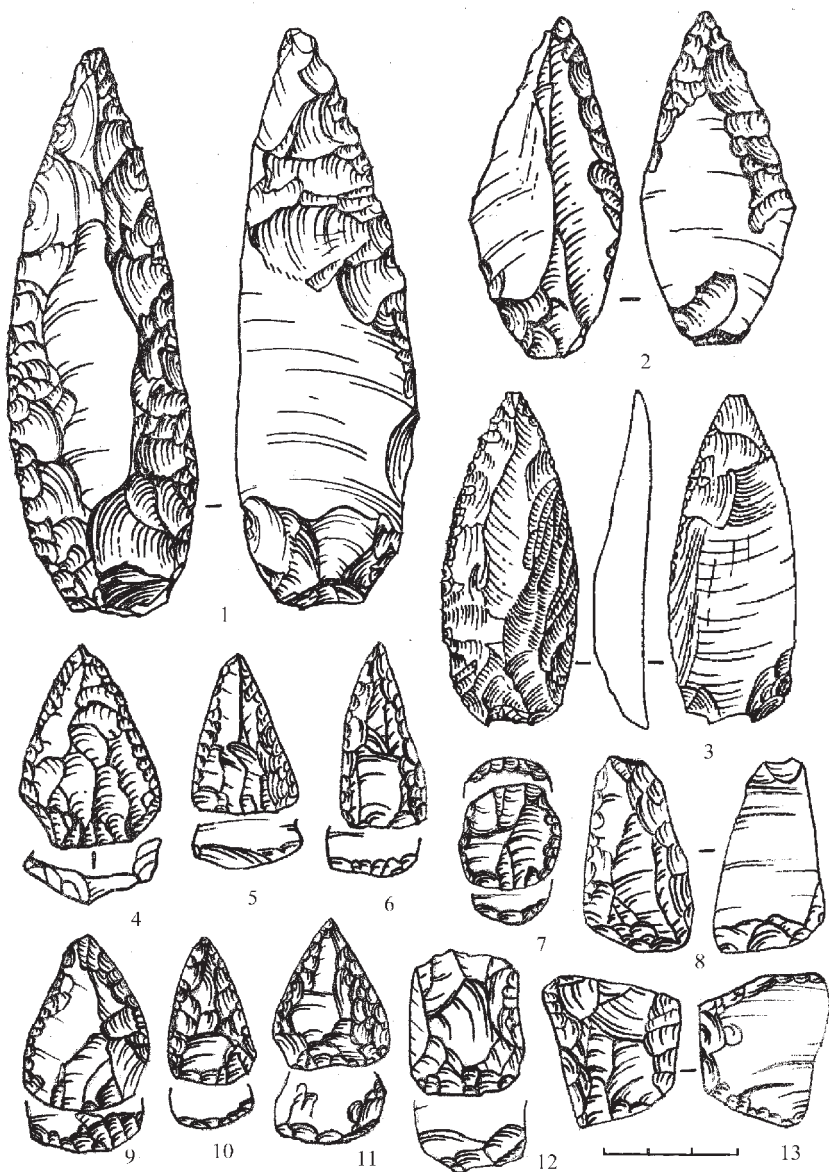


Figure 4.9 Partial bifaces from Mousterian cave sites in the Transcaucasus: Kudaro 3 (1), Djruchula (2), Kudaro 1 (3), Lusakert (4), Taglar (5, 6, 8, 13), Erevan (7, 10, 11), and Bronzovaya (9, 12). (Sources: [1-4], Liubin, 1989; [5, 6, 8, 13], Djafarov, 1983; [7, 10, 11], Eritcian, 1971; [9, 12], Tushabramishvili D., 1978)

1999:72). Unfortunately, the majority of these assemblages are not fully published and detailed statistical data are not available. The main differences among these sites lie in the proportions of three major tool classes. The Taglar industry is characterized by a dominance of points and sidescrapers accompanied by a high blade index; whereas, Erevan, Bronzovaya, and Ortvala-klde caves have lower blade indexes and higher percentages of denticulates (Table 4.7). The oldest assemblages have been dated to the beginning of the Würm glaciation. Level 4 in Erevan cave, for instance, has been radiocarbon dated to about 49,000 BP (Gr -7665) (Liubin 1989). The youngest assemblages have been assigned to Würm II-III (Taglar, upper level) or the middle Würm (upper levels in Bronzovaya and Ortvala-klde caves).

Isolated leaf-like bifacial projectile points have been found in the western Caucasus in some cave industries identified as denticulate Mousterian of Levallois facies. These include a mesial biface fragment from Ahshtirskaya cave (Figure 4.10:2) and a proximal biface fragment from layer 3B in Matouzka cave (Figure 4.10:3). Both finds have been tentatively dated to the middle of the Würm glaciation (Golovanova et al., 1995).

It should be noted that all leaf-like or laurel-leaf like bifacial projectile points known from the lower Middle Paleolithic in the Caucasus are isolated finds, and have been found in a variety of chronological and industrial contexts. The earliest double-convex projectile points were found in the Abin Upper Acheulian assemblage (Figure 4.5:6, 7) and the early Würmian industry from level 5B at Matouzka (Figure 4.10:1) (Golovanova, 1994). What appear to be the most recent projectile points come from layer 3B at Matouzka and from the Mousterian assemblage at Tcona cave (Kalandadze & Tushabramishvili 1978) (Figure 4.10:4). It was noted above that only plano-convex leaf-like projectile points are characteristic of eastern European Micoquian industries in the northwestern Caucasus (Figure 4.6:1; 7:1) and that these industries do not contain double-convex points.

Conclusion

What data are currently available allows us to hypothesize that bifacial shaping techniques appeared in the Caucasus as early as the Mindel-Riss interglacial, and that from their earliest appearance in this region pointed bifaces (e.g., amygdaloid, cordiform, triangular) were the dominant bifacial types. The majority of the Acheulian sites recognized in the region so far belong to the Upper Acheulian, and classic biface types become rather rare here in the Upper Acheulian. In the Transcaucasus, many sites are dominated by partial bifaces, often made on flakes, and include partial biface tool types such as *bachereau sur éclat*, backed bifaces and knives, and *Quina*-type sidescrapers with thinned backs. In the Northern Caucasus three local variants or groups of Acheulian sites are currently recognized, characterized, respectively, by small quantities of sub-triangular, sub-cordiform, and leaf-like bifaces.

In the Middle Paleolithic sites in the northwestern Caucasus, which contain eastern European Micoquian industries, a wide spectrum of bifacial and partially bifacially worked tools have been found: small triangular handaxes, leaf-like projectile points, different types of convergent scrapers, bifacial sidescrapers which are similar to *Bocksteinmesser*, *Prondnikmesser*, *Keilmesser*, and *Wolgogradmesser* knife types, as well as tools similar to Chokurcha-type triangular bifaces.

Table 4.7 Technological and Typological Indexes for Middle Paleolithic Sites in the Southern Transcaucasus.

Cave sites	Layer	Ilam	IFl.	IFst.	II	III	IV	IR	Points+ deje sidescrapers
Erevan	2	~ 8.0	~ 30.0	~ 16.0	?	?	6.6	27.0	?
	3	6.0	41.5	22.5	?	?	6.8	34.6	?
	4	6.2			?	?	6.7	28.2	?
	5-Z- 6-7	8.2	30.0	16.6	?	?	6.5	33.0	?
Lusakert	B	22.4	53.0	34.0	?	8.4	61.0	4.9	?
	CI	24.0	61.0	43.0	69.0	8.1	14.4	52.0	?
	CII	13.0	18.0	10.5	16.8	2.8	46.9	7.8	?
	D	3.0	18.0	7.0	?	?	15.3	?	?
Ortvale-kilde	1	12.7	21.9	16.5	30.8	23.9	7.0	25.9	9.8
	2	9.4	26.7	19.0	37.1	16.1	5.1	29.8	10.0
	3	11.0	23.8	19.4	44.9	6.6	6.2	35.6	13.6
	4	10.7	27.3	21.3	51.6	5.9	4.9	41.6	14.6
	5	8.6	24.5	20.3	43.3	8.5	5.0	35.6	23.2
	6	11.6	16.2	22.1	45.8	8.9	8.4	37.8	11.3
Bronzovaya	II	6.8	24.4	20.6	40.0	?	25.9	35.4	?
	III	12.2	30.5	24.4	38.2	?	28.5	30.6	?
	IV	9.7	29.6	24.4	36.6	?	28.1	30.0	?
	V	14.6	28.2	26.9	31.6	?	29.0	25.3	?
Taglar	2	36.0	69.9	27.5					
	3	33.1	73.1	29.7					
	4a	43.7	73.6	34.4	72.2	1.4	1.7	41.3	35.7
	4b	39.0	62.8	31.4					
	5	25.3	57.5	22.7					
	6	30.7	60.8	33.3					

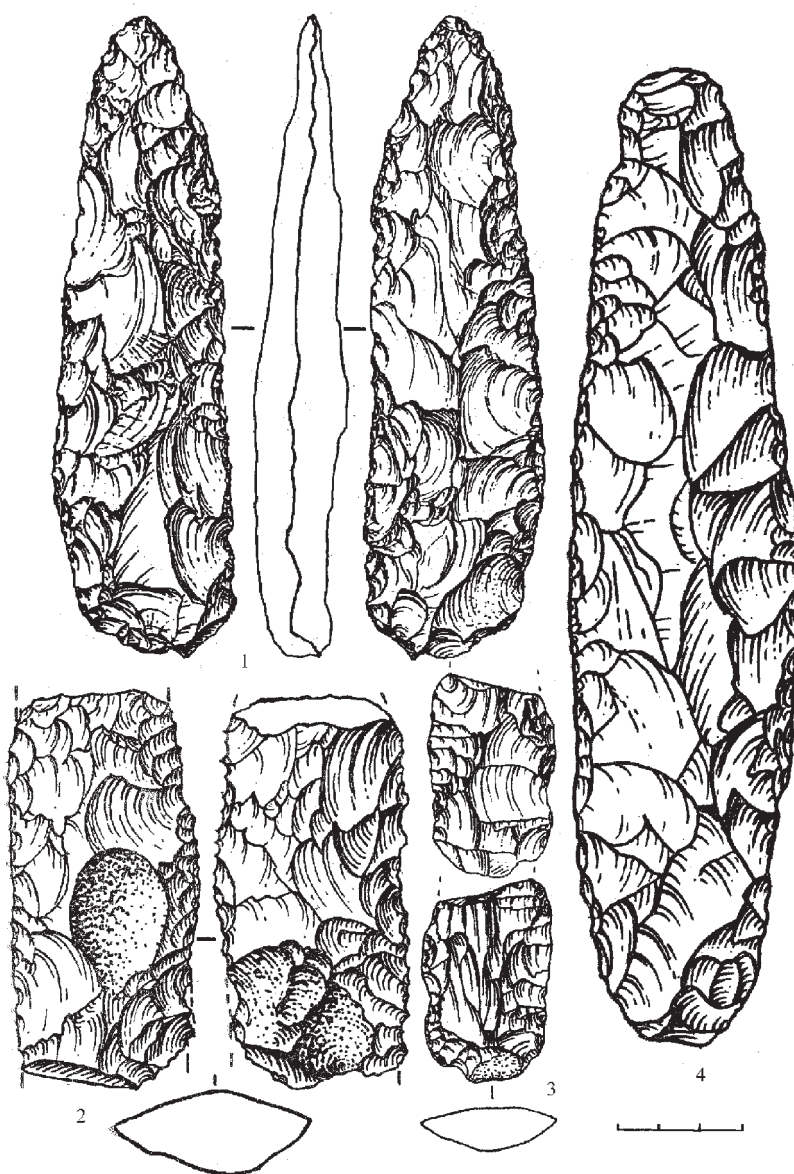


Figure 4.10 Bifacial leaf-like projectile points from Mousterian sites in the Caucasus—Matouzka cave, layer 5B (1), Abshtirskaya cave (2), Matouzka cave, layer 3B (3), Tconá, Mousterian layer (4). (Sources: [2], Zamiatnin, 1961; [4], Liubin, 1989; [1, 3], Golovanova, 1994; Golovanova et al, 1999).

In contrast, only isolated bifacial tools have been found in the Mousterian sites in the Transcaucasus, mainly in the earlier ones. In general, partial bifaces are what tend to be found in this region: Kudaro points, truncated-faceted Mousterian points, and sidescrapers. Some isolated bifacial leaf-like projectile points have also been found.

Based on currently available data, the northern Caucasus and Transcaucasus were inhabited by different cultural groups during the Lower and Middle Paleolithic. The northern Caucasus was characterized by industries with few or no bifaces during the Lower Paleolithic, and by eastern European Micoquian industries during the Middle Paleolithic. In contrast, Acheulian industries with higher numbers of bifaces (especially in surface collections) are typical of the later Lower Paleolithic in the Transcaucasus. Instead of Micoquian industries, Zagros-like (with truncated-faceted pieces) or Levantine-like (with highly developed blade techniques) Mousterian industries are characteristic of the Middle Paleolithic in this area. Interrelationships between these regions are visible only in the Upper Paleolithic.

References

Allsworth-Jones, P.

- 1990 Les industries à pointes foliacées d'Europe Centrale. Questions de definitions et relations avec les autres techno-complexes. Paleolithique moyen recent et paleolithique superieur ancien en Europe. *Actes du Colloque international de Nemours 9-10-11 Mai 1988*. Memoires du Musée de Préhistoire l'Ile de France, n. 3.

Anisiutkin, N. K.

- 1968 Two Assemblages from Il'skaya. *Soviet Archaeology* n. 2 (in Russian).

Autlev, P. U.

- 1981 Lower and Middle Paleolithic Hunter-gatherers in the Kuban Western Caucasus. *Questions on the Archaeology of Adigeia*. Pp. 8-47. Maikop (in Russian).

Bar-Yosef, O.

- 1998 Early Colonizations and Cultural Continuities in the Lower Paleolithic of Western Asia. In *Early Human Behavior in Global Context: The Rise and Diversity of the Lower Palaeolithic Record*. M. D. Petraglia and R. Korisettar, eds. Pp. 221-79. London: Routledge.

Belyaeva, E. V.

- 1999 *The Mousterian World of the Gubs Gorge (Northern Caucasus)*. St. Petersburg (in Russian): Peterburgskoe Vostokovedenie.

Bordes, F.

- 1961 *Typologie du paléolithique ancien et moyen*. Bordeaux.

Bosinski, G.

- 1967 *Die mittelpaläolithischen Funde im westlichen Mitteleuropa*. Cologne: Fundamenta.

Burdukiewicz, J. M.

- 2000 The Backed Biface Assemblages of East Central Europe. In *Toward Modern Humans. The Yabrudian and Micoquian 400-50 K-Years Ago*. Oxford: British Archaeological Reports.

Conard, N., and B. Fischer

- 2000 Are there Recognizable Cultural Entities in the German Middle Palaeolithic? In *Toward Modern Humans. The Yabrudian and Micoquian 400-50 k-years ago*. Proceedings of Congress, University of Haifa. November 3-9, 1996. BAR International Series 850, pp. 7-21.

Djafarov, A.K.

- 1983 *The Mousterian Culture of Azerbaidjan (Based on the Material of Taglarskaya Cave)*. Baku (in Russian).

Dibble, H. L.

- 1984 The Mousterian Industry from Bisitun Cave. *Paléorient* 10(2):23-34.

Dibble, H. L., and S. J. Holdaway

- 1990 Le Paléolithique moyen de l'Abri sous Roche de Warwasi et ses Relations avec le Moustérien du Zagros et du Levant. *L'Anthropologie* 94(4):619-42.

Doronichev, V. B.

- 1993 The Mousterian Industries of the Greater Caucasus. *St. Petersburg Archaeological Herald* 7: 14-24 (in Russian).
- 1998 Treugolnaya Cave—A New Lower Palaeolithic Site in the Northern Caucasus *Forli* 2:387-392.
- 2000 Lower Palaeolithic Occupation of the Northern Caucasus. In *Early Humans at the Gates of Europe*. D. Lordkipanidze, O. Bar-Yosef, and M. Otte, eds. Pp. 67-77. ERAUL 92.

Eritcian, B.G.

- 1970 *Erevanskaya Cave Site and Its Place Among the Caucasus Sites*. Moscow (in Russian).

Eritcian, B.G., and S.A. Semenov

- 1971 A New Lower Paleolithic Cave at Erevan. *Brief Reports of the Institute of Archaeology*, 126. Moscow (in Russian).

Farizy, C.

- 1995 Industries Charentiennes à influences Micoquiennes, l'exemple de l'Est de la France. Actes du Colloque de Miskolc, Juin 1995. *Paléo*, Supplément 1. Liège, 173-78.

Formozov, A.A.

- 1965 *Stone Age and Eneolithic of the Pre-Kuban*. Moscow (in Russian).
- 1977 *Stone Age Ethno-Cultural History Problems in the European USSR*. Moscow (in Russian).

Gabori, M.

1976 *Les civilisations du Paleolithique moyen entre les Alpes et l'Oural*. Budapest.

Gabunia, L., A. Vekua, D. Lordkipanidze, R. Ferring, A. Justus, G. Maisuradze, A. Mouskhelishvili, M. Nioradze, D. Sologashvili, C. Swisher III, M. Tvalchrelidze

2000 Current Research on the Hominid Site of Dmanisi. In *Early Humans at the Gates of Europe*. D. Lordkipanidze, O. Bar-Yosef, and M. Otte, eds. Pp. 13–27. ERAUL, 92.

Gabunia, M.

2000 On Ancient Man in the Volcanic Mountainous Region of South Georgia. In *Early Humans at the Gates of Europe*. D. Lordkipanidze, O. Bar-Yosef, and M. Otte, eds. Pp. 43–47. ERAUL, 92.

Golovanova, L. V.

1984 Morphological and Technological Analysis of Bifaces from Satani-Dar, Armenia). *Abstracts from Conference on "Problems in Studying the Old Stone Age of Eurasia."* Pp. 107–108. Krasnoyarsk (in Russian).

1986 *Acheulian Sites in the Northern Caucasus*. Leningrad (in Russian).

1994 *Problems of the Early to Middle Palaeolithic Transition in the Northwestern Caucasus*. St. Petersburg (in Russian).

2000 Late Acheulean of the Northern Caucasus and the Problem of Transition to the Middle Palaeolithic. In *Early Humans at the Gates of Europe*. D. Lordkipanidze, O. Bar-Yosef, and M. Otte, eds. Pp. 49–65. ERAUL, 92.

Golovanova, L. V., G. F. Barishnikov, G. M. Levkovskaya, and S. A. Nesmeyanov

1995 Matouzka: A Multilevel Mousterian Cave in the Northern Caucasus. *Russian Archaeology* 3–4: 77–86, 105–118 (in Russian).

Golovanova, L. V., and V. B. Doronichev

1997 *Study of a New Mousterian Site in the Northern Caucasus. New Investigations by Russian and NIS Archaeologists*. St. Petersburg (in Russian).

Golovanova, L. V., J. Hoffecker, V. M. Kharitonov, G. P. Romanova

1998a Mezmaiskaya Cave (1987–1995 preliminary research results). *Russian Archaeology* 3. Moscow (in Russian).

Golovanova, L. V., D. F. Hoffecker, S. Nesmeyanov, G. Levkovskaya, V. Kharitonov, G. Romanova, and I. Svejencev

1998b Site du Micoque Est-europeen du Caucase de Nord (Resultats presentifs des études de la grotte Mezmaiskaya, les fouilles des annees 1987-1993). *L'Anthropologie* 1: 45–66.

Golovanova, L. V., J. Hoffecker, V. M. Kharitonov, and G. P. Romanova

1999 Mezmaiskaya Cave: A Neanderthal Occupation in the Northern Caucasus. *Current Anthropology* 40(1):77–86.

Golovanova, L. V., G. M. Levkovskaya, G. F. Baryshnikov

- 1990 Le Nouveau Site Mousterian en Grotte de Matouzka, Caucase Septentrional (Resultats des Fouilles de 1985-1987). *L'Anthropologie* 94:739-62.

Guseinov, M. M.

- 1984 The Paleolithic in Azerbaidjan: Early Paleolithic. In *The Stone Age and Eneolithic in Azerbaidjan*. Baku (in Russian).

Ivanova, I. K.

- 1982 Fossil Man and His Culture. In *Stratigraphy of the USSR. Quaternary System*, 1:382-412. Moscow (in Russian).

Jelinek, A. J.

- 1975 A Preliminary Report on Some Lower and Middle Paleolithic Industries from the Tabun Cave, Mount Carmel (Israel). *Problems in Prehistory: North Africa and The Levant*. Dallas.

Kalandadze, A. N.

- 1969 Tconskaya Cave and Its Culture. *Actes du IV Congr. Intern. du speleologie en Yougoslavie (12-16. IX. 1965)* 4-5:339-353. Ljubljana.

Kalandadze, A. N., and D. M. Tushabramishvili

- 1978 Tconskaya Cave. In *Archaeology and Paleogeography of the Early Paleolithic in the Crimea and Caucasus*. Moscow (in Russian).

Kazarian, R. P.

- 1986 Atis I: An Upper Acheulian site. In *Archaeological Discoveries in 1984*. Moscow (in Russian).

Kolosov, U. G., V. N. Stepanchuk, and V. P. Chabai

- 1993 *The Early Paleolithic of the Crimea*. Kiev (in Russian).

Korobkov, I. I.

- 1971 On the Problem of Research at Lower Paleolithic Open-air Settlements with Destroyed Cultural Layers. In *Materials and Studies in the Archaeology of the USSR*, 173: 61-99. Moscow (in Russian).

Koulakovskaya, L., J. K. Kozłowski, K. Sobczyk

- 1993 Les Couteaux Micoquiens du Würm Ancien. *Préhistoire Européenne* 4:9-13.

Liubin, V. P.

- 1977 *Mousterian Cultures of the Caucasus*. Leningrad (in Russian).
1981 Lower Paleolithic of the Caucasus (History of Research, Sites, Local Peculiarities). In *Ancient East and World Culture*. Pp.12-16 (in Russian).

- 1984 Early Paleolithic of the Caucasus. In *Paleolithic of the USSR*. Pp. 45–93 (in Russian).
- 1989 Paleolithic of the Caucasus. *The Paleolithic of the Caucasus and Northern Asia*. Leningrad (in Russian).
- 1994 The Results of Complex Research of the Mousterian Site of Barakaevskaya. The Netherlands of Gups George. P. 238. Maikop (In Russian).
- 1998a *The Acheulian in the Caucasus*. St. Petersburg (in Russian).
- 1998b La grotte moustérienne Barakaevskaia (Nord Caucase). *L'Anthropologie* 102(1): 67–90.
- Malenfant, M.
- 1976 Les Civilisations du Paleolithique Inferieur dans le Jura Meridional et les Alpes du Nord. *La Prehistorique Francaise* 1(2): 879–93.
- Matiuhin, A. E.
- 1981 Technology of Production and Typology of Satani-dar's Bifaces. *Brief Reports of the Institute of Archaeology*, 165. Moscow (in Russian).
- Nesmeyanov, S. A.
- 1999 *Geomorphological Aspects of Paleolithic Paleoeecology of the Western Caucasus*. Moscow (in Russian).
- Panichkina, M. Z.
- 1950 *The Paleolithic of Armenia*. Leningrad (in Russian).
- Praslov, N. D.
- 1970 The Stratigraphy of Il'skaya. *Archaeological Discoveries in 1969*. Moscow (in Russian).
- 1984 The Early Paleolithic of the Russian Plain and Crimea. *Paleolithic of the USSR*. Moscow (in Russian).
- Rollefson, O. G.
- 1980 Late Acheulean Artifacts from Ain-el-Assad ("Lion's Spring"), near Azrag, Eastern Jordan. *Bulletin of the American Schools of Oriental Research* 240:1–20.
- Shelinskiy, V. E.
- 1998 Der Mittelpalaolithische fundplatz Il'skaya II im Westlichen Kubangebiet. *Jahrbuch des Romisch-Germanischen Zentralmuseums Mainz* 45. Jahrgang.
- Tcherdintcev, V. V.
- 1969 *Uran-234*. Moscow (in Russian).
- Tushabramishvili, D. M.
- 1978 Archaeological Excavations at the Tutchvaty Multi-level Cave Complex. *Study of Caves in Kolbida*. Tbilisi (in Russian).

Tushabramishvili, N. D.

- 1994 *The Middle Paleolithic in Western Georgia and the Stages of Its Transition to the Upper Paleolithic Based on the Assemblages from Ortvala-klde*. Tbilisi. (in Russian).

Tushabramishvili, N., D. Lordkipanidze, A. Vekua, M. Tvalcherlidze, A. Muskhelishvili, and D. Adler

- 1999 The Palaeolithic Rockshelter of Ortvale Klde in Imereti, Georgian Republic. *Prehistoire Européenne* 15.

Ulrix-Closset, M.

- 1975 *Le Paleolithique Moyen dans le Bassin Mosan en Belgique*. Liège.
 1990 Le Paleolithique moyen recent en Belgique. Paleolithique Moyen Recent et Paleolithique Superieur Ancien en Europe. *Actes du Colloque International de Nemours 9-10-11 Mai 1988*. Memoires du Musée de Prehistoire de l'Ile de France, n. 3.

Valoch, K.

- 1988 Die Erforschung der Kulna-Hohle 1961-1976. *Anthropos* 24:318. Brno

Zamiatnine, S. N.

- 1929 Station Mousterienne Il'skaya Province de Kouban (Caucase du Nord). *Revue Anthropologique* 7-8.
 1934 Results of Final Studies of the Il'skaya Paleolithic Settlement. In *Proceedings of the Second International Conference of the Association on Study of the Quaternary Period in Europe* 5. Leningrad (in Russian).
 1961 *Sketches on the Paleolithic*. Moscow-Leningrad (in Russian).



5

BIFACES AND RAW MATERIALS: FLEXIBLE FLAKING IN THE BRITISH EARLY PALEOLITHIC

Nick Ashton and Mark White

Recent interpretations of biface and assemblage variation in the British Lower Paleolithic are reviewed, in particular the reduction and raw material models. These models are further tested by analyzing stages in the knapping process through the identification of biface roughouts and biface refitting groups. It is argued that raw materials explain a major part of the morphological variation in bifaces, and that this can be identified on a very localized scale. This is examined through the neighbouring sites of Barnham and Elveden in Suffolk, England. It is emphasised that smaller scale variation can be recognised that might reflect differences in knapping traditions and on occasion the idiosyncrasies of individual knappers. Biface production is guided by a 'mental construct', consisting of a series of parameters relating to function and methods of production; it is their optimization that results in the production of ovate bifaces.

British Lower Paleolithic bifaces have traditionally been divided into two broad classes: points and ovates. This simple division was initially expounded by John Evans (1860) and later given more formal expression by Roe (1968) through the use of metrical and statistical analysis. Fundamentally, this division serves to provide a simple reference to the basic scale of morphological variation, although it also tacitly acts to conceal a much wider range of intermediate types, a continuum of variation from the most rounded ovate to the most elongated point. This has been demonstrated in a number of studies e.g., Hodson (1971), Doran and Hodson (1975), McPherron (1994) and White (1996, 1998a). The same variability is also a feature of the earlier part of the Middle Paleolithic, with a range of ovate and pointed forms being found at the OIS 7/8 site of Baker's Hole in Kent, England (Wenban Smith 1995) and at the OIS 7 site of Pontnewydd in Clywd, Wales (Green 1984). However, the use of these two major types of biface (as defined by Roe) as a basic tool of analysis has been valuable in demonstrating typological differences at the assemblage level. Assemblages do appear to divide broadly into those dominated by metrically defined ovates and those dominated by metrically defined pointed forms, with a concomitant bimodality in assemblage attribute composition.

Variations in biface form and in the resulting assemblage attribute composition have been attributed in the past to cultural differences, arguing that specific mental templates were culturally transmitted. This interpretation has received much criticism in recent years, in part due to the lack of chronological patterning in the data. Ovate-dominated assemblages are found from OIS 13 through to OIS 8/7, e.g., Boxgrove (Roberts and

Parfitt 1999) and High Lodge (Ashton et al. 1992) (both OIS 13), Elveden (Ashton and Lewis 1998; Ashton et al. 2000) (OIS 11) and Baker's Hole (Wenban-Smith 1995) (OIS 8/7). Assemblages dominated by pointed forms are found in the Swanscombe Middle Gravels (Conway et al. 1996) (OIS 11), at Furze Platt (Wymer 1962:17-27) (OIS 9/8), and at Pontnewydd (Green 1984) (OIS 7). Many of the point-dominated assemblages frequently include 30% to 40% ovates, whereas ovate-dominated assemblages also contain from 10% to 30% of pointed forms. The difficulty of interpreting this apparently complex patterning in cultural terms has prompted several alternative explanations.

Raw Material Models

The raw material interpretation as initially expounded by Ashton and McNabb (1994) viewed function as the starting point of any interpretation. Experiments (Jones 1980; Toth 1982, 1985; Isaac 1986; Mitchell 1995), site association (Villa 1990; Roberts and Parfitt 1999), and use-wear (Keeley 1980; Mitchell 1995) have shown that bifaces were manufactured for the range of tasks involved with butchery. Ashton and McNabb's contention was that the overall aim of manufacture was to maximize the length of durable cutting edge. Ovates were seen as the more efficient form, having an all-round symmetrical cutting edge with good prehensile qualities, whereas the variety of pointed forms were only produced because of the limitations of raw material. Typically, ovates were produced on large nodules of flint or from large flakes, but pointed forms were often produced on round elongated nodules on which ovates would be difficult, if not impossible, to make. This was supported by the analysis of the position and extent of cortex on bifaces from nine sites, where, in many cases, the form of the original nodule could be recognized (Ashton and McNabb 1994, fig. 3-4); between 34% to 50% of the bifaces from point dominated sites could be demonstrated to have been made on thick elongated nodules.

The work of White (1995, 1996, 1998a) has considerably strengthened these arguments with a much more extensive analysis incorporating 21 assemblages covering 1300 bifaces. Of the variety of data White marshalled in support of Ashton and McNabb's arguments, recognition of spatial patterning is the most important. White demonstrated a remarkable correlation between assemblage type and raw material source, whereby ovate-dominated sites are almost always those with local access to large pieces of good-quality flint from a primary source, but point-dominated sites are usually restricted to smaller, poor-quality gravel flint (Figure 5.1). This spatial correlation was supported by

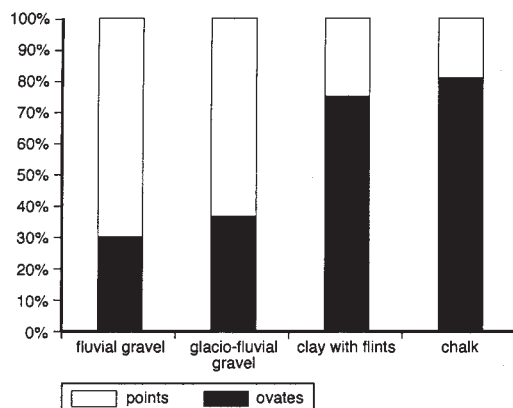


Figure 5.1 Percentage of biface types for different raw material sources (after White 1998b).

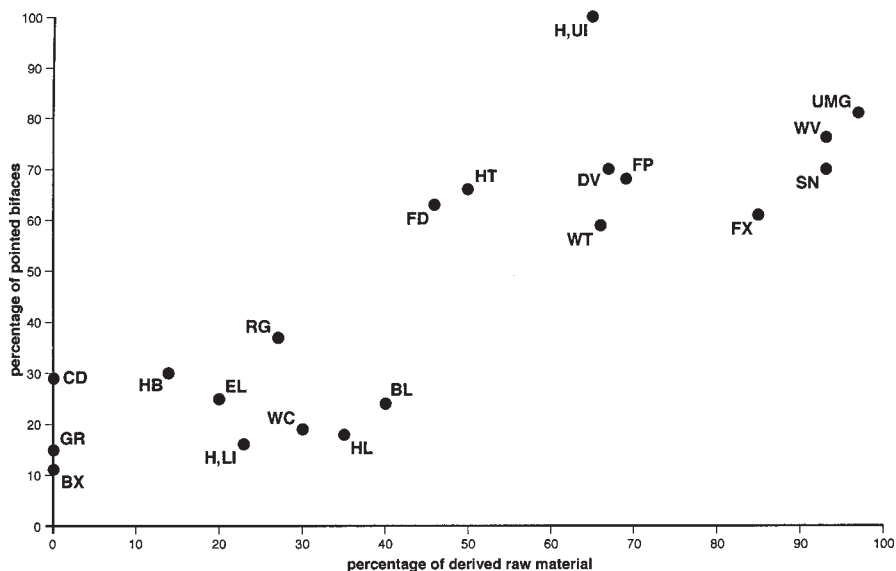
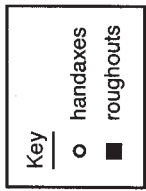
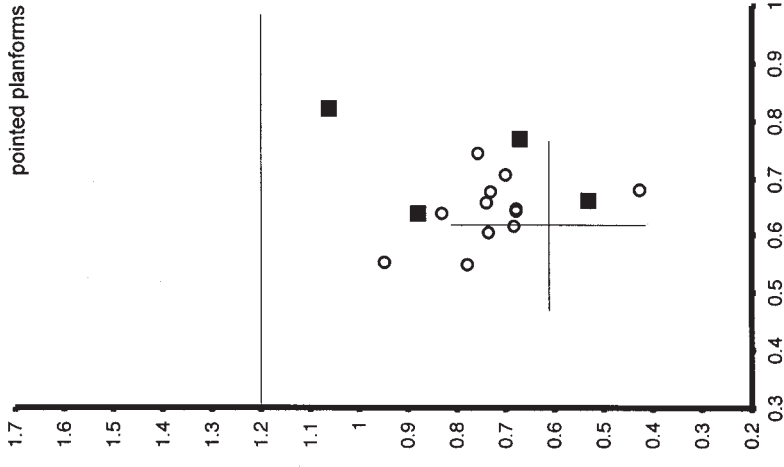
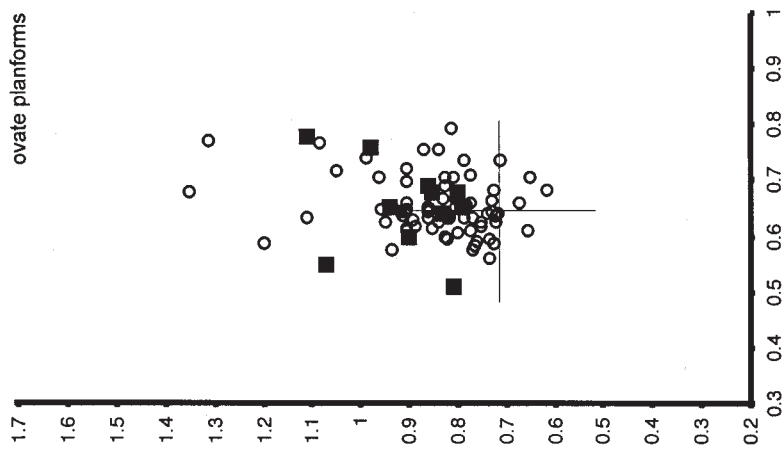
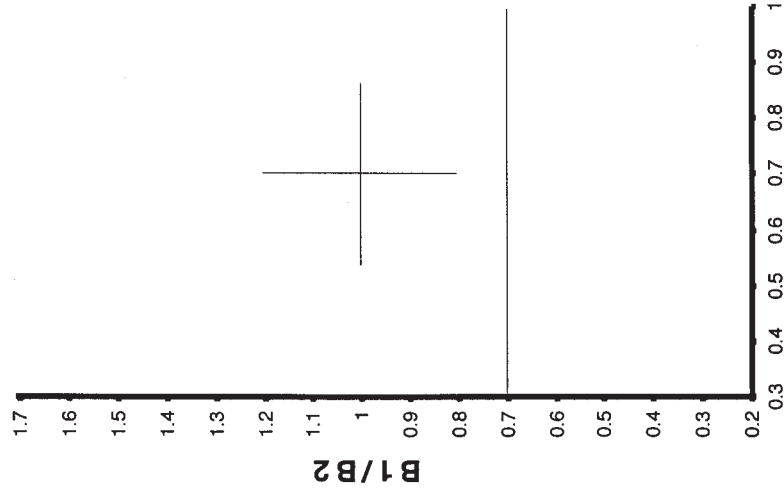


Figure 5.2 Percentage of pointed bifaces over percentage of derived raw material ($r=0.841$, $r^2=0.71$, $p=0$). Assemblage codes: BL = Bowman's Lodge, BX = Boxgrove, CD = Caddington, DV = Dovercourt, EL = Elveden, FD = Fordwich, FP = Furze Platt, FX = Foxhall Road, GR = Gaddesden Row, HB = Holybourne, HL = High Lodge, H,LI = Hoxne lower industry, HT = Hitchin, H,UI = Hoxne upper industry, RG = Round Green, SN = Stoke Newington, UMG = Swanscombe Upper Middle Gravels, WC = Wansunt Pit, WT = Whittlingham, WV = Wolvercote.

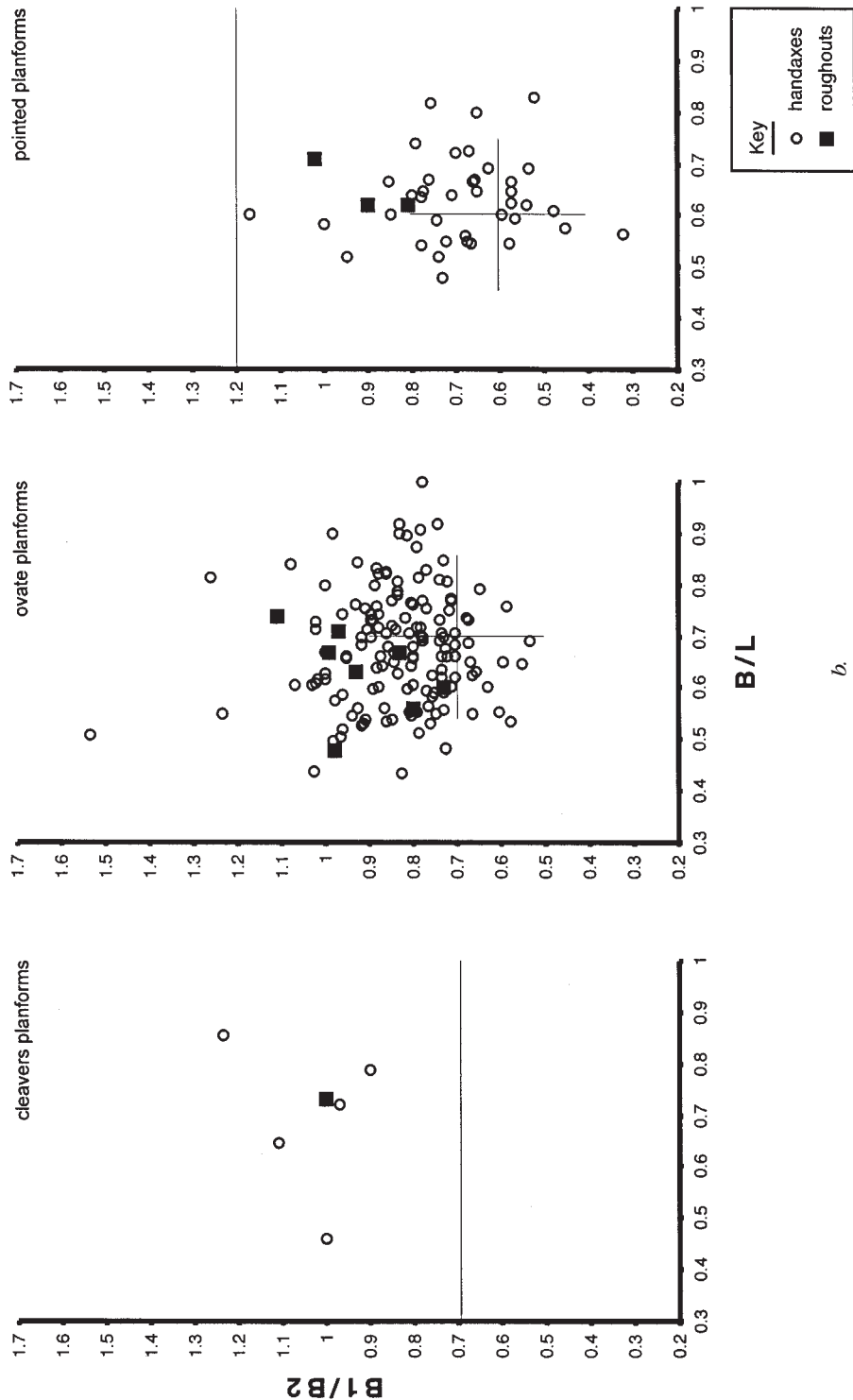
analysis of residual cortex, which examined the nature of the raw materials actually used at a site by distinguishing between fresh, unabraded cortex that had been removed directly from chalk and worn cortex that had been transported, sorted, and abraded in river gravels. This analysis showed a direct correlation between biface type and raw material source, with ovate-dominated assemblages generally manufactured on fresh flint, inferred to be of large dimensions; however, point-dominated assemblages predominantly found on river rolled flint (Figure 5.2), demonstrated to be generally smaller and elongated. White therefore concluded that assemblage level biface variation indicates how hominids tailored a generalized and flexible knapping strategy to meet local raw material contingencies; primary flint sources presented few restrictions and practically unlimited choices, and led to a dominance of well-worked ovates; gravel sources severely conditioned the actions of the knapper, and resulted in a proliferation of pointed forms.

Reduction Model

An alternative interpretation by McPherron (1994, 1995) views variation in form as being due to differences in the degree of reduction (resharpening) to which a biface has been subjected, with each episode of rejuvenation producing a predictable effect on biface morphology. He has argued that all bifaces began their use-life as large, elongated



a.



b.

Figure 5.3a,b Tripartite diagram (after Roe 1968) showing the morphology of biface roughouts and finished bifaces from a) Boxgrove b) Bowman's Lodge, Caddington, Gaddesden Row, Round Green and High Lodge.

pointed forms with long tips and low levels of refinement. Through continual resharpening of the tip, they were gradually transformed into smaller, less elongated ovate forms with small tips and high levels of refinement. McPherron (1994) tested this hypothesis by using a series of metrical predictions that examined the relationship between aspects assumed to change as a result of resharpening intensity (i.e., shape, elongation, and refinement) to proposed absolute measures of that resharpening (either length or tip length). Where available, these tests were complemented by cortex percentage data, using the simple prediction that more heavily reduced ovate bifaces should retain less cortex than pointed forms.

McPherron (1994) utilized data from four sites from France and the Channel Islands: La Cotte de St Brelade, Cagny la Garenne, Gouzeaucourt, and Longavesnes. The results from these sites allowed him to conclude that levels of reduction had played a role in causing biface variability. However, employing McPherron's methods in an independent test on 20 British assemblages, White (1996) found weaker correlations, all of which could feasibly be explained by factors other than resharpening intensity. White (1996) saw a key problem with McPherron's original formulation of his model to be the assumption (critical to its operation) that the raw materials used at each site were more or less of uniform shape and size and supported bifaces with almost identical initial dimensions. This assumption can be questioned simply by looking at the relative size of pointed and ovate forms at each site. For example, in general, the mid-point width of points is narrower than that for ovates, and therefore they are unlikely to form an early stage of the reduction sequence. It might be counter-argued that the bifaces survive in their final state of reduction, and that the pointed forms are merely that shape because it would be impractical to reduce them further. This, however, would fall in line with the predictions of the raw material model and would again seem to question the assumptions of the reduction model about raw material size.

Raw Material Versus Reduction

A problem from which both the raw material and reduction models suffer is the absence of information on process. Both models use the manufacturing process as explanators for the final outcome. The two models also concur on the notion that points and ovates have been subjected to different amounts of reduction (differently defined) and that this contrast is conditioned by local contingencies; however, they diverge in seeing this process as, respectively, either a single event or a continuous process. Neither model has found completely adequate ways by which these processes can be studied. A study of biface manufacturing process would help resolve the issue of whether nodules are initially knapped into pointed forms, and then into ovates through resharpening, or whether nodules are knapped in a single sequence (that may be spatially separated) into either pointed or ovate forms, dependent on the raw material. It could be argued that if McPherron is correct, any early evidence of the process of biface manufacture should reflect the production of pointed forms, and that only after resharpening would evidence of ovate manufacture be present. In contrast, if Ashton, McNabb, and White are correct, then the early stages of biface production would reflect the differing shapes of the raw material and their modification into both ovate and pointed forms, not just pointed forms.

Evidence of process can be looked at from two different angles: the first through a study of biface roughouts; the second through refitting and debitage analysis. The sim-

plest approach is the examination of biface roughouts from a range of ovate-dominated assemblages. It should be apparent from the shape of the roughouts whether a pointed or ovate biface was intended as the final form. There are of course problems in the definition of what constitutes a roughout, although these problems are no greater than in what defines a biface. For the purposes of this study, the distinction between bifaces and biface roughouts lies in the recognition of a functional cutting edge that forms a significant part of the artifact. To quantify this would remove significant pieces from the equation, such as nodular bifaces, which might only be worked on less than 50% of their circumference, but the areas that are flaked nonetheless form a clear functional cutting edge. The distinction between roughouts and cores is also not without problems. However, refitting has shown that in the Lower Paleolithic, at least, core and flake technology is rarely undertaken through discoidal flaking (Ashton 1992; Ashton and McNabb 1996; Ashton 1998), whereas this is the method that is used for the initial stages of biface manufacture (Bradley and Sampson 1978; Austin and Roberts 1999; Bergman and Roberts 1999). Through the recognition of these rather different techniques, it seems possible with some degree of certainty to identify the difference between biface roughouts and core working, particularly where refitting has been identified.

Unfortunately, in Britain very few assemblages contain sufficient quantities of roughouts to make valid comparisons. One exception, however, is the assemblage from the recent excavations at Boxgrove (Roberts and Parfitt 1999). Using Roe's methods of analysis and his tripartite diagrams (1968), the shape of the roughouts can be directly compared to finished bifaces (Figure 5.3a). This demonstrates convincingly that roughouts have the same range of shapes as the bifaces and suggests that it is the shape of the original nodule that influences the form of the biface. A further comparison can be made by combining the assemblages from the sites of Bowman's Lodge, Caddington, Gaddesden Row, Round Green, and High Lodge. Although it is not ideal to combine assemblages in this way, they do form a cohesive group: all have more than 70% ovates; all show the predominant use of fresh nodular flint; and together provide a larger number of roughouts. Again a similar picture emerges that the biface roughouts reflect the shape of the final bifaces (Figure 5.3b). By analyzing the process of biface manufacture, it is clear that there are problems with McPherron's interpretation when applied to the British Isles. Other sites need to be examined, however, before this can be used as a more general argument.

The site of Boxgrove also contributes evidence on process through technological analysis of the debitage and refitting. These show that the final stages of knapping were not part of a resharpening process in the reduction from points to ovates, but stages in a single production line from nodules to ovates (Bergman and Roberts 1999). This is demonstrated, for example, in site GTP17, in which virtually all stages of production are represented from roughouts and roughing-out flakes to finishing flakes, although not the final ovates interestingly. Refitting has clearly demonstrated, however, that ovates were the finished product. Importantly, they have also been interpreted as a single-episode knapping event, directly associated with horse butchery that took place over 'several hours' (Roberts 1999). This type of pattern is reflected in other areas of the site, although rarely as a single-episode knapping event. A similar pattern is evident at Caddington (Smith 1894), where partly complete refitting sequences clearly demonstrate that the knappers had either aimed to produce an ovate from the outset or adjusted their knapping strategy in response to the chosen blank, thus producing a variety of shapes (see Bradley and Sampson 1978).

Barnham and Elveden: Local and Regional Scales

The sites of Barnham (Ashton et al. 1998) and Elveden (Ashton and Lewis 1998; Ashton et al. 2000), both in Suffolk, provide anecdotal evidence of how raw materials play a role in determining biface morphology, and of how ovates appear to be the preferred form. Recent excavations have suggested that the two sites, separated by seven kilometres, are contemporary, dating to OIS 11, and that they lie on the edges of a buried river channel that probably runs between the two sites. Reconstruction of a swathe of landscape has included the location of the raw material resources used at both sites. Variation in raw material between the sites appears to have had a direct impact on both the quantity and form of bifaces.

At Barnham, the raw material source is a coarse, glacial gravel, in which generally the nodules, although sometimes large, have undergone a violent history since derivation from the chalk. As a result, there are frequent flaws in the flint, which experiments have shown results of 56% failure in biface manufacture, even after extremely careful selection of nodules (Wenban-Smith and Ashton: 1998, 238). The size of the nodules does not preclude ovate manufacture, and some of the excavated and collected examples are of this type. Others appear to have been affected by raw material deficiencies and take a less regular form. The quality of the raw material probably also explains the low quantity of bifaces from the site.

At Elveden, there are two sources of raw material. A coarse lag gravel forms one source where, as at Barnham, the nodules are sometimes large but often frost-fractured, providing the same problems for biface production. In addition, chalk cliffs flank the channel at Elveden, providing a better quality source of flint, in the form of large nodules, although in smaller quantity. As a consequence, bifaces form a major component of the assemblage and predominantly consist of ovates. Attempts have also been made to produce bifaces on the gravel flint, which differ in form, according to the nature of the nodule (White 1998a).

Both sites support the contention that raw material has a major impact on biface form, and that ovates are made where raw material permits. The examples of Barnham and Elveden serve to illustrate how the raw material model, by examining site-specific circumstances, can identify patterns of assemblage level variation at different points in the landscape, clearly demonstrating how hominids tailored a generalized knapping strategy to meet local raw material contingencies.

White's original analysis further pointed out that the patterns predicted by the raw material model were evident at both local and regional scales. An attempt has been made recently to test this independently, using handaxes from the Hampshire Basin (Hosfield 1999). Although the study concluded that the predictions of the raw material model were not met, it also acknowledged the limitation of the data, primarily the heavily derived nature of the material through complex transportation with final deposition in fluvial contexts. The failure of the data to show any clear ovate handaxe biases in the chalk valleys (where it is argued chalk and clay-with-flint lithic resources would have been widely available), and a similar lack of a pointed handaxe bias in sites overlying Tertiary bedrock (where gravel might be expected to form the principal flint resource), is probably a reflection of the extensive mixing and resorting of assemblages. It is perhaps not too surprising that the testing of the raw material model in the Hampshire basin has failed to show the predicted patterning.

The raw material model is based upon the premise that hominid technology is conditioned by local, if not immediate, resources. Assemblage level variation will rarely provide a straight reflection of bedrock geology. The variation depends far more on local availability and accessibility of raw material, a factor that changes on local micro-scales rather than regional macro-scales. There are no reasons to expect that all sites within a chalk valley would have had easy access to chalk flint. Most southern English river valleys would have presented a variety of lithic resources, both within and between different stretches, resulting in a diversity of handaxe types along it. Derived accumulations within these valleys will therefore be similarly mixed, reflecting the original diversity of materials incorporated into the fluvial system from heterogeneous patches and scatters. In other cases (e.g., Hoxne, Swanscombe) the nature of the available raw material changed over time (White 1998a). These microscale variations can be seen at Elveden and Barnham, where both lie in a chalk landscape, with chalk accessible as a low bluff at Elveden, but buried in a dry valley at Barnham; these differences in accessibility appear to have made a big impact on the archaeological signatures at the two sites (Ashton et al. 1998; Ashton and Lewis 1998; Ashton et al. 2000).

Raw Materials, Culture, and Human Idiosyncrasy

The raw material interpretation might be deemed by some to be extremely deterministic in approach, and to ignore the facts that bifaces were cultural items, that it was human individuals who made the bifaces, and that inevitably there must have been cultural transfer of techniques and behavior. The role of handaxes (or at least the *social* act of making them) in negotiating social relationships and the role of individuals in biface variability has also been discussed recently (Gamble 1998). It should be recognized that the raw material model is intended only to provide a background for the broad variation in the British record, and does not preclude smaller scale variation that can be related to the humans who made them. Three examples reflect this point: the first as an instance of transferred behaviour and the other two as a recognition of the role of the individual. The examples are as follows:

1. White (1998b) has looked in detail at the phenomenon of twisted ovates. Although twisted edges can be produced accidentally, White has argued that in the sites he studied, they were deliberately produced using a distinct method of manufacture. Although there appear to be few functional reasons for their manufacture, they do appear to be chronologically limited to late OIS 11 and initial OIS 10, a period during which Britain was most likely isolated from mainland Europe. This may be a genuine example of a socially transmitted tradition of manufacture that existed in the British Isles for a relatively short period.
2. Analysis of Nina Layard's (1904, 1906) turn of the century excavations at Foxhall Road in Ipswich (Plunkett and White, Personal Communication) has highlighted two spatially separate patterns of activity. On a gravel surface flanking the edge of a basin or channel, primary knapping activities took place; archival records report (sadly missing) refitting groups. On the fine clay sediments at the feather edge of this gravel lens, just 5 m to the west and further into the basin, Layard (1904) reported a blackened area that she described as a campfire, around which a number of bifaces were found, but with only small quantities of kidnapping debitage. The bifaces in this small cluster can be grouped into at least three pairs of

ovates showing remarkable similarity in technique and form. A further pair of pointed handaxes was found tip-to-tip 3 meters to the south of this main cluster. The remarkable similarity in the technology and form of the paired bifaces within this cluster leads strongly to the view that several individual knappers are represented (cf. Layard 1904). Given the apparent absence of associated debitage but the improbability of any post-depositional movement in such a low-energy environment, it is likely that the bifaces in this cluster were deliberately selected and carried either a few meters from the gravel horizon or from further afield. Some social activity is a speculative but attractive interpretation (e.g., the consumption of meat around a hearth or other group focus area). The differences in the technique and form of these pairs of handaxes suggest that some level of biface variability reflects idiosyncratic skill and style; a reasonable analogy might be differences in handwriting. Although the pointed forms have undoubtedly been influenced by the raw materials, the ovates are not, and again reflect the base-level preference.

3. One biface uncovered in the recent excavations at Elveden shows an individual mind at work. In the final stages in the production of an ovate, a knapping error seems to have led to a slight shoulder on one side of the base of the biface. For presumably aesthetic reasons, the knapper created a shoulder on the other side of the base, restoring the symmetry to the piece (Figure 5.4).

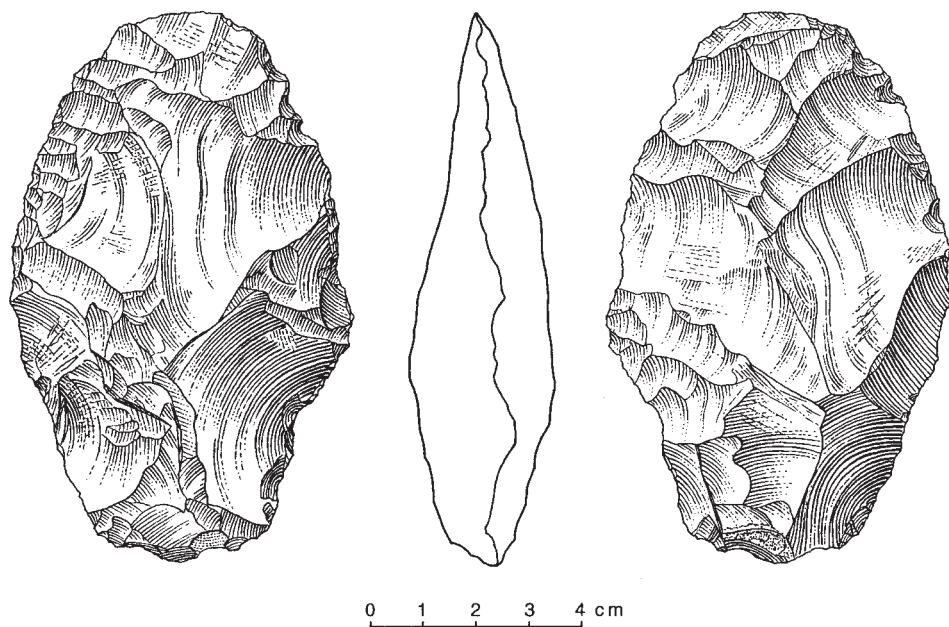


Figure 5.4 Biface from Elveden, Suffolk.

Numerous other examples could be cited, but these three suffice to demonstrate the need to go beyond the basic raw material arguments. Semantics cause part of the problem. The inherited system of analysis of dividing bifaces into ovate and pointed forms (and as a consequence into ovate and point-dominated assemblages) conceals the fact that more subtle variations exist in biface morphology that go beyond a bipartite distinction in planform. If the basic raw material perspectives are accurate, a better distinction would be between conditioned and non-conditioned forms (see Ashton and McNabb 1994 and White 1998a for full definitions of these terms). This immediately takes the argument beyond the planform analysis of Roe (1968), based largely on the relative position of the widest point, and invites other attributes such as the form of the original nodule, the extent of the usable cutting edge, and the prehensile qualities of the biface. Of course, some of these are difficult to measure, but that does not negate the importance of the attributes. In this way, for example, some cordiform bifaces that are worked all around, but under Roe's definition are pointed in planform, could be regarded as nonconditioned. There are clearly problems in determining what is conditioned; however, the simple removal of the most obvious examples would at least improve the situation.

To take the discussion beyond the raw material model, it might be argued that only nonconditioned bifaces should be used to uncover the more subtle variations in biface form. Although this would ignore a large percentage of bifaces (41% are pointed forms using Roe's measures, and demonstrably conditioned forms would probably be less than half this figure), it does provide a mechanism for examining particular biface attributes that might relate to cultural variation. If we assume that raw materials have forced the production of points at, say, Swanscombe and Stoke Newington (thus giving this base-line shape bias little cultural significance), there might still be evidence of finer-grained patterns that reflect local cultural practices. An alternative method might examine only those assemblages in which it could be argued that there was little conditioning, in this case mostly ovate assemblages. The differences between Roe's ovate sub-groups VI and VII, with more pointed and less pointed ovates respectively, is just one possible example. These approaches clearly have problems, and depend on the acceptance of the raw material arguments.

Individual Knappers, Function, and Raw Material: The 'Mental Construct'

None of the examples of individual motivation, idiosyncratic behavior, or the cultural transfer of techniques preclude the bigger picture of raw material potential and a concern with function as being among the key factors causing variation in biface morphology. Biface manufacture can be summarized as the practical realization of a 'mental construct', regardless of whatever Machiavellian motivations may lie behind the materialisation of this construct. This construct consists of four main aspects, as follows:

1. bifacial flaking
2. a sharp, durable cutting edge
3. broad symmetry
4. good prehensile qualities

The full expression of this mental construct using intensive circumferential working, where raw material permits, almost invariably leads to the production of ovate bifaces, a form that could justifiably be described as a *mental template*. The possibility remains that the ovate form is simply the unavoidable result of intensive bifacial techniques featuring full and half rotations, or in other words results passively from the rhythms of manufacture. This same basic mental construct is used in the production of other biface forms; however, in this case raw material has dictated the form that the bifaces take. Attributes, more subtle in form that might reflect cultural variation, almost certainly underlie the mental construct, the power of which is demonstrated by its survival from more than 1.5 million years ago in Africa to the end of the Middle Paleolithic in Europe. Whatever other motivations may have at one time or another been involved in handaxe manufacture remain a subject for future enquiry.

References

Ashton, N.

1992 The High Lodge Flint Industries. In *Excavations at High Lodge, G. de G. Sieveking 1962-1968, J. Cook 1988*. N. Ashton, J. Cook, S. Lewis, and J. Rose, eds. Pp. 124-63. London: British Museum Press.

1998 The Technology of the Flint Assemblages. In *Excavations at the Lower Paleolithic Site at East Farm, Barnham, Suffolk, 1989-94*. N. Ashton, S. Lewis, and S. Parfitt, eds. Pp. 251-58. London: British Museum Press.

Ashton, N., J. Cook, S. Lewis, and J. Rose, eds.

1992 *Excavations at High Lodge, G. de G. Sieveking 1962-1968, J. Cook 1988*. London: British Museum Press.

Ashton, N., and S. Lewis

1998 Elveden. *Proceedings of the Suffolk Institute of Archaeology and History* 39:371-73.

Ashton, N., S. Lewis, D. Keen, and S. Parfitt

2000 Excavations at Elveden, Suffolk (TL 809804). In *The Quaternary of Norfolk and Suffolk. Field Guide*. S. Lewis, C. Whiteman, and R. Preece, eds. Pp. 177-83. London: Quaternary Research Association.

Ashton, N., S. Lewis, and S. Parfitt, eds.

1998 *Excavations at the Lower Paleolithic Site at East Farm, Barnham, Suffolk, 1989-94*. London: British Museum Occasional Paper No. 125.

Ashton, N., and J. McNabb

1994 Bifaces in Perspective. In *Stories in Stone*. N. Ashton and A. David, eds. Pp. 182-91. London: Lithic Studies Society Occasional Paper No. 4.

1996 The Flint Industries from the Waechter Excavations. In *Excavations at Barnfield Pit, Swanscombe, 1968-72*. B. Conway, J. McNabb, and N. Ashton, eds. Pp. 201-36. London: British Museum Occasional Paper No. 94.

Austin, L., and M. Roberts

- 1999 Quarry 1, Area B. In *Boxgrove: A Middle Pleistocene Hominid Site at Eartham Quarry, Boxgrove, West Sussex*. M. Roberts and S. Parfitt, eds. Pp. 339–54. London: English Heritage Archaeological Report 17.

Bergman, C., and M. Roberts

- 1999 Quarry 2, Area A. In *Boxgrove: A Middle Pleistocene Hominid Site at Eartham Quarry, Boxgrove, West Sussex*. M. Roberts and S. Parfitt, eds. Pp. 354–61. London: English Heritage Archaeological Report 17.

Bradley, B., and G. Sampson

- 1978 Artifacts from the Cottages Site. In *Paleoecology and Archaeology of an Acheulian site at Caddington, England*. G. Sampson, ed. Pp. 83–138. Dallas: Southern Methodist University Press.

Conway, B., J. McNabb, and N. Ashton, eds.

- 1996 *Excavations at Barnfield Pit, Swanscombe, 1968–72*. London: British Museum Occasional Paper No. 94.

Doran, J. E., and F. R. Hodson

- 1975 *Mathematics and Computers in Archaeology*. Edinburgh: Edinburgh University Press.

Evans, J.

- 1860 On the Occurrence of Flint Implements in Undisturbed Beds of Gravel, Sand and Clay. *Archaeologia* 38:280–307.

Gamble, C.

- 1998 Handaxes and Paleolithic Individuals. In *Stone Age Archaeology: Essays in Honour of John Wymer*. N. Ashton, F. Healy, and P. Pettitt, eds. Pp. 105–09. Lithic Studies Society Occasional Paper No. 6. Oxford: Oxbow Monograph 102.

Green, S.

- 1984 *Pontnewydd Cave: A Lower Palaeolithic Hominid Site in Wales*. Cardiff: National Museum of Wales.

Hodson, F. R.

- 1971 Numerical Typology and Prehistoric Archaeology. In *Mathematics in the Archaeological and Historical Sciences*. F. R. Hodson, D. G. Kendall, and P. Tautu, eds. Pp. 30–45. Edinburgh: Edinburgh University Press.

Hosfield, R.

- 1999 *The Paleolithic of the Hampshire Basin: A Regional Model of Hominid Behaviour During the Middle Pleistocene*. Oxford: British Archaeological Report 286.

Isaac, G.

- 1986 Foundation Stones: Early Artefacts as Indicators of Activities and Abilities. In *Stone Age Prehistory: Studies in Memory of Charles McBurney*. P. Callow. and G. Bailey, eds. Pp. 221–41. Cambridge: Cambridge University Press.

Jones, P.

- 1980 Experimental Butchery with Modern Stone Tools and Its Relevance for Paleolithic Archaeology. *World Archaeology* 12:153–65.

Keeley, L.

- 1980 *Experimental Determination of Stone Tool Uses. A Microwear Analysis*. Chicago: University of Chicago Press.

Layard, N.

- 1904 Further Excavations on a Paleolithic Site in Ipswich. *Journal of the Royal Anthropological Institute* 34:306–10.
 1906 A Winter's Work on the Ipswich Paleolithic Site. *Journal of the Royal Anthropological Institute* 36:233–6.

McPherron, S.

- 1994 A Reduction Model for Variability in Acheulian Biface Morphology. Ph.D. dissertation, University of Pennsylvania.
 1995 A Re-examination of the British Biface Data. *Lithics* 16:47–63.

Mitchell, J.

- 1995 Studying Biface Butchery at Boxgrove: Roe Deer Butchery with Replica Handaxes. *Lithics* 16:64–69.

Preece, R., S. Lewis, J. Wymer, D. Bridgland, and S. Parfitt

- 1991 Beeches Pit, West Stow, Suffolk (TL 798719). In *Central East Anglia and the Fen Basin Field Guide*. S. Lewis, C. Whiteman, and D. Bridgland, eds. Pp. 94–104. London: Quaternary Research Association.

Roberts, M.

- 1999 Quarry 2 GTP17. In *Boxgrove: A Middle Pleistocene Hominid Site at Eartham Quarry, Boxgrove, West Sussex*. M. Roberts and S. Parfitt, eds. Pp. 372–378. London: English Heritage Archaeological Report 17.

Roberts, M., and S. Parfitt, eds.

- 1999 *Boxgrove: A Middle Pleistocene Hominid Site at Eartham Quarry, Boxgrove, West Sussex*. London: English Heritage Archaeological Report 17.

Roe, D.

- 1968 British Lower and Middle Paleolithic Handaxe Groups. *Proceedings of the Prehistoric Society* 34:1–82.

Smith, W. G.

1894 *Man the Primeval Savage*. London: Edward Stanford.

Toth, N.

1982 The Stone Technologies of Early Hominids at Koobi Fora, Kenya: an Experimental Approach. Ph.D. dissertation, University of California, Berkeley.

1985 The Oldowan Reassessed: A Close Look at Early Stone Artefacts. *Journal of Archaeological Science* 12:101–20.

Villa, P.

1990 Torralba and Aridos: Elephant Exploitation in Middle Pleistocene Spain. *Journal of Human Evolution* 19:299–309.

Wenban-Smith, F.

1995 The Ebbsfleet Valley, Northfleet (Baker's Hole) (TQ 615735). In *The Quaternary of the Lower Reaches of the Thames Field Guide*. D. Bridgland, P. Allen, and A. Haggart, eds. Pp. 147–64. Durham: Quaternary Research Association.

Wenban-Smith, F., and N. Ashton

1998 Raw Material and Lithic Technology. In *Excavations at the Lower Paleolithic Site at East Farm, Barnham, Suffolk, 1989–94*. N. Ashton, S. Lewis, and S. Parfitt, eds. Pp. 237–244. London: British Museum Occasional Paper No. 125.

White, M.

1995 Raw Materials and Biface Variability in Southern Britain: A Preliminary Examination. *Lithics* 15:1–20.

1996 Biface Variability and Human Behaviour: A Study from South-Eastern England. Ph.D. dissertation, University of Cambridge.

1998a On the Significance of Acheulean Biface Variability in Southern Britain. *Proceedings of the Prehistoric Society* 64:15–44.

1998b Twisted Ovate Bifaces in the British Lower Paleolithic: Some Observations and Implications. In *Stone Age Archaeology: Essays in Honour of John Wymer*. N. Ashton, F. Healy, and P. Pettitt, eds. Pp. 98–104. Lithic Studies Society Occasional Paper No. 6. Oxford: Oxbow Monograph 102.

Wymer, J.

1968 *Lower Paleolithic Archaeology in Britain as Represented by the Thames Valley*. London: John Baker.



6

MANUFACTURE, TRANSPORT, AND USE OF MOUSTERIAN BIFACES: A CASE STUDY FROM THE PÉRIGORD (FRANCE)

Marie Soressi and Maureen A. Hays

Whereas Acheulean handaxes have received much attention in the literature, late Pleistocene bifaces have been relatively neglected due to the current focus on Levallois debitage. Bifaces are a diagnostic feature of the Mousterian of Acheulean tradition, a Mousterian facies considered to be a forerunner of industries transitional to the Upper Paleolithic. Based on the analysis of raw material sources, technology, and use-wear of Mousterian bifaces from Grotte XVI, a cave site dated to approximately 65,000 years ago, there is strong evidence to suggest that these Mousterian bifaces were carefully designed and maintained implements that were transported from one location to another.

Bifaces are a diagnostic feature of the Mousterian of Acheulean Tradition (Peyrony 1920; Bordes 1961). This industry is considered by several authors (Mellars 1969, 1988, 1996; Peyrony 1948; Bordes 1972; Harrold 1983, 1989; Pelegrin, 1990, 1995:261–65) as a late Mousterian technocomplex, forerunner to the Châtelperronian, an industry transitional to the Upper Paleolithic in western Europe. How this change occurred is not completely clear. Some believe that the Châtelperronian was the product of acculturation, resulting from contact with the first Aurignacians (Demars and Hublin 1989; Mellars, 1989, 1999; Bocquet-Appel and Demars 2000). Others see it as an independent development from the local Mousterian of Acheulean Tradition (MAT) (Harrold 1983, 1989; Pelegrin 1990, 1995; Rigaud 2000; d'Errico et al. 1998; Zilhao and d'Errico 1999). The organization and use of the bifacial technology characteristic of the MAT is also poorly understood (however see Geneste, 1985). An analysis of raw material sources, technology, and use-wear of MAT bifaces dated to approximately 65,000 years ago from Grotte XVI, a cave site located in southwestern France (Guibert et al. 1999) are presented.

Bifaces from Grotte XVI were analyzed to test a model of expedient tool technology. Binford (1979, 1989) characterized early modern humans as using a poorly organized technology that tends “toward the expedient manufacture, use, and abandonment of instrumental items in the immediate context of use” (Binford 1977:34). This idea, in combination with an interpretation of faunal remains showing that early modern humans had limited predatory abilities (Binford 1981), has been used to argue that Neandertal societies were much less complex than modern ones (Binford 1981, 1989; White 1982). From this, it was further concluded that there was a difference, even a clear inferiority, in the

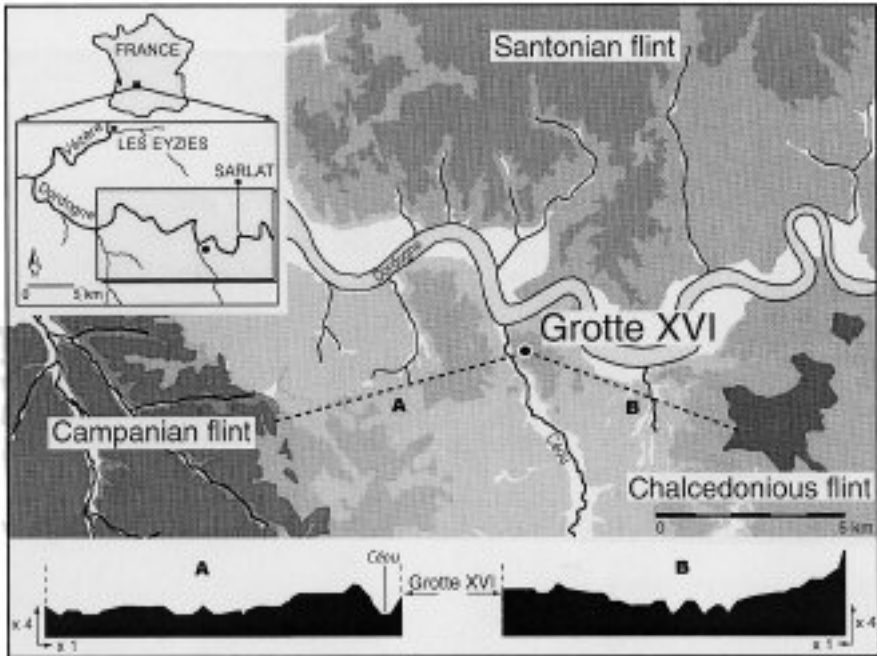


Figure 6.1 Location of Grotte XVI (Dordogne, France). Santonian, Campanian and Chalcedony are different sources of flint. A and B show variations in height from Grotte XVI to the nearest possible outcrops of Campanian and Chalcedonian flint.

cognitive abilities of Neanderthals when compared with early anatomically modern humans (Binford 1982, 1989; Noble and Davidson 1996; Foley 1995; Stringer and Gamble 1993).

According to Binford (Binford 1977, 1979, 1989), an expedient technology implies:

- a. A unity of location “the debris from manufacture, and the by-products of activities in which tools were used should be spatially associated” (Binford 1977: 34),
- b. A unity of time: stone tools were quickly manufactured to satisfy an immediate need, and were quickly discarded after the task was accomplished.
- c. A lack of standardization: tools are not characterized by any consistent morphotechnical features.

Grotte XVI Assemblage

Grotte XVI (Figure 6.1) is a large karstic cavity located in the Le Conte Cliffs of the Dordogne region of southwest France. Located near the better-known Vaufray Cave (or Grotte XV, Rigaud 1988), the site is 120 meters above the valley floor of the Céou, a small tributary that flows into the Dordogne river. Excavations began at Grotte XVI in 1985, and continued through the summer excavations of 2001, under the direction of Jean-Philippe Rigaud and Jan Simek, as a cooperative venture of the Institut de Préhistoire et de Géologie du Quaternaire at the University of Bordeaux and the Department of Anthropology at the University of Tennessee.

There are several Middle and Upper Paleolithic levels preserved in the Grotte XVI stratigraphy. These include: various Mousterian, MAT, Châtelperronian, Aurignacian, Gravettian, Solutrean, and final Magdalenian levels (Rigaud 1998, Rigaud et al. 2002). The MAT level studied here is located in and around a remarkably well-preserved combustion area (Rigaud et al., 1995; Karkanas et al. 2002). The heated sediment from this area has been dated to approximately $64,600 \pm 3,100$ years BP (weighted average) by thermoluminescence dating (Guibert et al. 1999). Thirty seven one-meter squares have been excavated, and yielded approximately 2500 lithic pieces larger than 1.5 cm. Nineteen bifaces were recovered, 13 of which were complete. These 19 bifaces are the focus of this study.

A Multi-Disciplinary Methodology

In order to test a model of expedient tool technology using the Mousterian bifaces, a multi-disciplinary approach was applied to understand: raw material type and origin, technology, and use-wear features.

Raw Material Analysis

The analysis to determine the geographic origin of the raw materials has benefited from the years of research that have been conducted in this area (Demars 1982; Rigaud 1982; Morala 1984; Geneste 1985; Séronie-Vivien and Séronie-Vivien 1987; Turq 2000). We employed both macroscopic and microscopic observations in this characterization. Macroscopic observations aimed to describe color, zonation, texture (using Dunham's 1962 classification), cortex (color, thickness, internal contact with the silicified zone, erosion), and give a preliminary description of the fossils visible to the naked eye. Microscopic observations using 10x to 70x magnifications allowed a precise analysis of the texture and the paleontological content. Using these criteria, combined with knowledge of flint formations in the area, we were able to determine the geological level or strata of origin. The nearest possible outcrop for the raw material was then located, and the distance to the site was calculated.

Technological Analysis

Technological procedures described here are based on knowledge of conchoidal fracture properties. Curvature of ripples on the removals, hackle marks, orientation of the trapezoidal microremovals, and observations of scar ridges were used to ascertain the

removal direction and chronology (Dauvois 1976:165–193; see also Cotterell and Kamminga 1979: 106–111):

- The ripples or undulations follow the direction of the fracture front initiated at the impact point.
- Hackle fractures or “lances” are perpendicular to the tangent of the front fracture curvature.
- The orientation of trapezoidal microremovals is the same as that of the initial fracture; the microremoval origination is narrower than the termination.
- Hackle fracture glaze and chains of trapezoidal microremovals on the limits of a scar indicate which scar was the last produced.
- When hackle marks or trapezoidal microremovals are absent on a scar ridge, the termination of the last scar is abruptly curved just before the separating ridge.

Previous experimental work was used to define the morphometric characteristics of bifacial technology debris (e.g., Newcomer 1971; Callahan 1979; Crabtree 1972; Wittaker 1994).

Use-wear Analysis

This study utilized the high-magnification approach to microwear analysis, often referred to as the *Keeley method*, after the work done by Lawrence Keeley (1980). High-magnification microwear analysis involves the optical microscopic study at a wide range of magnifications (up to 500X) of polishes and striations that develop on the edges of stone tools as the direct result of use. High-magnification microwear analysis complements, rather than replaces low-magnification microwear analysis. It emphasizes the assessment of use polishes and striations but does not overlook the interpretive potential of the microscars and edge rounding, that are the foci of low-magnification studies.

The bifaces were cleaned in a dilute NaOH solution. A metallurgical binocular microscope, with an incident-light attachment, and 5x, 10x, 20x, and 50x objectives with a 10x oculars was employed to assess use-wear damage. Attributes such as scar type and edge rounding were first viewed at 50x magnification. The entire piece was then scanned for polish and striations. These were generally located on the implement edge using 100x magnification. After the polish was located, magnifications up to 200x were used to evaluate the polish type and to interpret function. The identification of microtraces was made with reference to an experimental collection (Hays 1998). Experiments focused on general prehistoric activities: projection, cutting, scraping, graving, boring, and wedging of various materials.

Results

To investigate the expedient technology model, the concepts of “unity of location” and “unity of time” were addressed. Did manufacture, use, and abandonment of the bifaces take place at the same location? And, were the bifaces manufactured quickly to fulfill an immediate need, and then abandoned after the task was accomplished?

First, “unity of location” was assessed using the raw material analyses. Proximity to the site and availability of raw material were determined. Next, the manufacture location was determined through an analysis of the flaking debris. “Unity of time” was addressed by an analysis conducted to determine episodes of sharpening and use.

“Unity of Location”

Biface Raw Material Type and Origin

Flint is available around the site in Coniacian strata (Rigaud 1982; Astruc 1990; Turq *et al.* 1999). It is blond in color (2.5 Y 5/2 on the Munsell chart), with a matte glitter, and it is found in small (<25 cm), oval or oblong nodules. It has an isometric cortex (1–5 mm) with a sharp inferior limit. The siliceous matrix is often homogeneous and has a mudstone texture. Sponge spicules, bryozoaires, and a scarcity of foraminifer are the principal paleontologic characteristics of this local flint (Séronie-Vivien and Séronie-Vivien 1987:74).

An important source of chalcidionous flint is located on the Dome plateau 6 km away from the site (Rigaud 1982; Astruc 1990; Figure 6.1). This lacustrine Oligocen deposit was formed in a specific location (Salomon and Astruc 1992). These silicifications are present in tabular form ranging from 0.70 to 2.5 meters thick. The color (from white and to red, often translucent), as well as the texture, and the homogeneity are highly variable. The cortex, when it is present, is very fine and irregular (Turq 2000). Its lacustrine origin has a most recognizable feature: the presence of Charophyte oogone and lacustrine snails (Demars 1994). Because this chalcidionous flint outcrop is upstream on the Dordogne river from Grotte XVI, blocks could have been picked up in the river 2 km away from the site.

An outcrop of Campanian flint is located 7 km from the site in the Belvès area (Dubreuilh *et al.* 1988; Turq 2000; Figure 6.1). This brown flint (10 YR 3/1 on the Munsell chart), with a greasy glitter, is found in oval, oblong, or twisted nodules between 10 and 30 cm long. The cortex is friable, generally less than 1-cm thick, with a contorted (“foam-flecked”) inferior limit. The homogeneity is variable, and the texture is wakestone to packstone. Large foraminifera such as *Subalveolina dordonica major* or *Orbitoides tisseti*, are characteristics of this outcrop (Séronie-Vivien and Séronie-Vivien 1987:76–77).

Raw material analysis of the Grotte XVI bifaces (Table 6.1) indicates that four of the bifaces were made out of chalcidionous flint; of these, two have cortex. Because this cortex is fresh, we conclude that they were manufactured from a raw material located at least 6 km away. The raw material used to produce two other bifaces, for which we have no indication of cortex erosion, may have been gathered from the Dordogne river, just 2 km from the site. Campanian flint was used to produce an additional six bifaces. The flint used to make the last seven bifaces is different from the raw materials previously described. Its origin is still unknown. It may be a Santonian flint for which the nearest outcrops are located on the other bank of the Dordogne, 3 km to the north (Figure 6.1). Two bifaces were manufactured on the local Coniacian flint. Therefore, 16 of the 18 bifaces studied were manufactured from raw materials not found at the site or in the immediate vicinity of the site.

Biface Location of Manufacture

To determine if these bifaces were manufactured at the site, or were instead imported in finished form into the site, the artifact assemblage was analyzed to identify manufacturing debris. If these bifaces were produced on site, the characteristic debris (from the same raw material) should:

Table 6.1 Biface Raw Material and Location (n = 18)

Outcrop Geological Level	Minimum distance from the site	Total
Coniacian	Several meters	2
Chalcedonious flint in primary context	6 kilometers	2
Chalcedonious flint from unknown (primary or derived) context	2 kilometers	2
Campanian	7 kilometers	6
Indeterminate (non local)	? but greater than 3 kilometers	6

- be knapped with soft-hammer percussion (Ohnuma & Bergman, 1982; Wenban-Smith, 1989, 2000; Pelegrin, 1995:20–3),
- possess curvature indicative of bifacial thinning flakes (Newcomer 1971; Geneste 1985:244-245 ; Callahan 1979; Crabtree 1972).

Two characteristic bifacial thinning flakes are present in the assemblage. One was possibly made of Campanien flint, the other one of chalcedonious flint. However, both are too large to be from the manufacture of even the largest biface in the assemblage. They are almost as long as the longest bifaces (2 mm and 6 mm difference; see Figure 6.2). These large biface thinning flakes were probably imported separately, and are not evidence of biface manufacture at the site. It is also the case that few retouch flakes are present in the assemblage. They are small relative to the biface dimensions. It is difficult to distinguish biface retouch flakes from scraper retouch flakes; therefore, these retouch flakes could have been produced during biface as well as during scraper retouch. In sum, the Grotte XVI bifaces were made on non-local raw materials, and they were manufactured away from the location where they were abandoned. However, biface edges could have been retouched at the site.

“Unity of Time”

The second part of this analysis, “unity of time,” examined whether Mousterian bifaces were manufactured and used to satisfy immediate needs, and then once the task was completed, abandoned (Binford 1977, 1979, 1989). To investigate the expedience of biface use, evidence for episodes of re-sharpening and use was analyzed.

Patterns of Re-Sharpening

To assess patterns of re-sharpening, a study of use-wear location was combined with an analysis of the chronology of the scars that shaped the edges. Three bifaces (K11-550, I14-741, and J13-976) exhibit evidence that the piece was reshaped after it was used. At least one, (K11-550) was used again after a reshaping episode. The right edge (Figure 6.3) was shaped by removal series number 2, and was then used to scrape wood. The polish

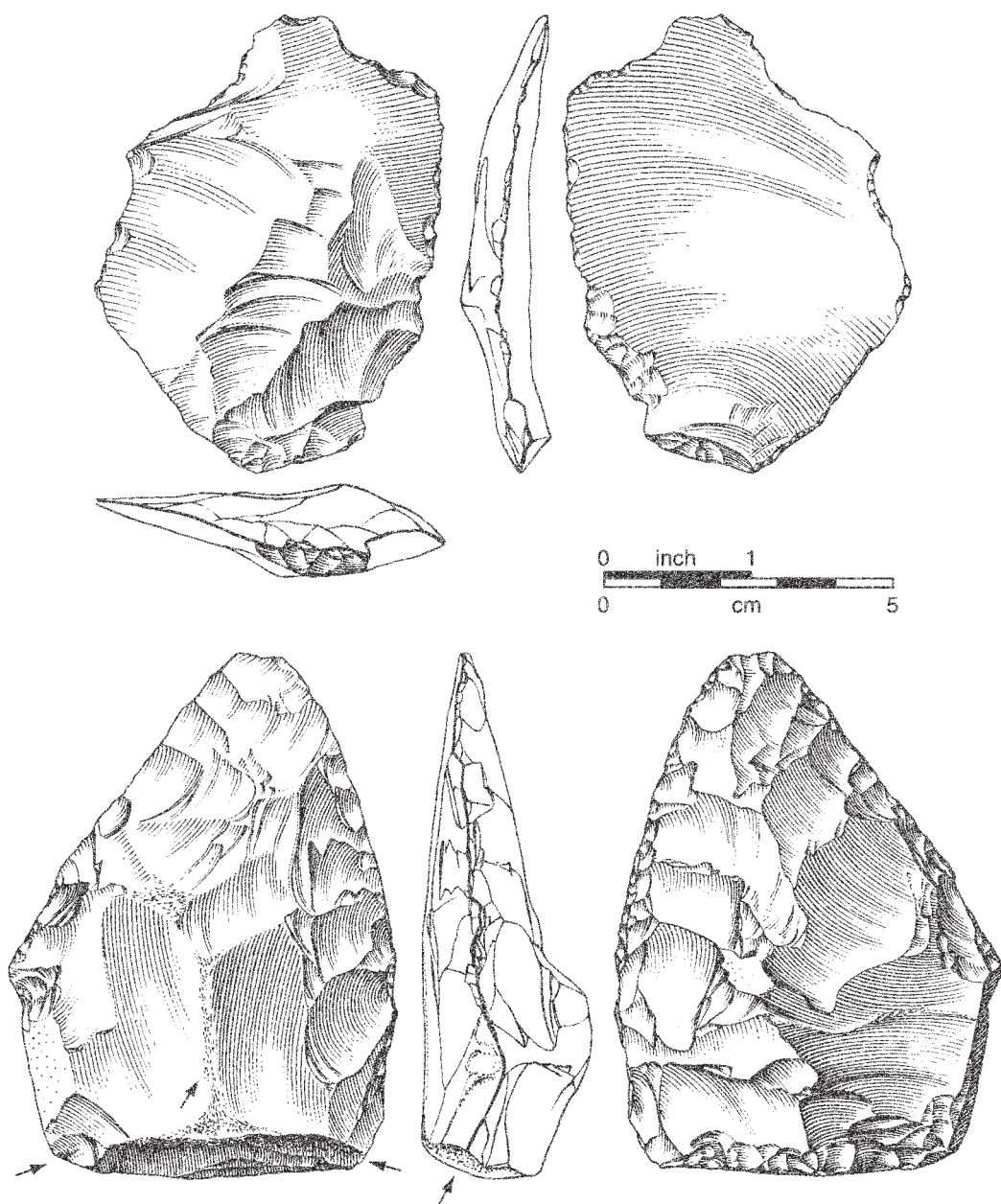


Figure 6.2 Grotte XVI, couche C. Biface thinning flake J11-597 and biface K17-855. Arrows indicate grounded zones. (Drawings by J.-G. Marcillaud)

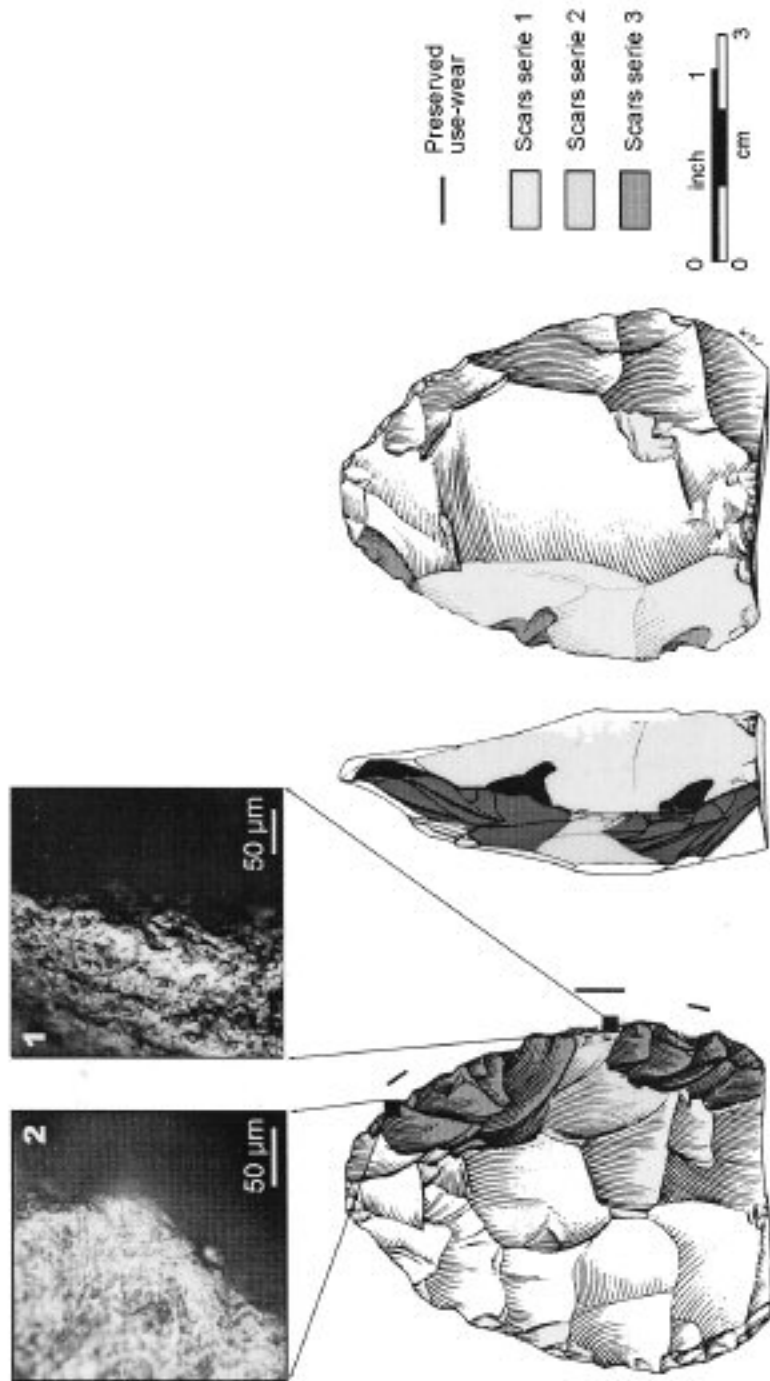


Figure 6.3 Grotte XVI, coudche C. Biface K11-777 showing traces of use on wood (1), re-sharpening (scars series number 3) and additional use on wood (2). Photomicrographs taken at 200x. (Drawing by J.-G. Marcillaud.)

is very bright, smooth, and domed. It appears mainly on the high points of the piece. What is noteworthy is that the use-wear on removal series number 2 is truncated at each of its extremities by the next series of scars shaping the edge. This third series was then itself used to scrape wood. Here we have evidence that the biface was shaped, used, reshaped, and used again. On the two other bifaces (I14-741 and J13-976), there is only evidence for a reshaping episode after use. Use-wear areas are truncated by the reshaping scars; however, no use-wear is visible after the final reshaping (Figure 6.4).

This pattern involving use and reshaping is visible on only a few bifaces. This is probably due to the fact that this evidence requires a precise determination of scar chronology (which is not always possible) in combination with use-wear observations (which are not always preserved) on key locations.

Biface Use on Different Materials

In addition to the bifaces previously described, ten other bifaces exhibit diagnostic microwear patterns. In total, five bifaces were used to work wood, four were used for butchery, and two bifaces exhibit evidence of multiple uses, these are described below. Except for these two bifaces exhibiting multiple uses, the use-wear on these additional bifaces is not critical to the arguments presented here (however, see Table 6.2 and Figure 6.5 for descriptions of use wear features and locations).

Biface Use on Multiple Contact Materials

Two bifaces were used on two different contact materials. One biface (Figure 6.6) exhibits two separate polishes that are characteristic of bone and wood. The bone polish is located on both sides of each of the edges on the area closest to the tip of the biface. It is not continuous, which may be a factor of how polish develops on bifacial scars. The bone polish is slightly pitted and somewhat grainy in texture. It is concentrated on the high points and near the edge for the most part. Occasional striations, which

Table 6.2 Angle Variation Along Each Used Edge

Biface ID	Edge use	Edge length (mm)	Mean angle (degree)	Standard deviation (degree)
I14-550	Scraping hide/meat	47	40	4
J13-976	Scraping wood	35	59	4
I11-756	Cutting wood	30	55	2
I14-678	Butchering	46	48	4
J12-361	Butchering	41	54	3
H14-979	Butchering	64	54	3
J12-361	Butchering	47	55	1

(2 measurements done on each edge, 3 for edges used on bone)

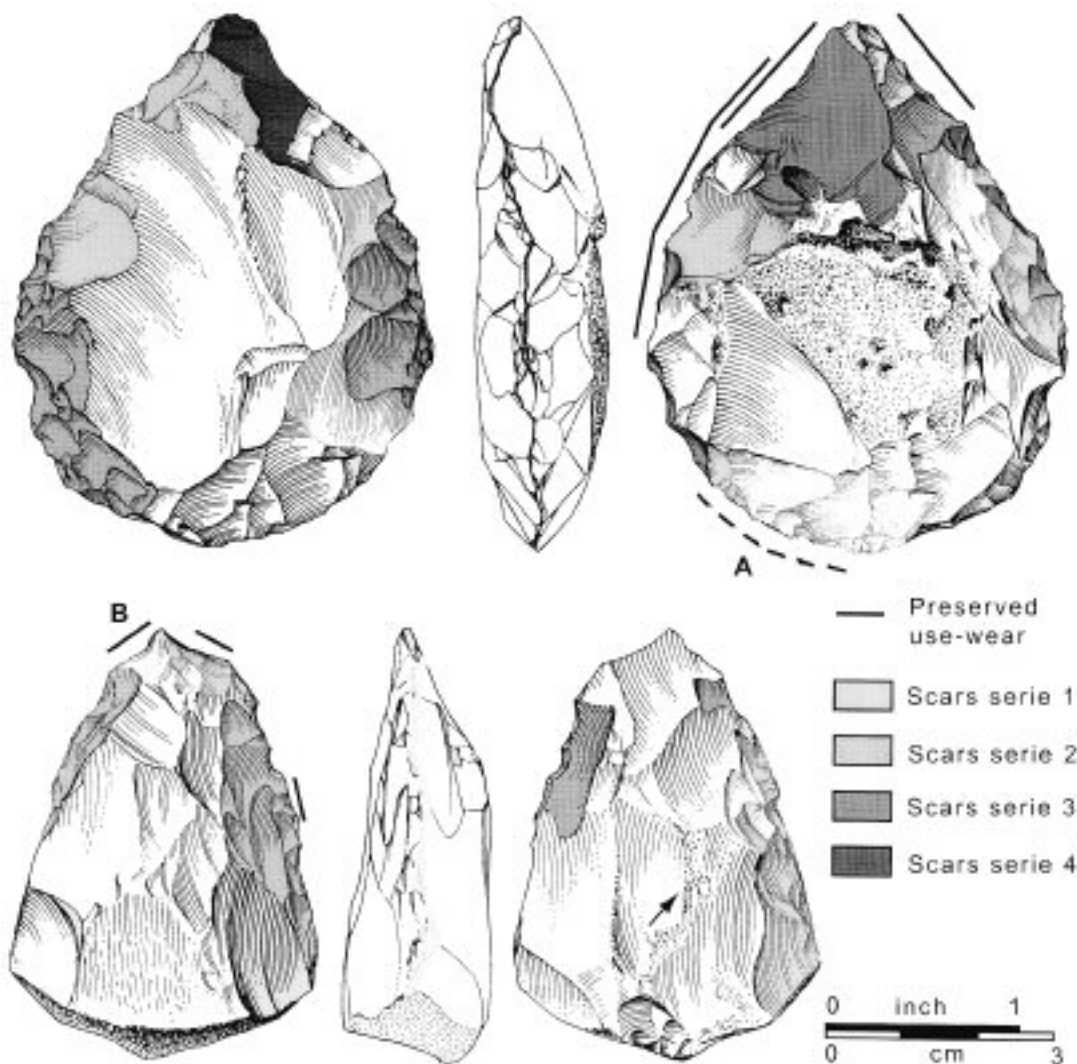


Figure 6.4 Grotte XVI, couche C. Biface J13-976 and I14-741 showing traces of use to scrape wood followed by resharpening on area A and B. Arrow indicates grounded zone. (Drawings by J.-G. Marcillaud.)

run parallel to the edge and may indicate a cutting motion, are associated with this polish. Given the noncontinuous nature of the polish and the direction of the striations, this biface may have been used in butchery. The wood polish is located near the base of the biface, but does not appear to be evidence of hafting. Given the directionality of the polish, which is perpendicular to the edge, this area of the biface appears to have been used to scrape wood. The chronology of these use events is unresolved.

On the thinner edge of the second biface, there appears to be polish characteristic of hide or meat processing (Figure 6.5). In archaeological contexts, meat polish is often quite indistinguishable from hide polish. Here, the polish is relatively dull, somewhat

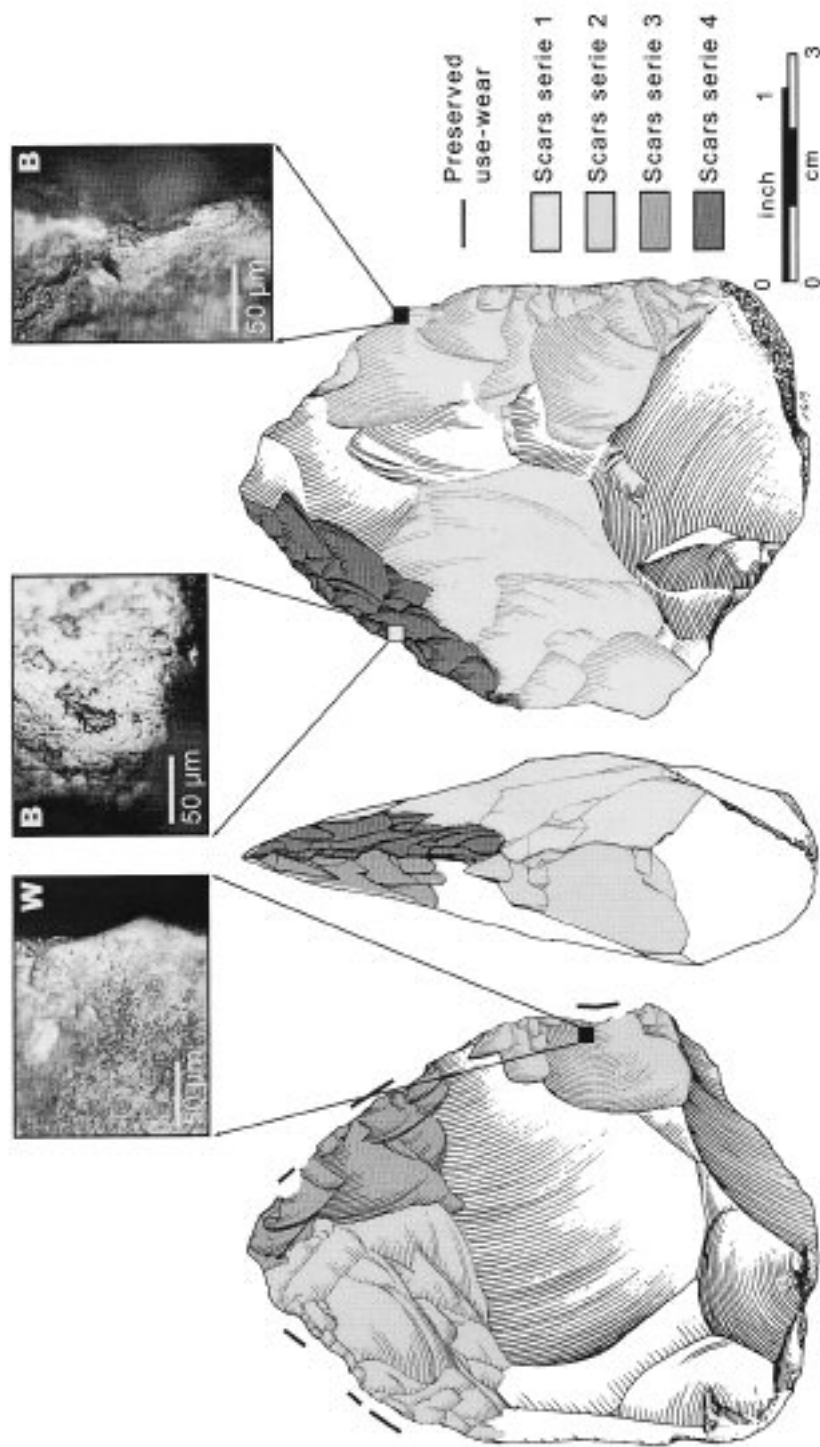


Figure 6.5 Grotte XVI, couche C. Biface 114-678 used on wood (W) and bone (B). Photomicrographs taken at 200x. (Drawing by J.-G. Marcillaud)

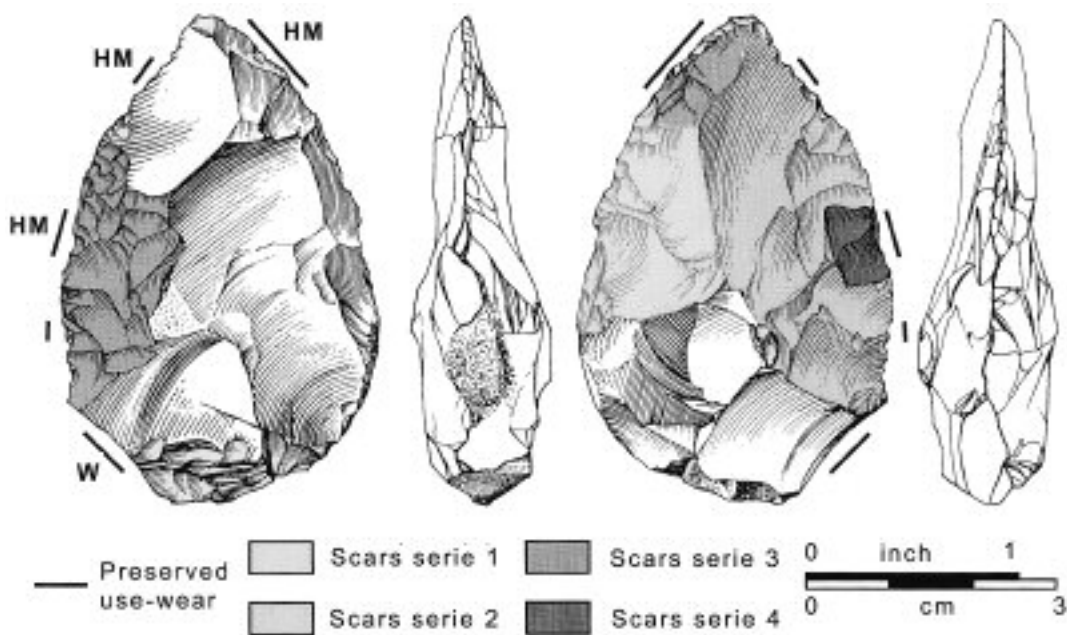


Figure 6.6 Grotte XVI, couche C. Biface I14-550 used on hide or meat (HM) and wood (W). (Drawing by J.-G. Marcillaud)

greasy in appearance, with a rough and bumpy topography. The entire surface has been altered, and thus there is little contrast between the polished area and the unaltered surface of the flint. For this reason, it was impossible to capture as a digital image. On the thicker portion of the biface, where the edge angles are much steeper, the contact material was wood. Similar to the first biface, this polish also had directionality on a slight angle perpendicular to the edge. This steep edge angle, in combination with the direction of the polish, indicates a scraping motion was used. Again, the order of these use events remains unresolved. The evidence indicates that some of these bifaces were shaped, used, resharpened, and used again, and that a single tool might be used to work two different materials. This contradicts a hypothesis of expedient uses.

Biface Design

The final point to be considered concerns formal tool design and whether these tools were manufactured according to standardized morphotechnical features. This question is examined by looking at the location of use-wear traces and the specificity of edge morphology.

Location and Sharpness of Used Edges Versus Unused Edges

In eight out of ten cases, use-wear traces appear on each side of the biface point; no traces were observed on the base. On nine out of ten bifaces, this use location occurs opposite a thick "edge." This edge has a flat fracture surface, so that the edge is U-shaped (see Figure 6.1 and Figure 6.4), or a steep angle greater than 75 degrees (Figure 6.4 and Figure 6.5). Additionally, on four bifaces, part of the lateral edge had been crushed or ground (Figure 6.2 and Figure 6.4). Moreover, two of the bifaces have relief on a section of one or two faces that have also been ground (Figure 6.6). The area that was ground and the thick edge are always opposite the point where use-wear is located.

We interpret this repetitive pattern of a dulled or abraded zone without visible use-wear, opposite a sharp use zone, as a prehensile zone opposite an active zone. There is no evidence, macroscopic or microscopic, for hafting. Therefore, this pattern is interpreted as a hand held prehensile zone. This is similar to the pattern Hughes Plisson (Veil *et al.* 1994) observed on backed bifaces and scraper bifaces (*keilmesser* and *blattförmiger schaber*) from the Middle Paleolithic site of Lichtenberg in Germany.

Morphology of Used Edges

The delineation of used edges is regular, straight or convex in plan and profile view. The angles are fairly constant on each edge, and from one biface to the next, by task. Angles were measured on each used edge where lengths were greater than 30 mm. This was accomplished by taking two measurements at each of the extremities, 4 mm from the edge, using a caliper (Dibble & Bernard 1980). An additional measurement was taken in the mid section of an edge when the tool was used on bone. The standard deviation for used edges over 30 mm is approximately 3°. This is relatively low given the angle values (Table 6.2). Moreover, biface edge angles are not highly variable, with a standard deviation within each activity varying from 4° to 8° (Table 6.3). Nonetheless, the relationship between angle value and activity is highly significant according to the ANOVA test (Table 6.3).

Discussion

Our analysis shows that the Grotte XVI bifaces were not manufactured at the site and that the raw materials used were not picked up *in situ*. The minimum distance from the raw material outcrops to the abandonment location is rather short, but we must keep in mind that this is a minimum distance in a straight line from the site and that the area is rich in high quality raw material. This last point probably implies that long distance transport of raw material was not essential. Other neighboring sites provide evidence of transport of

Table 6.3 Edge Angles and Functional Interpretations

	Scraping Wood	Scraping Hide/Meat	Cutting Wood	Butchering
N of edges	9	2	2	6
N of measurements	11	4	4	17
Minimum edge angle (degree)	58	37	42	45
Maximum edge angle (degree)	71	42	57	71
Mean edge angle (degree)	62	40	49	56
Standard deviation (degree)	8	4	7	7
ANOVA (comparison of four groups combined) F = 8.406, df: 3/15, P = 0.0016				

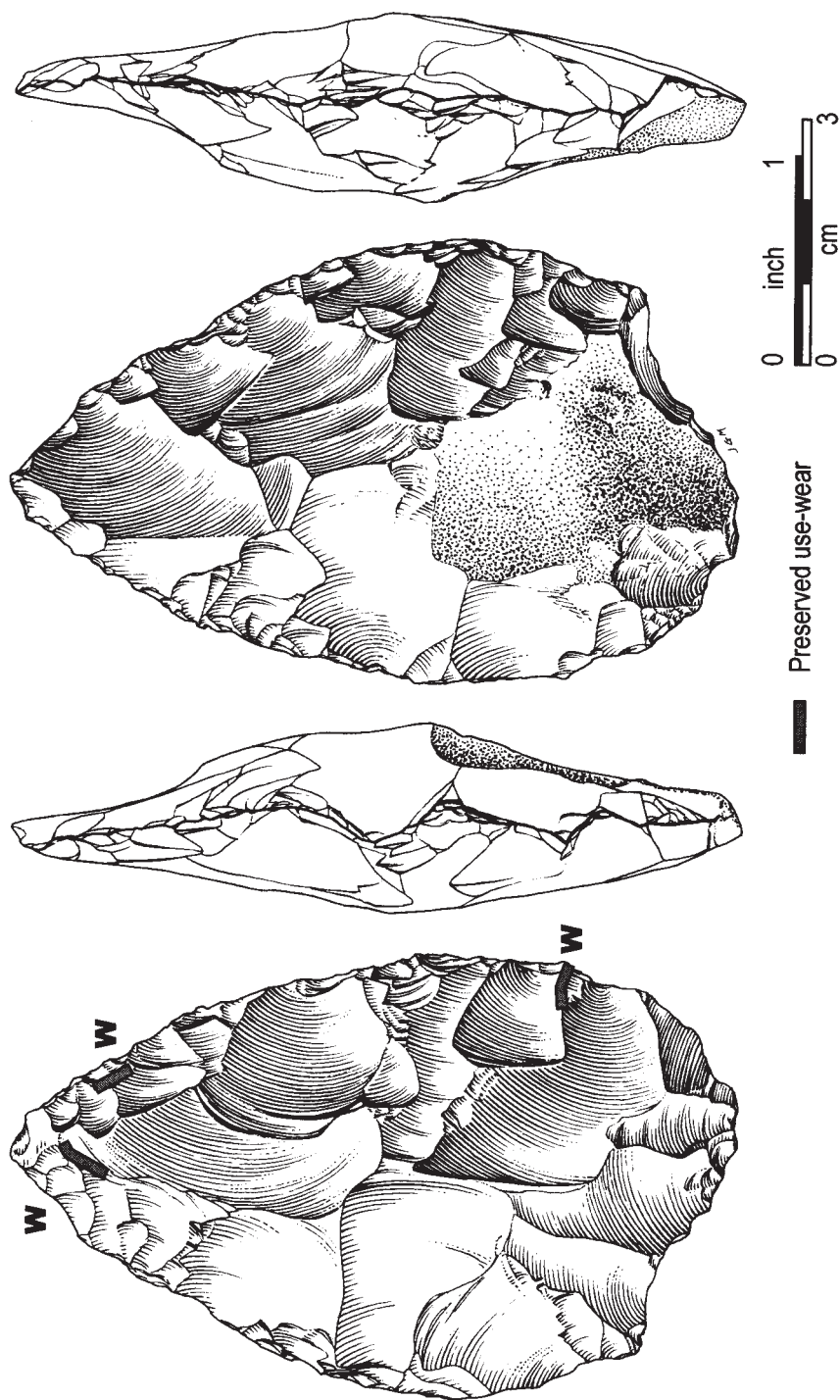


Figure 6.7 Grotte XVI, couche C. Biface J12-36 used on wood (use-wear are preserved only on one face). (Drawing by J.-G. Marcillaud)

MAT bifaces more than 60 km (Abri Brouillaud - Geneste 1985:357, 363; Pech-de-l'Azé I - Soressi, unpublished). Moreover, these bifaces were not discarded immediately after their initial use as illustrated by successive stages of re-shaping and use on the edges; and some were used successively on two different materials. Finally, their edge morphology appears to be standardized. Technological and use-wear analyses indicate that the bifaces have a cutting edge with a continuous regular angle opposite to a thick and grounded zone without evidence of use-wear. There may be a consistent pattern involving an active sharp edge opposite a dull prehensile edge.

Grotte XVI bifaces do not possess any of the requisite factors that would suggest an expedient technology. An alternative to an expedient technology is a curated technology (Binford 1973, 1977, 1979). If the biface technology used at Grotte XVI was a curated one, what may have prompted the use of this technology by these Neandertals?

The use of one or another technology may have been directly related to global subsistence settlement systems (Binford 1979; see also Bettinger 1987:126-127) and time scheduling (Torrence 1983:11-13). However, maintenance and recycling can also be closely related to raw material availability (Bamforth 1986; Dibble 1995; Khun 1991; Marks *et al.* 1991; Andresfsky 1994; Odell 1996). Odell (1996:53) proposed ways to "discriminate between the effects of raw material availability and the forces of curation." These criterion include shattered cores and high levels of tool breakage as a means to economize raw materials. Grotte XVI shows none of these. In contrast, there is evidence for the transport of tools from their manufacture location to another location for use and abandonment. In addition, occasionally single tools may have been used for multiple tasks. These features are characteristic of tool curation related to mobility (Odell 1996).

Conclusion

Examined in light of the criteria used to categorize assemblages as being either expedient or curated (Binford 1973, 1977, 1979), the Grotte XVI Mousterian of Acheulean Tradition bifaces show evidence of having been curated, as do a number of other Middle Paleolithic stone tools assemblages (Geneste 1985, 1989, 1990; Callow 1986:374-75; Roebroeks *et al.* 1988; Marks 1988; Meignen 1988; Henry 1992; Nash 1996; Conard and Adler 1997). However, it is probably not justifiable to treat expedience and curation as mutually exclusive systems (cf. Nash 1996; Shott 1996:268) primarily because both behaviors occur in contexts associated with modern humans and also in contexts associated with archaic humans. Secondly, when associated with modern humans, expedience and curation are just planning options (Nelson 1991:65). In fact, we should be cautious about debating the cognitive implications for the use of either technology (see Toth 1985; Khun 1992). As Lévi-Strauss (1952:chapter 6) outlined, the definition of an "archaic" culture versus a "modern" culture is situationally dependent and the observer influences the diagnostics. We may define a culture developed in a way similar to our own, i.e. significant to our system of reference, as modern. Thus, to interpret Neandertal behavior, we must take care to explore its originalities and try to understand them in their own context (Liolios 1995). Future research on MAT assemblages in the same geographical contexts with different site uses (i.e., in-situ manufacture and use) should help clarify Neandertal regional organization of bifacial technology.

The importance of integrating different methods of analysis is worth reiteration. The combination of analytical techniques designed to investigate raw materials, technology,

and use provide insights into Mousterian behavior (e.g., tool mobility and re-sharpening patterns) that could not have been reached by one approach alone.

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References

Andrefsky, W.

1998 *Lithics. Macroscopic Approaches to Analysis*. Cambridge: Cambridge University Press.

Astruc, J.G.

1990 *Carte Géologique France (1/50 000), Feuille Gourdon (832) et Notice Explicative*. Orleans: Bureau de Recherches Géologiques et Minière.

Bamforth, D.

1986 Technological Efficiency and Tool Curation. *American Antiquity* 51:38–50.

Bettinger, R. L.

1987 Archaeological Approaches to Hunter-Gathers. *Annual Review of Anthropology* 16:121–42.

Binford, L. R.

1973 Interassemblage Variability: The Mousterian and the Functional Argument. In *The Explanation of Culture Change*, C. Renfrew, ed. Pp. 227–54. London: Duckworth.

1977 Forty-seven Trips. In *Stone Tools as Cultural Markers*, R. V. S. Wright, ed. Pp. 24–36. Canberra: Australian Institute of Aboriginal Studies.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255–73.

1981 *Bones: Ancient Men and Modern Myths*. New York: Academic Press.

1982 Archaeology of Place. *Journal of Anthropological Archaeology* 1:5–31.

1989 Isolating the Transition to Cultural Adaptations: An Organizational Approach. In *The Emergence of Modern Humans: Biocultural Adaptations in the Later Pleistocene*. E. Trinkaus, ed. Pp. 18–41. Cambridge: Cambridge University Press.

Bocquet-Appel, J.-P., and P. -Y. Demars

- 2000 Neanderthal Contraction and Modern Human Colonization of Europe. *Antiquity* 74:544-52.

Bordes, F.

- 1961 Mousterian Cultures in France. *Science* 134:803-10.
1972 Du Paléolithique moyen au Paléolithique supérieur, continuité ou discontinuité? In *Actes du Colloque Origine de l'Homme Moderne Organisé par l'UNESCO en coll. avec l'Union Internationale pour l'Étude du Quaternaire (INQUA)*, Paris, 2-5: 211-18.

Callahan, E.

- 1979 The Basics of Biface Knapping: A Manual for Flint Knappers and Lithic Analysis. *Archaeology of Eastern North America* 7:1-79.

Callow, P.

- 1986 Pleistocene Landscapes and the Palaeolithic Economy. In *La Cotte de St. Brelade 1961-1978 Excavations by C. B. M. McBurney*. P. Callow and J. Conford, eds. Pp. 365-376. Norwich: Geo Books.

Cornford, J., eds.

La Cotte de St. Brelade 1961--978 Excavations by C.B.M. McBurney.
Norwich: Geo Books.

Conard, N. J., and D. S. Adler

- 1997 Lithic Reduction and Hominids Behavior in the Middle Paleolithic of the Rhineland. *Journal of Anthropological Research* 53:147-75.

Crabtree, D.

- 1972 An Introduction to Flintworking. *Occasional Papers* 28. Pocatello: Idaho State University Museum.

Dauvois, M.

- 1976 *Précis de Dessin Dynamique et Structural des Industries Lithiques Préhistoriques*. Fanlac: CNRS.

D'errico, F., J. Zilhao, M. Julien, D. Baffier, and J. Pelegrin

- 1998 Neanderthal Acculturation in Western Europe? A Critical Review of the Evidence and Its Interpretation. *Current Anthropology* 39:S1-S44.

Demars, P. Y.

- 1982 L'Utilisation du silex au Paléolithique Supérieur: Choix, Approvisionnement, Circulation. L'exemple du Bassin de Brive. *Cahiers du Quaternaire* 5. Paris: CNRS.

- 1994 *L'Économie du Silex au Paléolithique Supérieur dans le Nord de l'Aquitaine*. Thèse de Doctorat d'État en Sciences Naturelles de l'Université de Bordeaux I.
- Demars, P.Y. and Hublin, J. J.
- 1989 La Transition Néandertaliens/Hommes de Type Modernes en Europe Occidentale, In *L'Homme de Néandertal*, vol. 7: *l'extinction*. B.Vandermeersch, B., ed. Pp. 23–38. Liège: Liège: Etudes et Recherches Archeologiques de l'Université de Liège.
- Dibble, H. L.
- 1995 Raw Material Availability, Intensity of Utilization, and Middle Paleolithic Assemblage Variability. In *The Middle Paleolithic Site of Combe-Capelle Bas (France)*. H. L. Dibble and M. Lenoir, eds. Pp. 289–315. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology
- Dibble, H. L., and M. Bernard
- 1980 A Comparison of Basic Edge Angle Measurement Techniques. *American Antiquity* 45:857–65.
- Dubreuilh J., J.-P. Capdeville, J.-P. Platel, B. Kervazo, A. Turq, J.-P. Ruhard, and A. Bambier
- 1988 *Carte Géologique France (1/50 000), Feuille Belvès (831) et Notice Explicative*. Orleans: Bureau de Recherches Géologiques et Minières.
- Dunham, R.J.
- 1962 Classification of Carbonate Rocks According to Depositional Textures. In *Classification of Carbonates Rocks*. W. E. Ham, ed. Memoire 1:108–121. Tulsa, OK: American Association Petroleum Geologists.
- Foley, R.
- 1997 *Humans Before Humanity: An Evolutionary Perspective*. Malden, MA: Blackwell.
- Geneste, J.M.
- 1985 Analyse Lithique d'industries Moustériennes du Périgord: Une Approche Technologique du Comportement des Groupes Humains au Paléolithique Moyen. Thèse de l'Université de Bordeaux I.
- 1989 Economie Des ressources Lithiques dans le Moustérien du Sud-Ouest de la France. In *L'Homme de Néandertal*, Vol.6 *La Subsistence*. M. Otte, ed. Pp. 75–98. Liège: Etudes et Recherches Archeologiques de l'Université de Liège.
- 1990 Développement des Systèmes de Production Lithique au cours du Paléolithique Moyen en Aquitaine septentrionale. In *Paléolithique Moyen Récent et Paléolithique Supérieur Ancien en Europe*. C. Farizy, ed. Pp. 203–13. Mém. du Musée de Préhistoire d'Ile-de-France.
- Guibert, P., F. Bechtel, M. Schvoerer, J. P. Rigaud, and J. F. Simek
- 1999 Datations par Thermoluminescence de Sédiments Chauffés Provenant d'une iaire de Combustion Moustérienne (Grotte XVI, Cénac et St-Julien, Dordogne, France). *Revue d'Archéométrie* 23:163–75.

Harrold, F. B.

- 1983 The Châtelperronian and the Middle-Upper Paleolithic Transition. In *The Mousterian Legacy: Human Biocultural Change in the Upper Pleistocene*, E. Trinkaus, ed. Oxford: British Archaeological Reports International Series.
- 1989 Mousterian, Châtelperronian and Early Aurignacian in Western Europe: Continuity or Discontinuity? In *The Human Revolution*. Mellars, P. and C. Stringer, eds. Pp. 677–713. Edinburgh: Edinburgh University Press.

Hays, M.

- 1998 *A Functional Analysis of the Magdalenian Assemblage From Grotte XVI (Dordogne, France)*. Ph.D. dissertation, Department of Anthropology, University of Tennessee, Knoxville.

Henry, D. O.

- 1992 Transhumance During the Late Levantine Mousterian. In *The Middle Paleolithic: Adaptation, Behavior, and Variability*. H. L. Dibble and P. Mellars, eds., Pp. 143–62. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Karkanias P., J.-Ph. Rigaud, J. F. Simek, R. M. Albert, and S. Weine

- 2002 Ash Bones and Guano: A Study of the Minerals and Phytoliths in the Sediments of Grotte XVI, Dordogne, France. *Journal of Archaeological Science* 29, 7:721–32.

Keeley, L. H.

- 1980 *Experimental Determination of Stone Tool Use: A Microwear Analysis*. Chicago: University of Chicago Press.

Kuhn, S. L.

- 1991 'Unpacking' Reduction: Lithic Raw Material Economy in the Mousterian of West-Central Italy. *Journal of Anthropological Archaeology* 10:76–106.
- 1992 On Planning and Curated Technologies in the Middle Paleolithic. *Journal of Anthropological Research* 48:185–214.

Lévi-Strauss, C.

- 1952 *Race et Histoire*. Paris: UNESCO

Liolios, D.

- 1995 Neandertal et Sapiens Sapiens: Présupposés et Obstacles. *Acta Mus. Moraviae, Sci. Soc.* 80: 3–28.

Marks, A. E.

- 1988 The Curation of Stone Tools during the Upper Pleistocene: A View from the Central Negev, Israel. In *Upper Pleistocene Prehistory of Western Eurasia*. H. L. Dibble and A. Montet-White, eds., Pp. 275–286. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Marks, A. E., J. Shokler, and J. Zilhão

- 1991 Raw Material Usage in the Paleolithic: The Effects of Local Availability on Selection and Economy. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*. A. Montet-White, and S. Holen, eds. Pp. 127-40. Lawrence: University of Kansas Publications in Anthropology 19.

Meignen, L.

- 1988 Un exemple de comportement technologique différentiel selon les matières premières: Marillac, couches 9 et 10. In *L'Homme de Neandertal, Vol. 4, La Technique*. L. Binford and J.-Ph. Rigaud, eds. Pp. 71-80. Liège: Etudes et Recherches Archeologiques de l'Université de Liège.

Mellars, P.

- 1969 The Chronology of Mousterian Industries in the Périgord Region of Southwest France. *Proceedings of the Prehistoric Society* 35:134-71.
- 1988 The Chronology of the South-West French Mousterian :A Review of the Current Debate. In *L'Homme de Neandertal, Vol. 4, La Technique*, L. Binford and J.-Ph. Rigaud, eds. Pp. 97-119. Liège: Etudes et Recherches Archeologiques de l'Université de Liège.
- 1989 Technological Changes across the Middle-Upper Palaeolithic Transition: Economic, Social and Cognitive Perspectives. In *The Human Revolution*, Mellars, P. and C. Stringer, eds. Princeton: Princeton University Press, pp. 339-65.
- 1996 *The Neanderthal Legacy. An Archaeological Perspective from Western Europe*. Princeton: Princeton University Press.
- 1999 The Neanderthal Problem Continued. *Current Anthropology* 40:341-50.

Morala, A.

- 1984 Périgordien et Aurignacien en Haut-Agenais. Etude D'ensembles Lithiques. *Archives d'Ecologie Préhistorique, École des hautes Études en Sciences Sociales de Toulouse*, n. 7.

Nash, S. E.

- 1996 Is Curation a Useful Heuristic? In *Stone Tools: Theoretical Insights into Human Prehistory*, G. Odell, ed. Pp. 81-99. New York: Plenum Press.

Nelson, M. C.

- 1991 The Study of Technological Organization. In *Archaeological Method and Theory*, Vol. 3, M. B. Schiffer, ed. Pp. 57-100. Tucson: University of Arizona Press.

Newcomer, M.

- 1971 Some Quantitative Experiments in Handaxe Manufacture. *World Archaeology* 3:85-94.

Noble, W., and I. Davidson

- 1996 *Human Evolution, Language and Mind: A Psychological and Archaeological Inquiry*. Cambridge: Cambridge University Press.

Odell, G. H.

- 1996 Economizing Behavior and the Concept of "Curation." In *Stone Tools: Theoretical Insights into Human Prehistory*, G. Odell, ed. Pp. 51–80. New York: Plenum Press.

Ohnuma, K., and C. Bergman

- 1982 Experimental Studies in the Determination of Flaking Mode. *Bulletin of the Institute of Archaeology* 19:161–70.

Pelegrin, J.

- 1990 Observations Technologiques sur Quelques Séries du Châtelperronien et du MTA B du sud-ouest de la France: Une Hypothèse d'Évolution. In *Paléolithique Moyen Récent et Paléolithique Supérieur Ancien en Europe*. Farizy, C., ed. Pp. 195–202 Paris: CNRS.
- 1995 Technologie Lithique, le Châtelperronien de Roc-de-Combe (Lot) et de La Côte (Dordogne). *Cahiers du Quaternaire*, 20. Paris : CNRS.

Peyrony, D.

- 1920 Le Moustérien ses faciès. *Association Française pour l'avancement des Sciences* 44th session, Strasbourg, Pp. 1–2.
- 1948 Une Mise au Point au Sujet de L'industrie de L'abri Audit et de Celle de Châtelperron, *Bulletins de la Société Préhistorique Française* 45:34–5.

Rigaud, J.-P.

- 1982 Le Paléolithique en Périgord : Les Données du Sud-Ouest Sarladais et Leurs Implication. Thèse de Doctorat d'état es Sciences, Université de Bordeaux.
- 2000 Late Neandertals in the Southwest of France and the Emergence of the Upper Paleolithic. In *Neanderthals on the Edge*. C. B. Stringer, R. N. Barton, and J. C. C. Finlayson, eds. Pp. 27–31. London: Oxbow Books.

Rigaud, J.-P., G. Lucas, and J. Simek

- 1998 Cénac-et-Saint-Julien. Grotte XVI. In *Bilan Scientifique de la Région Aquitaine 1998*. Direction régionale des Affaires culturelles d'Aquitaine, Service Régional de l'Archéologie, ed. Pp. 21. Ministère de la Culture et de la Communication.

Rigaud J.Ph, J. F Simek, and M.A. Hays

- 2000 The Magdalenian of the Grotte XVI (Dordogne, France) and Regional Approaches to Magdalenian Settlement and Economy. In *Regional Approaches to Adaptation in Late Pleistocene Western Europe*. G. Peterkin and H. Aiken, eds. Pp. 9–24. Oxford: British Archaeological Report International Series 896.

Rigaud, J.-P., J. F Simek, and G. Thierry

- 1995 Mousterian Fires from Grotte XVI (Dordogne, France). *Antiquity* 266:902–12.

Roebroeks, W., J. Kolen, and E. Rensink

- 1988 Planning Depth, Anticipation, and the Organization of Middle Paleolithic Technology: The 'Archaic Natives' Meet Eve's Descendants. *Helinium* 28:17–34.

Salomon, J. N., and J. G. Astruc

- 1992 Exemple en Zone Tempérée d'un Paléocryptokarst Tropical Exhumé (La Cuvette du Sarladais, Dordogne). In *Karst et évolutions climatiques*. J. N. Salomon and R. Maire, eds. Pp. 431–47. Talence: Presses Universitaires de Bordeaux.

Séronie-Vivien, M., and M. R. Séronie-Vivien

- 1987 Les Silex du Mésozoïque Nord-aquitain. Approche Géologique de l'Étude du Silex Pour Servir à la Recherche Préhistorique. *Suppl. au Tome XV du Bulletin de la Société Linéenne de Bordeaux*.

Shott, M. J.

- 1996 An Exegesis of the Curation Concept. *Journal of Anthropological Research* 52:259–80.

Stringer, C., and C. Gamble

- 1993 *In Search of the Neanderthals: Solving the Puzzle of Human Origins*. London: Thames and Hudson.

Toth, N.

- 1985 The Oldowan Reassessed: A Close Look at Early Stone Artefacts. *Journal of Archaeological Science* 12:101–21.

Torrence, R.

- 1983 Time Budgeting and Hunter-Gatherer Technology. In *Hunter-Gatherer Economy in Prehistory*. G. Bailey, ed. Pp. 11–22. Cambridge: Cambridge University Press.

Turq, A.

- 2000 Paléolithique inférieur et moyen entre Dordogne et Lot. *Paléo*, Supplément 2.

Turq, A., G. Antignac, and P. Rousel, P.

- 1999 Les Silicifications Coniaciennes du Sarladais et du Gourdonnais: Inventaire et Implications Archéologiques. *Paléo* 11:145–60.

Veil, S., K. Breest, H. C. Höfle, H. H. Meyer, H. Plisson, B. Urban-Kütel, G. A. Wagner, and L. Zöller

- 1994 Ein Mittelpaläolithischer Fundplatz aus der Weichsel-Kaltzeit bei Lichtenberg, Lkr. Lüchow-Dannenberg. *Germania* 72, 1: 1–66.

Wenban-Smith, F. F.

- 1989 The Use of Canonical Variates for Determination of Biface Manufacturing Technology at Boxgrove Lower Palaeolithic Site and the Behavioural Implications of this Technology. *Journal of Archaeological Science* 16:17–26.
- 1999 Knapping Technology. In *Boxgrove: A Middle Pleistocene Hominid Site at Earham Quarry, Boxgrove, West Sussex*. M. B. Roberts and S. A. Parfitt, eds. Pp. 384–95. London: English Heritage. Archaeological Report 17.

White, R.

- 1982 Rethinking the Middle-Upper Paleolithic Transition. *Current Anthropology* 23(2):169-92.

Whittaker, J.

- 1994 *Flintknapping. Making and Understanding Stone Tools*. Austin: University of Texas Press.

Zilhão, J., and F. D'errico

- 1999 The Chronology and Taphonomy of the Earliest Aurignacian and Its Implication for the Understanding of Neandertal Extinction. *Journal of World Prehistory* 13:1-68.



7

FROM BIFACES TO LEAF POINTS

Janusz K. Kozłowski

The oldest leaf points in Europe are found in Levallois industries outside the distribution range of the Acheulian. In the Middle Palaeolithic, leaf points have been found in both the east-central European Micoquian and in the Mousterio-Levalloisian industries of southeastern Europe. The Micoquian bifacial tradition continued into “transitional” industries (Altmublian, Szeletien, Streletskian, Jerzmanowician), which evolved in the fully fledged Upper Palaeolithic, whereas the Mousterian leaf point tradition vanished at the end of the Middle Palaeolithic. Leaf points appear in a number of unrelated industries and are not the marker of a distinctive evolutionary line that continued “mode 2” industries.

In Palaeolithic archaeology it is widely held that the *façonnage* technique represents an evolutionary trend that developed without any outside influences. As a consequence, it is assumed that there is a developmental continuum from bifacially retouched tools—Acheulian hand-axes, Micoquian bifaces and knives, and Mousterian bifaces—to Middle and Upper Palaeolithic leaf points. In a paper presented at the Miskolc conference (Kozłowski 1995), I tried to demonstrate a connection between leaf point production and specific environmental conditions. Instead of a continuity in bifacial technological traditions, I proposed that convergent development of leaf points took place several times in different regions. This problem is re-examined with a focus on the appearance of the earliest leaf points in Europe.

The “Movius Line” in Europe: Acheulian Bifaces and the First Leaf Points

Despite considerable progress in our knowledge of the Lower Palaeolithic of Europe and the Near East, the range of distribution of the Acheulian remains limited to western Europe and the Near East. The demarcation line between the range of “mode 2” industries and the regions where Acheulian bifaces are not found runs along the Rhine and the Alps, separating the Acheulian in western and southwestern Europe from pebble and flake industries (“mode 1”) in central Europe. The line then continues through the Taurus and Caucasus Mountains, separating the Acheulian industries in the Near East and Transcaucasia from the pebble and flake industries of eastern Europe, southeastern

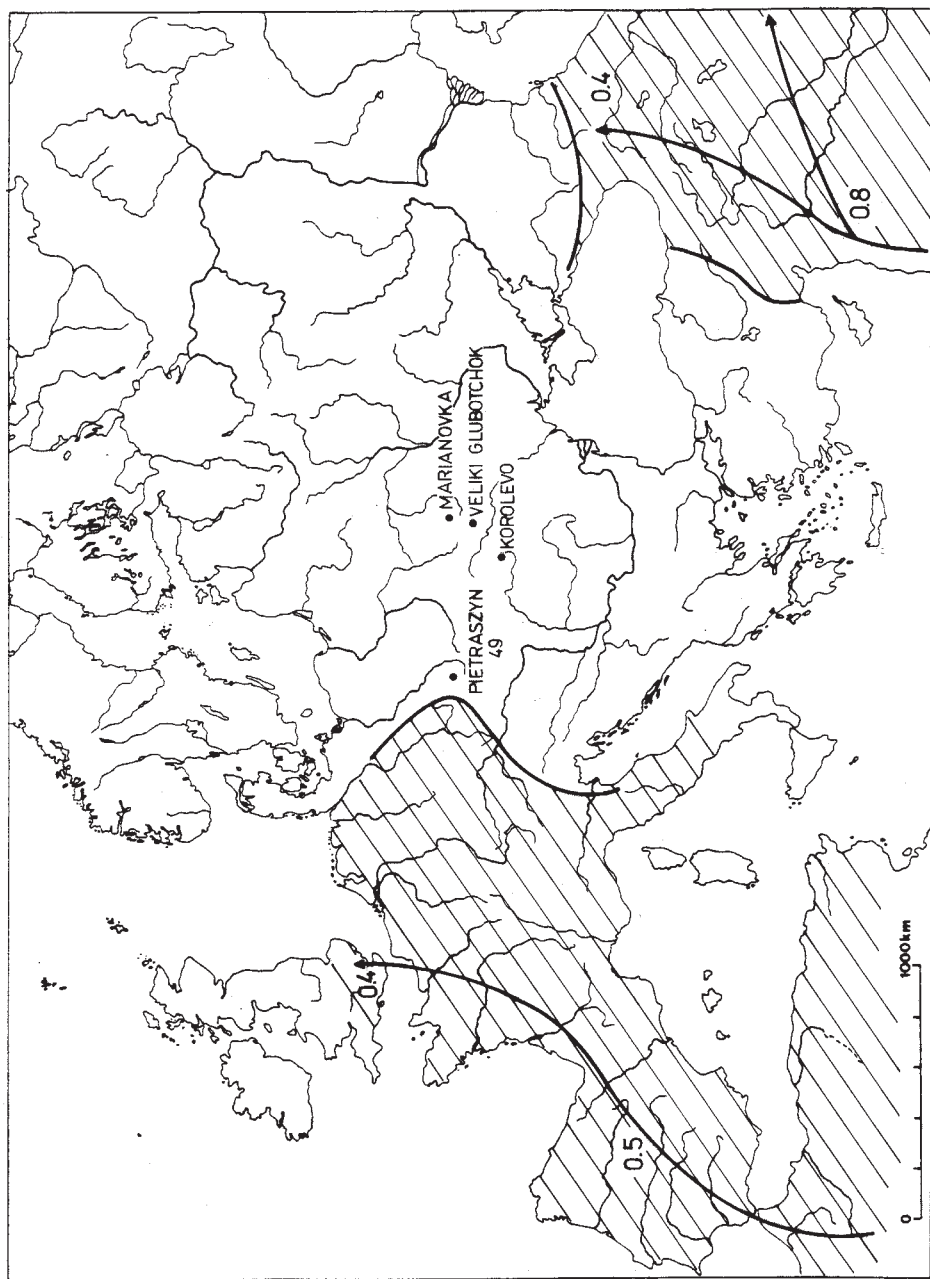


Figure 7.1 "Motius line" and spread of "Out-of-Africa" Acheulian industries. The oldest leaf points in Central Europe in Levallais context (Korolevo, Veliki Glubotchok, Marianovka?) and the Micoquian (Pietraszyn 49) are marked.

Europe, and western Anatolia. We can, therefore, hypothesize that the appearance of Acheulian industries in western Europe approximately 500,000 years ago was the result of a new wave of migration “out-of-Africa” (Carbonell et al. 1999), similar to the emergence of Acheulian industries of African origin in the Near East around 780,000 years ago (Goren-Inbar et al. 2000; Bar-Yosef 1998). The European “Movius line” thus constitutes the demarcation line between the more conservative pebble and flake technologies (“mode 1”) and the new Acheulian technology (“mode 2”) introduced by African migrants (Figure 7.1).

Does this mean that central and eastern Europe did not generate their own technological developments? Quite the opposite is true. The Levallois and leaf point technologies were first developed in the territories of central and eastern Europe. The Levallois technique on preferential cores was found in layer VI at the open-air site of Korolevo in Transcarpathian Ukraine (Adamenko and Gladilin 1989; Kulakovskaya 1999). The soil in this layer has been dated by palaeomagnetism and thermoluminescence dating to more than 350,000 years ago (oxygen-isotope stage 10). The Levallois technique has often been viewed as part of a technological “package” in the Acheulian industries in the Near East and western Europe. At Korolevo, however, the Levallois technique is not associated with Acheulian bifaces, which means that it must have been a technological innovation that developed quite independently of the Acheulian.

Leaf point-shaped fragments are plentiful in layer VI at Korolevo. Layer Va has been dated to between 220,000 to 280,000 years ago (oxygen-isotope stage 7). Because Korolevo is located outside the range of Acheulian bifacial technology, we cannot interpret these leaf points as the result of evolution of an Acheulian bifacial technological tradition¹. Instead, they must have been an independent technological innovation.

Leaf points have also been recovered from layer Va in trench XIII on Beyvar Hill at Korolevo (Gladilin and Sitlivyi 1990, p. 49). Most of these leaf points were manufactured from large fragments of andesite, but some were made from thick andesite flakes. The specimens are slender and narrow (up to 12- to 20-cm long), with one flat face shaped first, followed by the second (an approximately flat-convex cross-section was obtained using this technique). Sometimes the sequence of shaping the faces was altered, resulting in an asymmetrical and nearly rhomboidal cross-section. Along with 18 elongated and slender points (Figure 7.2: 1, 2, 4), there are two specimens that resemble laurel leaf points (Figure 7.2: 5, 6); they are broad and short (less than 7-cm long). The leaf points in layer Va were found with a large number of partially bifacial sidescrapers, often on Levallois flakes.

Similar leaf points were also found in layer III at the site of Veliki Globochok I dated, on the basis of the sedimentary sequence, to the beginning of oxygen-isotope stage 8 (Sitnik 2000), and at Marianovka, in Volhynia, situated further north, where the leaf points were found in association with a Levallois industry. Marianovka probably dates to oxygen-isotope stage 6 (Kozłowski, Sachse-Kozłowska 1997).

Gladilin and Sitlvy believe some artifacts from Korolevo II, layer VI, Vb and Va should be categorized as handaxes (rubila) (1990, pl. XII 3, XVI 1, XIX). We do not agree with this

1. Gladilin and Sitlvy believe some artifacts from Korolevo II, layer VI, Vb and Va should be categorized as handaxes (rubila) (1990, pl. XII 3, XVI 1, XIX). We do not agree with this opinion because the artifact shown in pl. XII 3 is a pre-form for a Levallois core, and the artifacts in pl. XVI 1 and XIX are clearly pre-forms of unfinished leaf points. In the Korolevo sequence there are no typical Acheulian hand-axes; in layers VI, Vb, Va well developed bifacial leaf points appear (1990 Pl. XIV 1, 2; XXII 1-3; XXIII 1-5), and the rare examples of crude bifacially worked implements are pre-forms for such points.

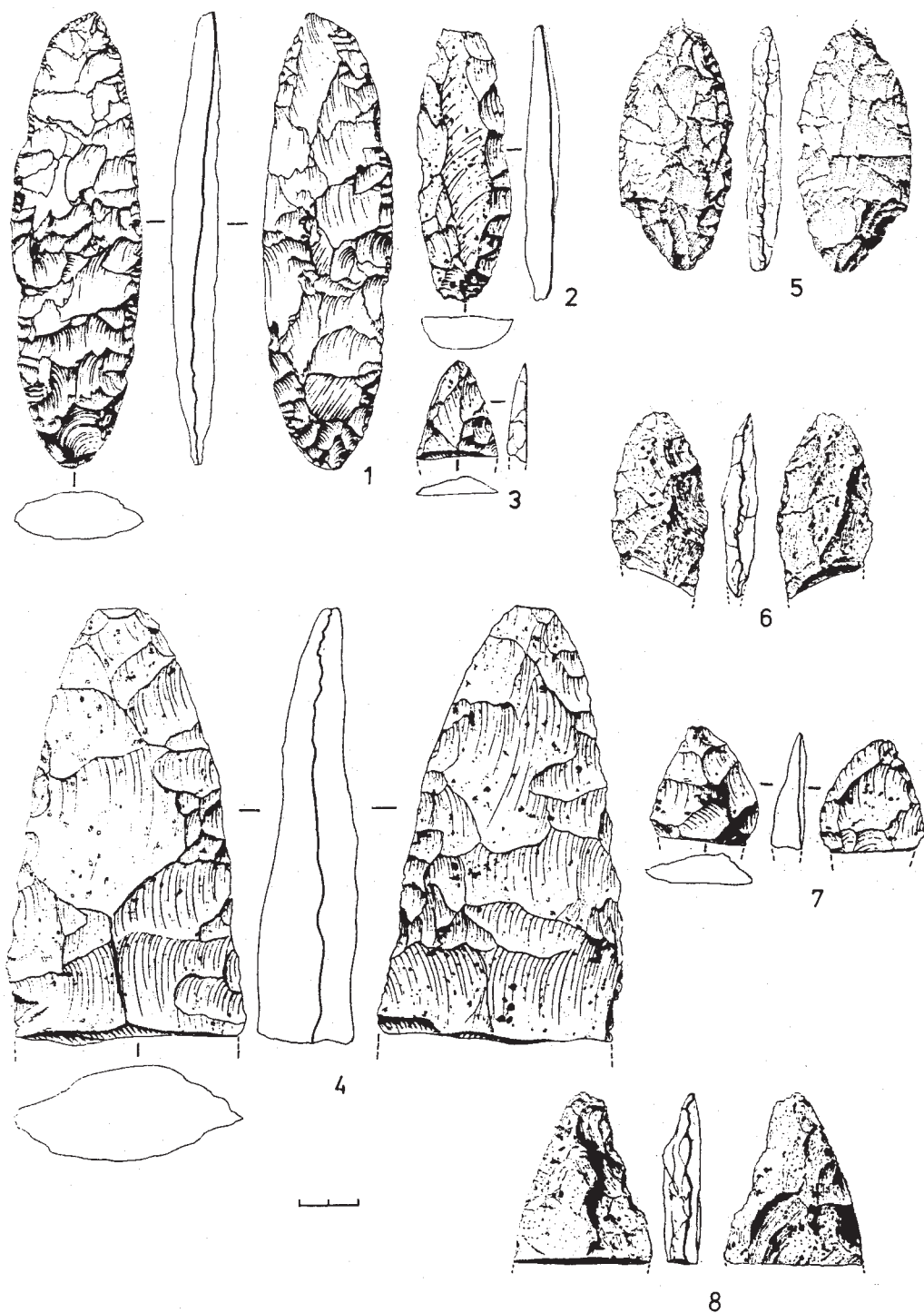


Figure 7.2 Leaf points from Korolevo, layer Va (Transcarpathian Ukraine) (according to Gladilin and Sitlivy).

opinion because the artifact shown in pl. XII3 is a pre-form for a Levallois core, and the artefacts in pl. XVI1 and XIX are clearly pre-forms of unfinished leaf points. In the Korolevo sequence there are no typical Acheulian hand-axes; in layers VI, Vb, Va well developed bifacial leaf points appear (1990 Pl. XIV 1, 2; XXII 1-3; XXIII 1-5), and the rare examples of crude bifacially worked implements are pre-forms for such points.

The Problem of the Genesis of the “Eastern Micoquian” and the Chronology of the Oldest Micoquian Leaf Points

It is generally held that the Micoquian developed from the Acheulian bifacial tradition in western Europe, similar to the appearance of the so-called Acheulo-Yabrudian in the Near East. The type definition of the western European Micoquian is based upon the assemblage from level 6 at the eponymic site of La Micoque. New investigations at this site indicate the continuous presence of the “Micoquian technological tradition” in layers 3, 4, 5, 5', and 6 (i.e., from about 300,000 BP to the beginning of the last glaciation) (Delpech et al. 1995). Moreover, new thermoluminescence dates for Tabun (Mercier et al. 1995) push back the origin of the Acheulo-Yabrudian in the Near East to more than 250,000 years ago (see also Copeland 2000).

As a consequence of such chronological shifts, the time span for the Micoquian in western Europe has not only been extended through the beginning of the Middle Palaeolithic (250,000–120,000 years) it also becomes temporally closer to the Acheulian. It would seem that the roots of the Micoquian should be sought in western Europe as it is only during the last glaciation that the Micoquian tradition spread to central and eastern Europe and gave rise to the eastern Micoquian (Delpech et al. 1995; Soriano 1999). On the other hand, some researchers—taking into account the relatively late chronology of the German “Keilmessergruppen” and the eastern Micoquian in the Ukraine, Crimea, and Volga basin—see no connection between the Micoquian in these areas to that in western Europe (Conard and Fischer 2000; Kuchartchuk 1999; Richter 1999). Previous arguments that the eastern Micoquian was the result of post-Acheulian influences from the Caucasus (Gabori 1976) are no longer convincing (Golovanova 1994; Liubin 1994).

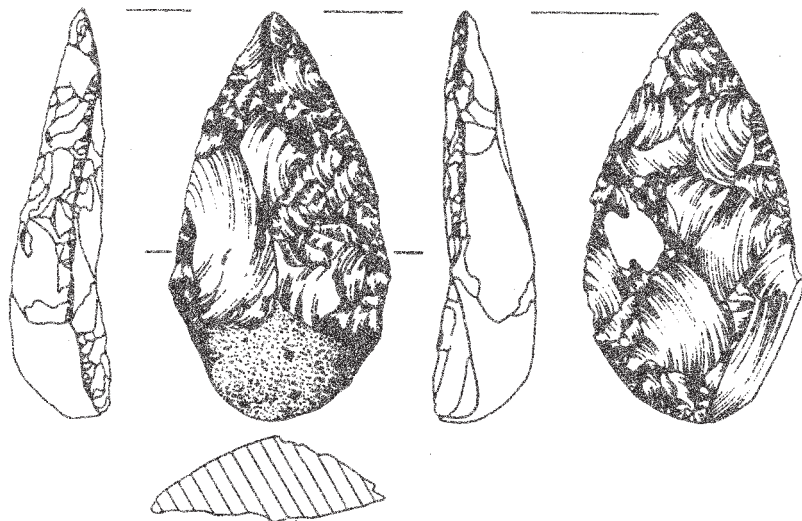
The development of the eastern Micoquian independently of western European and Transcaucasian Acheulian industries has recently been confirmed by the discoveries of Micoquian sites in southern Poland (Foltyn et al. 2000; Fajer et al. 2001), which are as early as the Micoquian sites in western Europe. Most importantly, isolated artifacts have been found at the site of Dzierzyslaw I in Upper Silesia which have been dated to 180,000±35,000 years, or to oxygen-isotope stage 6, and a large number of artifacts have been found in alluvial sediments dated to the Warta stage at Pietraszyn 49 in Upper Silesia (or oxygen-isotope stage 6). The latter site is exceptionally interesting because it yielded a large number of different Micoquian forms (bifaces, asymmetrical bifacial knives, sidescrapers, and even leaf points). The tools were manufactured mainly by the *façonnage* technique on unworked chunks of local erratic flint. There are almost no cores; most flakes in the Pietraszyn 49 assemblage are the product of shaping of bifacial tools. This undermines the view that the eastern Micoquian arose through the combination of bifacial and unifacial technologies with the *façonnage* and *debitage* techniques. Richter (1997, 1999) is a strong supporter of this view, basing his argument on data from what he

assumes is the oldest Micoquian industry, from layer G at Sesselfelsgrötte. This layer, however, has been dated to no earlier than oxygen-isotope stage 5c/d.

We can say that the “eastern Micoquian” is not a continuation of the evolution of the Acheulian bifacial technological tradition; it can neither be explained as the manifestation of technological flexibility in manufacturing uni- and bifacial tools, nor can it be seen as representing different stages of tool reduction (first as Mousterian unifacial tools and lastly as Micoquian bifacial tools) as Jöris (1994) and Richter (1997) want to believe. The most likely explanation of the eastern Micoquian seems to be that it represents the independent discovery of a specific type of bifacial technology (i.e., working each side of a tool sequentially instead of alternating the shaping of each edge as is done in the case of Acheulian bifaces). The Micoquian technique produced mainly asymmetrical knives and sidescrapers (Keilmesser and Blattschaber), but it also included some leaf points.

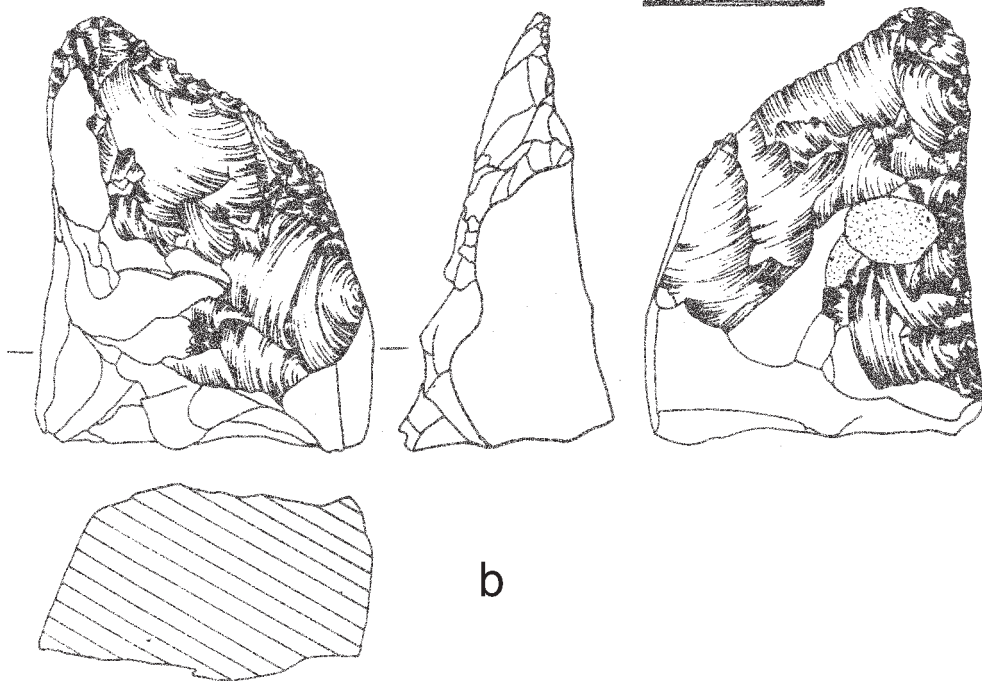
The oldest Micoquian leaf points discovered to date in Poland come from the site of Pietraszów 49, dated to oxygen-isotope stage 6, and from layer 12 of Bisnik Cave, dated to oxygen-isotope stage 5e (U-series dates, taking into account linear accumulation, between 106,000±20,000 and 143,000±21,000 years B.P. – cf. Hercman and Gorka 2000; Mirosław-Grabowska 2000). Pietraszów 49 yielded a partially cortical, fairly thick, flat-convex point with a rounded base resembling Faustkeilblatt rather than typical leaf points (Figure 7.3:a). On the other hand, a fairly flat laurel leaf point with a rounded and thinned base and sequential treatment of both faces from opposed edges, and a partially bifacial point shaped transversally to the axis of a short and broad flake were found in layer 12 of Bisnik Cave. The point was shaped by multiseriate retouch on the dorsal side and by retouch of one edge to thin the butt on the ventral side. A Micoquian industry with typical Blattschaber was also found in layer 7 of Bisnik Cave and dated to oxygen-isotope stage 5/4 (Cyrek 2002).

The proportion of laurel leaf points increased over time in the eastern Micoquian, especially in oxygen-isotope stages 4 and 3a, as did industries with leaf points (Blattspitzengruppe), which were ascribed by some German scholars to the Late Middle Palaeolithic (Conard and Fischer 2000). I believe these are transitional industries to the Upper Palaeolithic (Kozłowski 2000). In the western part of central Europe these industries exhibit continuity from the Middle Palaeolithic (Rörsheim–Hahn 1990, Kösten–Zotz 1975) to the transitional Altmühlian (von Königswald et al. 1974), and later the Ranisian (Hülle 1977) industries. In the Carpathian basin, analogous evolution took place from the Babonyan, dated to as early as oxygen-isotope stage 5 (Ringer 1983), to the transitional and Upper Palaeolithic Szeletian (Dobosi 2000; Ringer 1983). In eastern Europe, the continuation of the Micoquian tradition in transitional industries with leaf points is harder to prove, because the two traditions developed in parallel. This parallel development is documented in the sequence from Buran Kaya Cave III where the eastern Micoquian and leaf points are interstratified (Chabai et al. 1998). The sequence at the open-air site of Biriutcha Balka on the Lower Don (Matioukhine 1990) and at Neprakhino on the Volga (Zakharikov 1999) suggest, however, the possibility of continuation from the eastern European Micoquian to “transitional” industries with leaf points.



a

0 3



b

Figure 7.3 Leaf point (a) and asymmetrical side scraper (b) from Pietraszryn 49 (Upper Silesia, Poland).

Genesis of Leaf Points in Southeastern Europe

In the early stage of the last glaciation in Europe, we can distinguish between the northern Micoquian—based on the *façonnage* of bifacial tools and a non-Levallois debitage technique—and the typical Mousterian and Mousterio-Levallois in southeastern Europe (Figure 7.4). This territorial distribution provides support for the view that the Micoquian and Mousterian were manufactured by two separate ethnic groups (Kozłowski 1992), although it does not entitle us to attribute them to two anthropologically different populations (Thissen 1998).

Leaf points should not occur in the Balkans and the Lower Danube basin because older industries with bifacial tools are absent in these areas. Contrary to expectations, leaf points are found in the entire zone of distribution of Mousterian industries utilizing the Levallois technique (Figure 7.5). In several industries, Levallois flakes were even used as blanks for leaf point production, although the *façonnage* technique was also used on tabular flint. These industries include the following:

1. The Kokkinopilos Mousterian in Greece and the Muselievo-Samuilitsa in Bulgaria (Kozłowski 1976; Sirakova 1990; Sirakova and Ivanova 1988)
2. The Ripiceni Mousterian in Moldavia (Paunescu 1993)
3. The Stinka Mousterian in the Dnester basin (Anisiutkin 1990; Sitnik 1999)
4. Isolated sites in the middle Danube basin, the so-called Jankovichian (Gabori-Csank 1993), and in southern Poland, for example: Kraków-Prądnik Czerwony, Kraków-Zwierzyniec layer 11 (Kozłowski and Kozłowski 1996)

The occurrence of leaf points in these Middle Palaeolithic industries has been dated mainly to oxygen-isotope stages 4 and 3 by radiometric determinations from Bulgaria, Rumania and the Ukraine. (Only one bifacially worked implement from Kokkinopilos was ascribed to the Penultimate Glaciation and considered by Runnels and van Andel (1993) to be a “Micoquian hand-axe”).

A common feature shared by leaf points in Mousterian assemblages from southeastern Europe is that they were all made from flakes (resulting in flat-convex cross-sections), or from tabular flint by using lateral walls as striking platforms for removals, which proportionally thinned both flat sides. The remnants of such walls/platforms can often be seen on the proximal portions of points (in particular the specimens from Mouselievo, Ripiceni-Izvor, and Kraków-Zwierzyniec). The latter technique is thought to have been a Micoquian influence (Allsworth-Jones 1986) used in shaping asymmetric specimens, especially unfinished leaf points. I believe, however, that this technique of thinning tabular flint should not be confused with the intentional shaping of the blunted backs of Micoquian Keilmesser. It should also be noted that Micoquian tools occur, as a rule, in non-Levallois contexts (see Boěda 1995), whereas southeastern European points are found within fully-fledged Levallois industries.

Another important feature shared by leaf points in the Balkans and the Lower Danube basin is that in both of these regions they were often manufactured in specialized workshops (e.g., at Kokkinopilos and Muselievo). The products of the workshops were then brought to base camps, such as Samuilitsa I, where they have been found in several levels (Sirakov 1982). These types of workshops only begin to appear in the northern and central areas of eastern Europe in transitional industries such as the Szeletian and Streltskian.

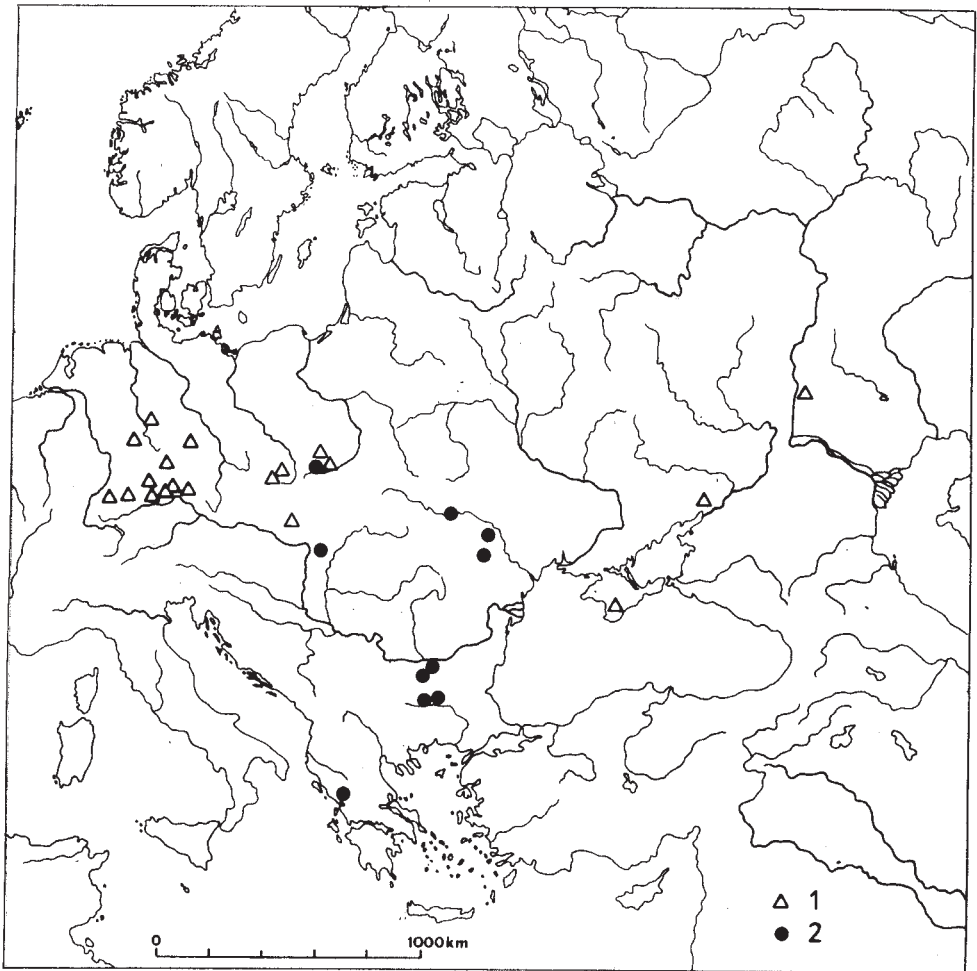


Figure 7.4 Map of the Micoquian (1) and Mousterian-Levalloisian (2) with leaf points dated to isotope stages 5-3.

The technological and typological contexts of leaf points in the Balkans and the Lower Danube basin during isotope stages 4-3a provide evidence that these leaf points were separate from the Micoquian bifacial tool tradition. These leaf points represent either an independent innovation in southeastern Europe at the boundary of oxygen-isotope stage 5 and 4, or, possibly the continuation of the tradition represented by the oldest leaf points in central-eastern Europe, which also included Levallois technology, in the period from oxygen-isotope stage 10 to oxygen-isotope stage 7. The sequence from Korolevo in which leaf points appear in layer IIa/II cannot, however, unequivocally corroborate that continuation took place because there were no bifacial points found in levels IV-IIb.

Although Micoquian leaf points continued to evolve in transitional and even in Upper Palaeolithic industries, for example, in the Late Szeletian industries of the Middle Danube

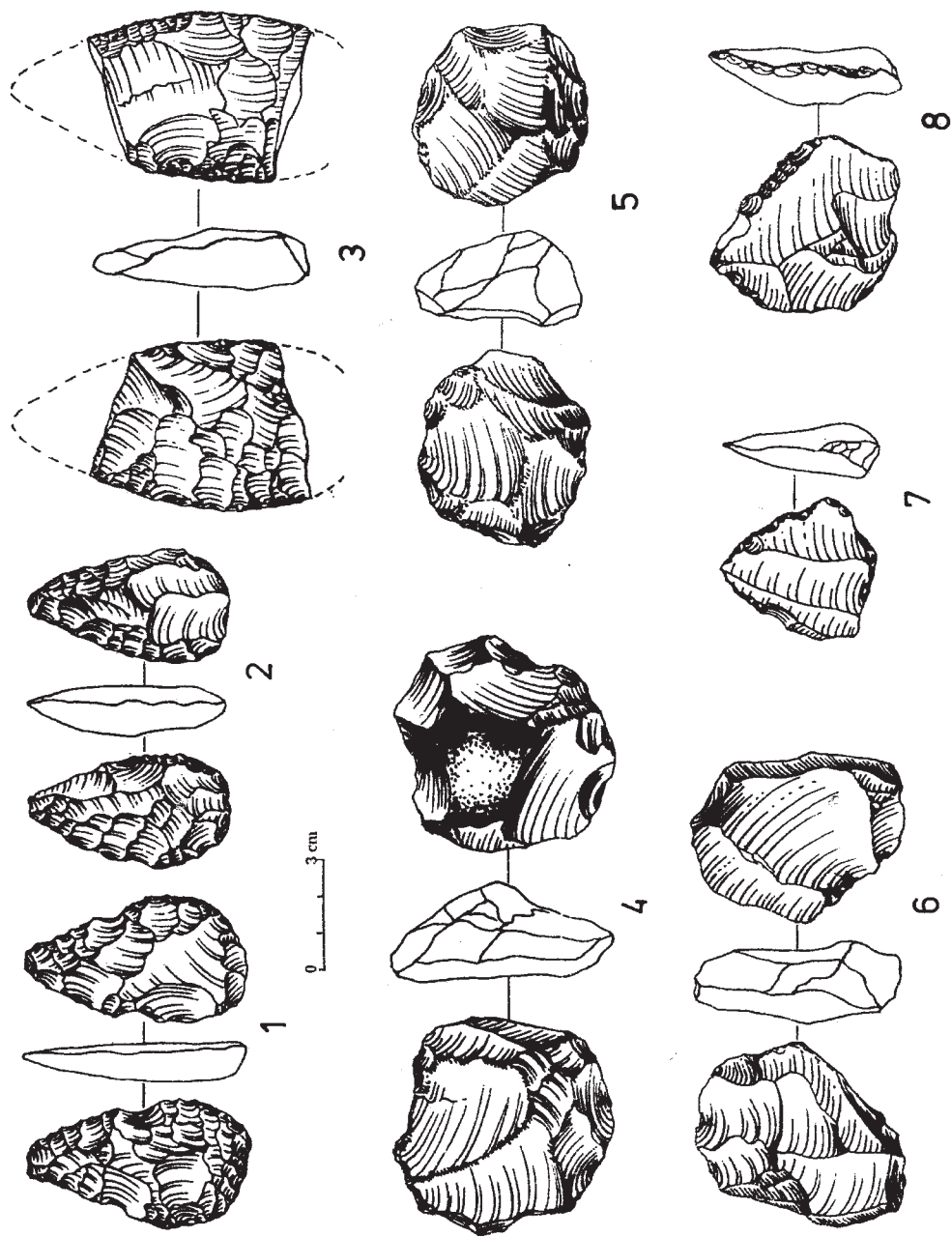


Figure 7.5 Pylipche XI (Podolie, Ukraine). Leaf points and Levallois cores (according to Stinik).

basin, in the so-called Moldavian Szeletian, and in the Sungirian in the Russian Lowland (Otte et al. 1992; Borziak 1990; Barta 1992; Sinitsin and Praslov 1997), the leaf points associated with the Mousterio-Levallois industries in south-eastern Europe show no such continuation, vanishing, most probably, before 35,000 B.P.

Conclusions

Bifacial toolmaking based both on *façonnage* and debitage does not mark a distinct technological tradition that, supposedly, extended from the Lower to the Upper Palaeolithic. We cannot, therefore, interpret the leaf points that appear in the Middle Palaeolithic as the result of the evolution of an Acheulian bifacial tradition. The oldest leaf points in Europe occur outside the range of the Acheulian, in the context of Levallois industries. In the Middle Palaeolithic, leaf points are found both in the east-central European Micoquian and in the Levallois Mousterian of southeastern Europe. The Micoquian bifacial tradition continued in transitional industries (Altmühlian, Szeletian, Streletsian), which evolved in the direction of the Upper Palaeolithic, whereas the Mousterian leaf point tradition vanished at the end of the Middle Palaeolithic. To sum up: leaf points appeared in a number of unrelated episodes in several regions. They are not a marker for a distinctive technology that developed from “mode 2” industries.

References

- Adamienko, O., and V. Gladilin
 1989 Korolevo, un Site des plus Anciens Habitats Acheuléens et Moustériens en Transcarpatien Sovietique. *L'Anthropologie* 4:689–712.
- Anisioutkin, N. K.
 1978 Varianty Srednego paleolita Pridniestrovia (Stynkovskaya Kultura). *Arkheologicheski Sbornik* 19:133–141.
- Allsworth-Jones, P.
 1986 *The Szeletian and the Transition from the Middle to the Upper Paleolithic in Central Europe*. Oxford: Oxford University Press.
- Bar Yosef, O.
 1998 Early Colonizations and Cultural Continuities in the Lower Palaeolithic of Western Asia. In *Early Human Behaviour in Global Context. The Rise and Diversity in the Lower Palaeolithic Record*. M. D. Petraglia and R. Korisettar, eds. Pp. 221–279. London: Routledge.
- Bartá, J.
 1992 Trenčianske Bohuslavice—Un Habitat Gravettien en Slovaquie Occidentale. *L'Anthropologie* 93:1.
- Boëda, E.
 1995 Caractéristiques Techniques des Chaines Opératoires Lithiques des Niveaux Micoquiens de Kulna (Tchécoslovaquie). *Paléo*, Supplément 1:7–22.

Borziak, I.

- 1990 Bifacial Stone Tools of Late Palaeolithic in the Dniester—Prut Interfluve. In *Les Feuilles en Pierre*. J. K. Kozłowski, ed., Pp. 125–136. ERAUL 42.
- Carbonell, E., M. Mosquera, X. P. Rodríguez, R. Sala, and J. Van Der Made
1999 Out of Africa: The Dispersal of Earliest Technical Systems Reconsidered. *Journal of Anthropological Archaeology* 18:119–136.
- Chabai, V.P., A. Marks, and M. Otte
1998 Variabilitnost Sredniego i Rannej Pory Verkhniego Paleolita Kryma. *Archeologia* 4:19–47.
- Conrad, N., and B. Fischer
2000 Are There Recognizable Cultural Entities in the German Middle Palaeolithic? In *Towards Modern Humans*. A. Ronen and M. Weinstein-Evron, eds. Oxford: British Archaeological Reports.
- Copeland, L.
2000 Yabrudian and Related Industries: The State of Research in 1996. In *Towards Modern Humans*. A. Ronen and M. Weinstein-Evron, eds. Oxford: British Archaeological Reports.
- Cyrek, K.
2002 *Die Bisnik Hoble. Rekonstruktion der Besiedlung der Hoble auf dem Hintergrund der Anderungen der Naturmilieus*. Torun: Uniwersytet Mikolaja Kopernika.
- Delpech, F., J. M. Geneste, J. P. Rigaud, and J. P. Texier
1995 Les Industries Antérieures à la Dernière Glaciation en Aquitaine Septentrionale: Chronologie, Paléoenvironnements, Technologie, Typologie et Economie de Subsistance. *Paléo*, Supplément 1:133–163.
- Dobosi, V.
2000 Middle Palaeolithic Phenomena in Hungary. In *Towards Modern Humans*. A. Ronen, and M. Weinstein-Evron, eds. Oxford: British Archaeological Reports.
- Foltyn, E. M., E. Foltyn, and J. K. Kozłowski
2000 Premières Évidences de l'âge Pré-émien en Europe Centrale. In *Towards Modern Humans*. A. Ronen, and M. Weinstein-Evron, eds. Oxford: British Archaeological Reports.
- Fajer, M., E. M. Foltyn, E. Foltyn, and J. K. Kozłowski
2001 Contribution à l'Évolution du Micoquien en Europe Centrale (Nouvelles Découvertes du Micoquien en Haute Silésie, Pologne) In *Les Industries à Outils Bifaciaux du Paléolithique Moyen d'Europe Occidentale*. D. Cliquet, ed. Pp. 195–207. ERAUL 98.

Gábori, M.

1976 *Les Civilisations du Paléolithique Moyen entre les Alpes et l'Oural*. Budapest.

Gábori-Csánk, V.

1993 *Le Jankovichen: Une Civilisation Paléolithique en Hongrie*. Liège: ERAUL 53.

Gladilin, V. N., and V. Sitlivy

1990 *Aszel Centralnoy Evropy*. Kiev.

Gladilin, V. N., V. Sitlivy, and V. Tkachenko

1995 Les Premières Industries à Pointes Foliacées en Europe Centrale. *Paléo*, Supplément 1: 111–116.

Golovanova, L.

1994 *Problemy Perekhoda ot Rannego k Sredniemu Paleolitu na Severo-Zapadnom Kavkaze*. St. Petersburg.

Goren-Inbar, N., C. Feibel, K. L. Verosub, Y. Malemed, M. Kisler, E. Tchernov, and J. Saragusti

2000 Pleistocene Milestones on the 'Out of Africa' Corridor at Gesher Benot Ya'aqov, Israel. *Science* 289:944–947.

Hahn, J.

1990 Le technologie des pointes bifaciales de Rörshein et leur relations avec l'Allemagne du Sud. In *Feuilles de Pierre*. J. K. Kozłowski, ed. Pp. 79–93. ERAUL 42.

Hercman, H., and P. Górka

2000 U-series Dating of Bones from Bisnik Cave—Open System Dating Models. In *Climate Changes—The Karst Record II*. Krakow.

Hülle, W. W.

1977 *Die Ilsenböhle unter Burg Ranis/Thüringen: Eine Paläolithische Jägerstation*. Stuttgart.

Jöris, O.

1994 Neue Untersuchungen zum Mittelpaläolithikum von Buhlen, Hessen. *Ethnographische-Archäologische Zeitschrift* 35:88–97.

Königswald, W., H. J. Von Müller-Beck, and E. Pressmar

1974 *Die Archäologie und Paläontologie in der Weinbergböhlen Mauern (Bayern). Grabungen 1937–1967*. Tübingen: Archaeologia Venatoria 3.

Koulakovskaya, L.

1999 Paleolicheskkiye Mestnakhozhdeniya v Rayone Korolevo. *Arkheologicheski Almanakh* 8:153–158.

Kozłowski, J. K.

- 1976 Badania nad Przejściem od Środkowego do Górnego Paleolitu na Balkanach. *Przegląd Archeologiczny* 23:5–48.
- 1992 The Balkans in the Middle and Upper Palaeolithic. The Gate to Europe or a Cul-de-sac? *Proceedings of the Prehistoric Society* 58:1–20.
- 1995 La Signification des “Outils Foliacées.” *Paléo*, Supplément 1:91–99.
- 2000 The Problem of Cultural Continuity between the Middle and Upper Palaeolithic in Central and Eastern Europe. In *The Geography of Neandertals' and Modern Humans in Europe and the Greater Mediterranean*. O. Bar-Yosef and D. Pilbeam, eds. Cambridge, MA: Peabody Museum of Archaeology and Ethnology, Harvard University.

Kozłowski, J. K., and S. K. Kozłowski

- 1996 *Le Paléolithique en Pologne*. Grenoble: Millot.

Kozłowski, J. K., and E. Sachse-Kozłowska

- 1996 Wschodnioeuropejskie Kulturyz Ostrzami li ciowatymi na przykładzie Stanowiska Marianówka na Ukrainie. *Archeologia Polski* 42:3–35.

Kukharchuk, Y.

- 1999 Metamorphozy Mikoka. *Arkheologicheski Almanakh* 8:25–36.

Liubin, V. P.

- 1984 Ranniy Paleolit Kavkaza. In *Paleolit SSSR*. Moscow: Nauka.

Matioukhine, A. E.

- 1990 Les Formes Bifaciales d'ateliers et de Stations-Ateliers. In *Les Feuilles en Pierre*. J. K. Kozłowski, ed. ERAUL 42.

Mercier, N., H. Valladas, G. Valladas, J. L. Reyss, A. Jelinek, L. Meigner, and J. L. Joron

- 1995 TL-Dates of Burnt Flint from Jelinek's Excavations at Tabun and Their Implications. *Journal of Archaeological Science* 22(4):495–510.

Mirosław-Grabowska, J.

- 2000 Geological and Archaeological Value of Bisnik Cave sediments (Polish Jura). In *Climate Changes—The Karst Record II*. Krakow.

Otte, M., L. Bayon, L., P. Noiret, I. Borziac, and V. Chirica

- 1996 Recherches sur le Paléolithique Supérieur en Moldavie. *Anthropologie et Préhistoire* 107:45–80.

Paunescu, A.

- 1993 *Ripiceni-Izvor, Paleolithic si Mesolithic*. Bucharest: Editura Academiei Romane.

Richter, J.

- 1997 Der G-Schichten-Komplex der Sesselfsgrotte: Zum Verständnis des Micoquien. *Quartär—Bibliothek* 7. Saarbrücken.

Richter, J.

- 1999 Pozdnieye Srednepaleoliticheskiye Industrii c Bifasami iz Seselfelsgrota v Yuzhnoy Germanii. *Arkheologicheski Almanakh* 8:91-98.

Ringer, A.

- 1983 Babonyien: Eine Mittelpaläolithische Blattwerkzeugindustrie in Nordostungarn. *Dissertationes Archaeol. Ser. II*, 11. Budapest.
- 1989 L'origine du Szélétien de Bükk en Hongrie et son Évolution vers le Paléolithique Supérieur. *Anthropologie* 27:223-229.

Runnels, C., and T. H. Andel

- 1993 A Hand Axe from Kokkinopilos and Its Implications for the Palaeolithic of Greece. *Journal of Field Archaeology* 20:191-203.

Sinitsin, A. A., and N. D. Praslov

- 1997 *Radieuglerodnaya Chronologia paleolita Vostochnoy Evropy i Sredney Azii: Problemy i Perspektivy*. St. Petersburg: RAN.

Sirakov, N.

- 1982 Reconstruction of the Middle Palaeolithic Flint Assemblages from the Cave Samuilitsa II (Northern Bulgaria) and Their Taxonomical Position Seen against the Palaeolithic of South-eastern Europe. *Folia Quaternaria* 55:2-100.

Sirakova, S.

- 1990 Leaf-points of Musselievo. In *Les Feuilles en Pierre*. J. K. Kozłowski, ed. Pp. 189-198. ERAUL 42.

Sirakova, S., and I. Stefanka

- 1988 Le Site Paléolithique près de Village Mousselievo, dept. de Pleven. *Studia Prehistorica* 9:63-77.

Sitnik, O.

- 1999 Stinkivska Musterska Kultura: Analiz ta Interpretacya Dzherel. *Arkheologicheski Almanakh* 8:171-192.
- 2000 *Sredniy Paleolit Podilia*. Lviv: National Academy of Sciences.

Soriano, S.

- 1999 Statut Fonctionnel des Outils Bifaciaux dans l'Industrie de Mesvin IV. In *Les Industries à Outils Bifaciaux du Paléolithique Moyen d'Europe Occidentale. Résumé des Communications*. D. Cliquet, ed. Pp. 9-11. Rennes.

Thissen, J.

- 1998 Die aktuellen Ausgrabungen 1995-1997 in der Ziegeleigrube Dreesen, Fundschicht B1, und Neuste Ergebnisse zur Menschheitsgeschichtlichen Entwicklung. *Rheinischen Almanach* 1998:18-39.

Zakhariov, A.

- 1999 Industrii s Bifasami i Perekhod ot Mustie k Pozdnemy Paleolitu v Evropie. *Arkheologicheski Almanakh* 8:197–206.

Zotz, L. F.

- 1959 Kösten, ein Werkplatz des Praesolutreen in Oberfranken. *Quartär-Bibliothek* 3. Bonn: Röhrscheid Verlag.



8

SOLUTREAN LAUREL LEAF POINT PRODUCTION AND RAW MATERIAL PROCUREMENT DURING THE LAST GLACIAL MAXIMUM IN SOUTHERN EUROPE: TWO EXAMPLES FROM CENTRAL FRANCE AND PORTUGAL

*Thierry Aubry, Miguel Almeida,
Maria João Neves, and Bertrand Walter*

The variability in laurel leaf point morphology and the shaping and sharpening techniques utilized on them are examined. Both intra- and inter-regional Solutrean group differences are studied, using data obtained from recent excavation projects in Central France and Portugal. Models are proposed to explain similarities and disparities in the production, function, and discard of laurel leaf points at a regional level in the two study areas.

Lithic industries from southeastern Europe, which contain foliated points and which have been associated by radiometric dates to the Last Glacial Maximum, are examined. Archaeological research on the Solutrean techno-complex has been privileging caves and shelters in sedimentary regions where settlements are easier to detect for a long time. It is only in the past decade that this bias has been overcome and more systematic survey and excavation projects undertaken, which have looked for open air Solutrean settlements (Vialou and Vilhena-Vialou 1990; Rasilla Vives 1994; Aubry 1998).

The archaeological sample studied in this chapter consists of lithic assemblages recovered from the Solutrean levels of sites located on the extremities of the Solutrean techno-complex site distribution area in southwest Europe and which appear to belong to two different regional groups. Although the quality and quantity of chronological information available for these two groups is uneven, all the radiometric dates fall within the Last Glacial Maximum (Zilhão 1997; Rasilla Vives and Rodríguez 1994; Strauss 1983; Duarte et al. 1999).

The northern group, located on the southern margin of the Paris sedimentary basin at the border of the Massif Central, consists of five archaeological sites—Monthaud, excavated at the beginning of the century; Les Roches d'Abilly, excavated during the 1950's, the Fritsch shelter, excavated during the 1980's; and two ongoing excavations, Fressignes and Les Maitreaux—plus three isolated superficial finds (Figure 8.1). The only available radiometric date for Abri Fritsch, from level 8d at 19,180 B.P. (Gron - 5499), places it during the late Solutrean (Allain 1976). Similarities to lithic assemblages from sites on the southwest border of the Massif Central in Aquitaine, which have been radiocarbon dated,

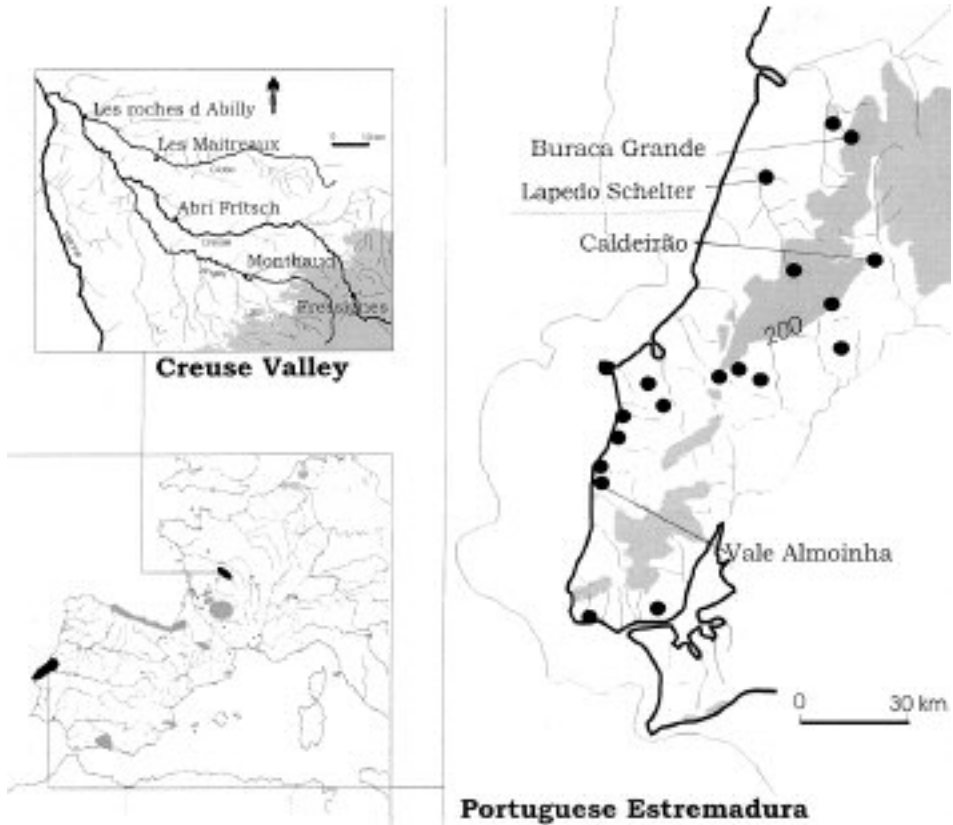


Figure 8.1 Distribution map of Solutrean sites in southern Europe and location of the two regional groups studied.

indicate that this site was occupied between 20,000 and 19,000 B.P. (Geneste and Plisson 1986).

The second group consists of sites in the Portuguese Estremadura (Figure 8.1) located in the drainage basins of the Tagus and Mondego rivers and their tributaries (Zilhão 1997). These sites are situated on Mesozoic and Cenozoic sedimentary rocks. The radiocarbon dates available (Zilhão 1997; Duarte et al. 1999) indicate they were occupied between 20,500 and 18,000 B.P., which is congruent with dates available for the rest of Iberia (Strauss 1983; Rasilla Vives 1994). It should be noted that the Solutrean lithic assemblages that do not contain shouldered points all seem to be older than 20,000 B.P.

Various paleoclimatic models (Climap 1976; Zilhão 1997; Ellwood et al. 1998) have shown differences in climatic parameters that would have influenced the faunal resources available in the two regions during the Lower Glacial Maximum (Cardoso 1992; Bayle 2000). This may be contrasted with the high degree of similarity apparent in the lithic assemblages of the two regions, including the morphology of lithic foliate points

and the specificity and complexity of technical procedures for their manufacture. Coupled with the climatic and faunal differences, these similarities have been used to argue in favor of the cultural unity of the regions and against the possibility of technological convergence having occurred as the result of environmental constraints (Smith 1966; Bordes 1969; Tiffagom 1998).

The similarities and differences that have been observed in the movement patterns of the raw materials used to manufacture laurel leaves in the two regions are discussed. The production processes for these tool types and their discard contexts will also be examined. Functional analyses of laurel leaf points, such as the experimental protocol developed to study microscopic use wear traces on the Solutrean shouldered points from Combe-Saunière cave, will not be discussed (Geneste and Plisson 1993; Chadelle et al. 1991).

The French group from the Creuse Valley contains 128 tools that fit the definition of laurel leaves. The Portuguese tools consist of 131 preforms—entire pieces or pieces fractured during manufacturing or use. We can divide these groupings into two subdivisions. The first, which was called group J by Smith (1996), consists of tools with lengths exceeding 25 cm, whereas the second subgroup consists of pieces whose reconstituted length is less than 15 cm.

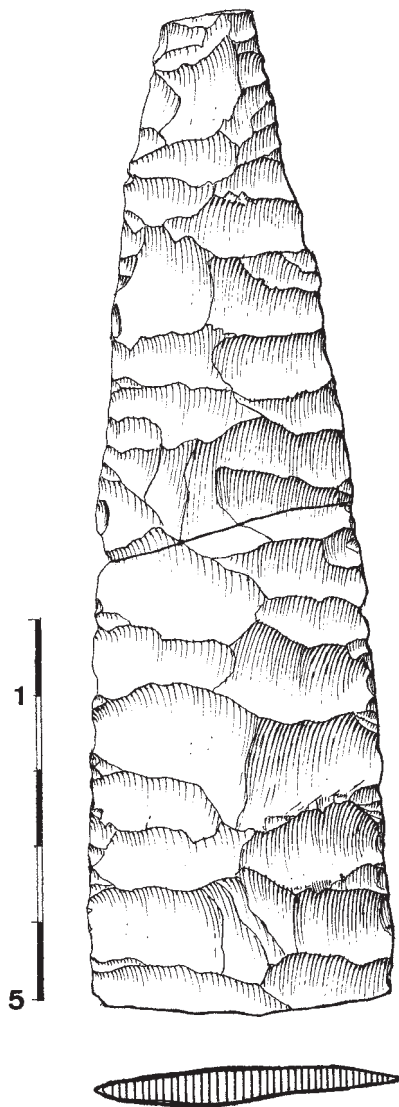


Figure 8.2

Large-sized Laurel Leaf Points

The larger tool subgroup shares similarities with laurel leaves found at Volgu (Smith 1966), which when complete range between 25 and 40 cm., characteristic of regional groups in the drainage basins of rivers arising in the French Massif Central. All the known pieces in this subgroup from the Creuse drainage basin are fragmented. It can be further broken down into two categories based on morphology and the type of retouch utilized for the final thinning of the pieces. The first category consists of narrow (4- to 5-cm wide) points less than 5-mm thick, with straight edges and parallel narrow serial flake removals (Figure 8.2).

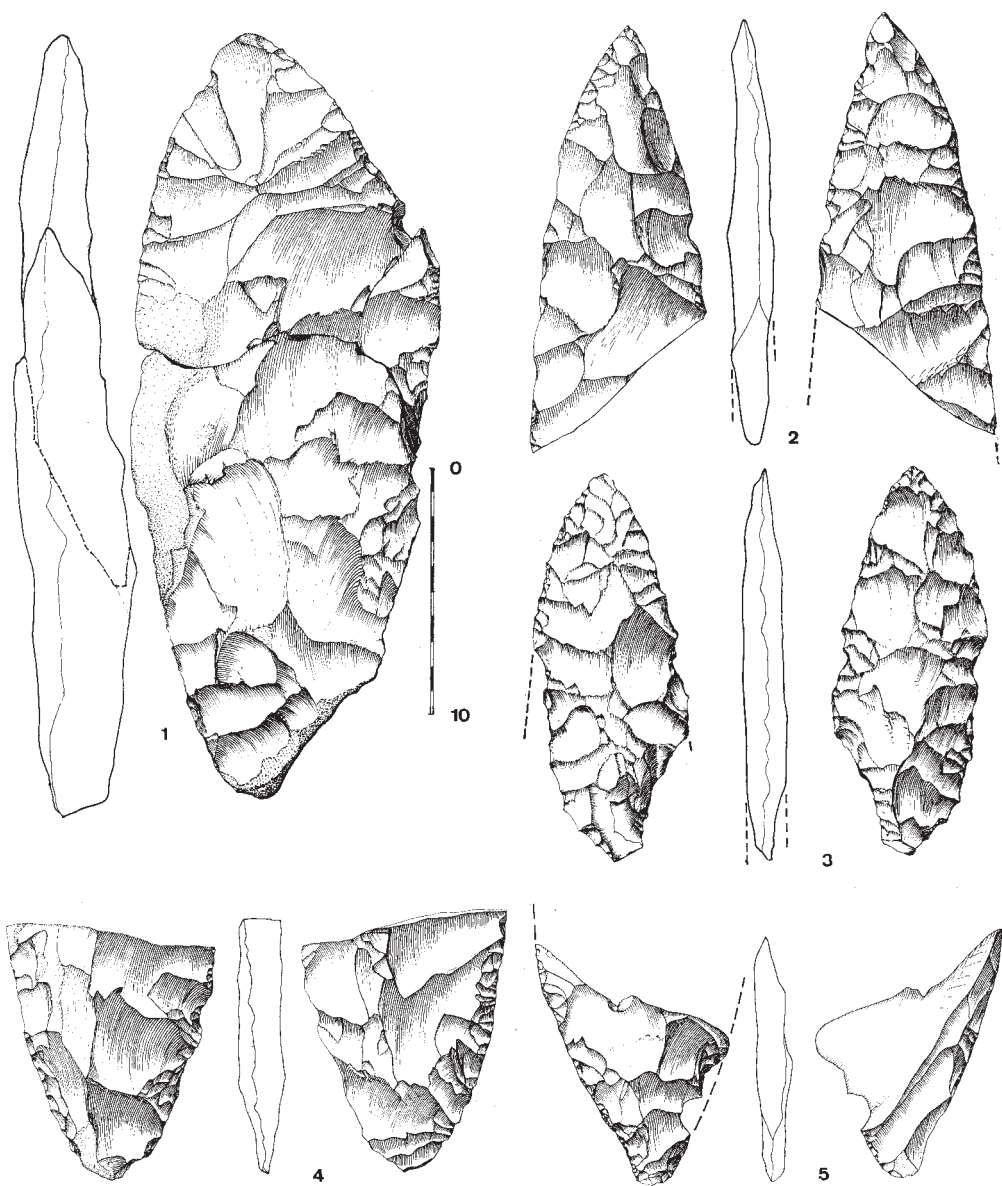


Figure 8.3 Preform and fragments obtained during the shaping of the second group of large laurel leaf points at Les Maitreaux (Indre-et-Loire).

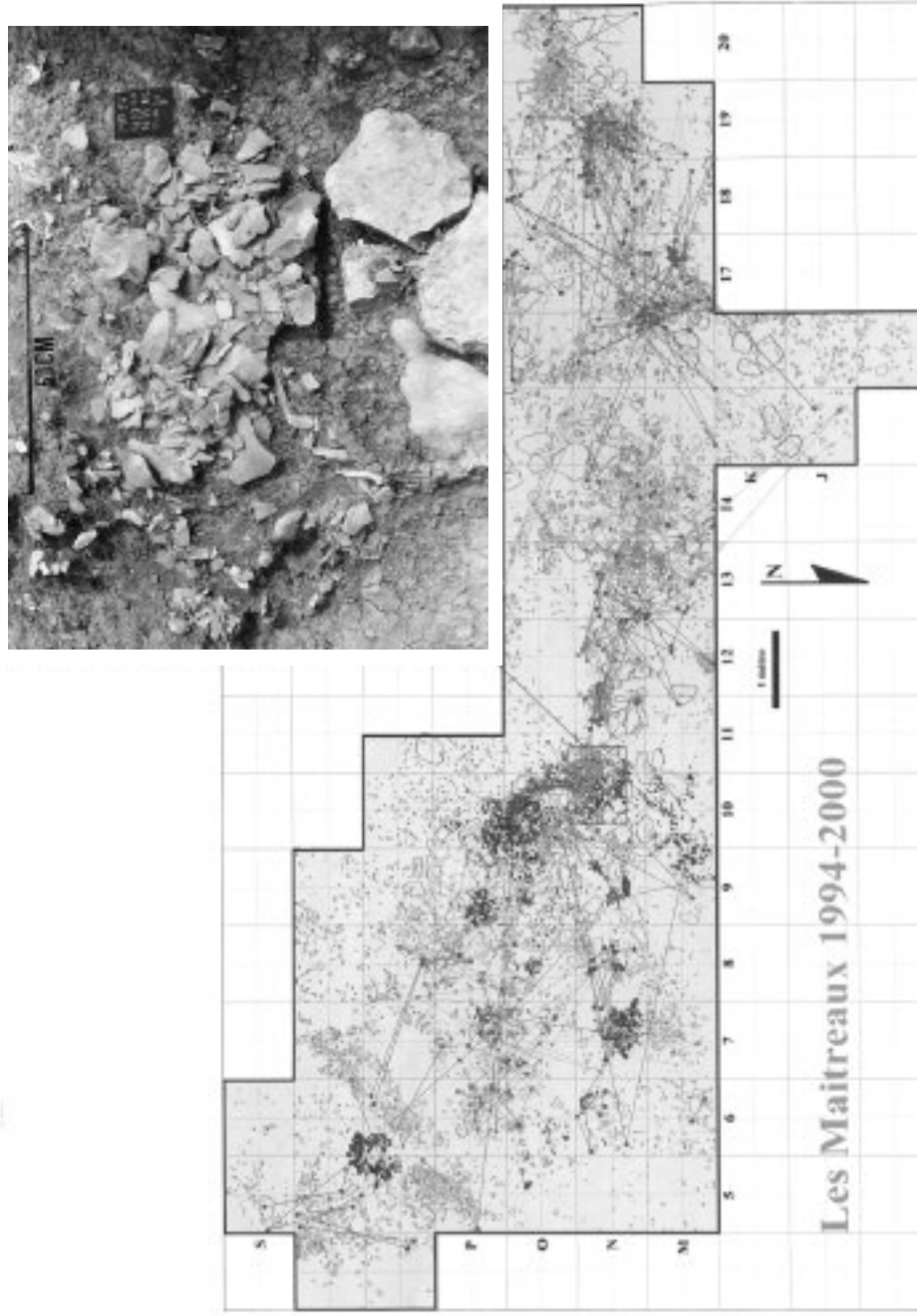


Figure 8.4 Distribution of lithic artefacts in level 2a at Les Maitreaux showing one of the concentrations of large flakes obtained during the shaping of large laurel leaves at this site.

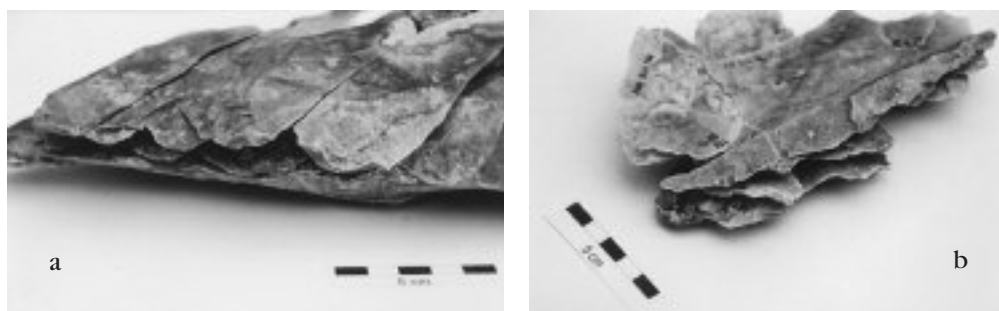


Figure 8.5

Although the retouch technique in the final phase of thinning has never been replicated experimentally, it was probably pressure retouch performed using a crutch or a lever. Where serial retouch completely covers both faces of the points, it is not possible to determine what technique was used during the first phase of thinning without doing refitting. The second category consists of larger laurel leaves covered by expanding removal scars, with divergent denticulated edges formed by the detachment negatives of short flakes (Figure 8.3).

Reconstruction of the Production Sequence

The second category of laurel leaf points has been replicated by Pelegrin (1981). Using red deer antlers of different weights, and pebbles and sandstone for grinding, Pelegrin found it was necessary to prepare each platform by isolating and grinding a spur in order to obtain a width/thickness ratio similar to the pieces from the archaeological sites. Using archaeological data, it has been difficult to confirm whether this was the actual procedure used during the Solutrean. The first step performed in thinning large laurel leaf points is usually missing in Solutrean assemblages as the fragments found were usually discarded after a complicated process of use.

The excavation, beginning in 1994 (Aubry et al. 1998), of a Solutrean settlement at Les Maitreaux, has helped to overcome this sampling problem to some extent and provided data that aided in reconstructing the entire production sequence of these pieces. The site, discovered by Walter during a superficial survey, lies along the bank of a small tributary of the Claise valley that cuts through Upper Turonian limestone (Figure 8.1). The clay layers produced by the weathering of this limestone yield flint nodules of excellent knapping quality, some being more than 1-m long and less than 10-cm thick. Excavation of more than 60 square meters of this site produced 23,400 lithics (coordinated pieces of more than 1.5 cm), which were found lying in concentrations (Figure 8.4) within a wind deposited silty shale (Aubry et al 2000). Technological and spatial studies conducted through refitting showed that these concentrations consisted of preparation flakes, cores, blades (either not selected for shouldered point manufacturing or selected and fractured during retouch), bifacial shaping flakes, and laurel leaves fractured during manufacturing. The association in each concentration of shouldered points and backed bladelets with the two morphological categories of laurel leaves previously defined demonstrates that they were contemporaneously produced. Only a few retouched pieces (61 out of a total of 23,400 pieces) have been found in the concentrations: blades with traces of use, scrapers, burins, and perforators. A use wear study performed by Plisson on 6 scrapers and 6

blades confirmed that these pieces were used as tools, leading to the dismissal of the hypothesis that they had been manufactured but not selected for use.

Examination of a refitted series of shaping flakes proved that thinning of large laurel leaves was performed exclusively by soft-hammer percussion (Figure 8.5), with the thickness being reduced to less than 1.5 cm. The first step of thinning was to detach a series of covering flakes on one edge after grinding the entire edge. These flakes were frequently overshot. The platform for each removal was carefully prepared, with a spur created by removing small flakes and grinding, as described by Pelegrin (1981). As we previously hypothesized (Aubry et al. 1998), thinning was not performed symmetrically and alternatively on the two faces. Instead, the choice of one face for thickness reduction permitted the conservation of the sub-cortical part of the blank, which was homogeneous, finer in grain, and more suitable for flaking (Figure 8.6). The relative rapidness with which the first step of shaping was performed could explain the higher frequency of breakage during this phase. The analysis of large-sized laurel leaf preforms and fragments shows fractures that are similar to fractures created at the point of impact during shaping in experimental knapping of such pieces or which could be the result of raw material flaws or weaknesses (Figure 8.3).

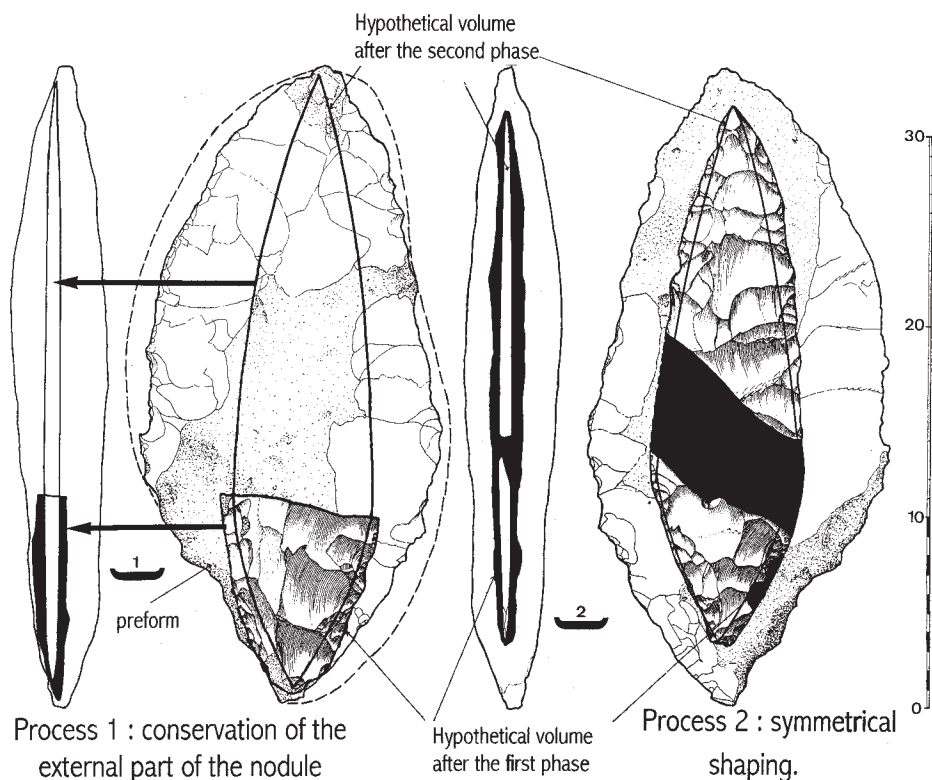


Figure 8.6 Hypothetical reconstruction of two solutions for the shaping of large nodules based on the preforms and fragments of laurel leaf points recovered at Les Maitreaux.

Table 8.1 Sites with Solutrean Levels

Small Size			P	M	MS	EN	B	M	D	F
Sites										
Les Roches	C3c-1	0 km		2						
	C3c-2	10 km								1
Les Maitreaux	C3c-1	0 km	1	13						
	E7b	0 km								1
Fritsch Shelter	C3c-1	15 km			1					
	C3a-1	50 km					1			
	J2/1	5 km					1		1	
	J2-4	20 km	1							
	E7b	10 km							1	
Les Riaux	C3a-2	45 km						1		
Monthaud	C3c-1	40 km					2	1		
	C3c-2	40 km				1		1		
	C3a-1	60 km					1		1	
Monthaud	J1	0 km	56 entieres and fragments							
Large Size n1			P	M	MS	EN	B	M	D	F
Fritsch Vignaud	C3c1	15 km								1
Fritsch c9	C3c-4	15 km								1
Large Size n2			P	M	MS	EN	B	M	D	F
Les Roches d'Abilly	C3C-1	0 km	1	2						1
	C3C-2	10 km			1					
Maitreaux	C3C-1	0 km	7	21						3
Fritsch Shelter	C3C-1	15 km								
	C3A-1	50 km			1					
Monthaud Shelter	C3A-1	60 km			1					

P=Preforms; MS= mesial fragment resharpened; EN=entire; B= basal fragment with projectile use stigmata; M= mesial fragment related to projectile uses; D= distal fragment related to projectile use; F= non diagnostic fragment

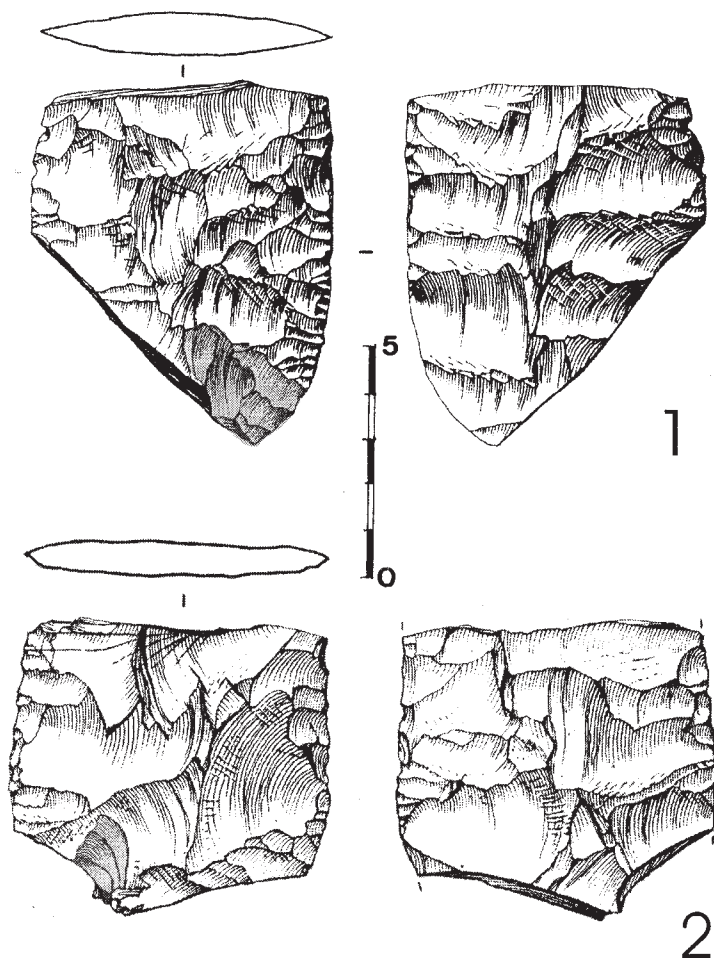


Figure 8.7 Mesial fragments of a large laurel leaf point with several detachments revealing resharpening after fracture. 1: Montbaud shelter; 2: Fritsch shelter level 9.

Use and Discard of Large Laurel Leaves

In the Creuse region, the type of raw material used for the production of large laurel leaves at Les Roches d'Abilly, La Guitière, Montbaud, and Fritsch points to the probable existence of similar workshops near the Upper Turonian and Low Turonian outcrops even though Solutrean sites are unknown at these locations (Table 8.1). Larick (1983) suggests that evidence for the transportation of unshaped nodules has not been found in the Perigord (Table 8.1) because of the high frequency at which breakage occurs during the complicated production sequence for this kind of tool. Analysis of non-local raw material in Solutrean assemblages shows resharpening of the edges after breakage, however, suggesting that these pieces were used after breaking (Table 8.1 and Figure 8.7). Turonian flint flakes found in level 10 at the Fritsch Shelter provide evidence in support of this hypothesis as the nearest outcrop is 15 km away. Flakes were produced during the final

retouch of pieces larger than 6 cm by a process that involved the use of spur platforms and grinding. This hypothesis should be tested by an examination of the raw materials used, the discard patterns, as well as use-wear analysis of the fragments. It would explain the carefulness evident in the final retouching of the edges with concave protected removals and the rarity of shaping flakes at campsites, such as level 10 of the Fritsch shelter.

Small Laurel Leaves

There is a cluster of small laurel leaves, consisting of those less than 15-cm long when complete, within the laurel leaf group categories (Figure 8.8 and Figure 8.9), which has been described by Smith (1966) and Zilhão (1997). There is little variability in their length. Geneste and Plisson (1993) have hypothesized that they are functionally equivalent to longer shouldered points. There is a high frequency of basal and medial fragments with hinge fractures and spall removals, which are characteristic of projectile breakage.

In the Creuse basin, small- and large-sized laurel leaves (Table 8.1) were manufactured from the same raw materials, which had been transported from as far away as 60 (Aubry 1991), the same distance as in the Perigord (Larick 1983; Demars, 1996). Larick (1983) suggests that the presence of shaping flakes at Les Roches d'Abilly, Les Maitreaux and Monthaud shows that this kind of foliate point was produced near the flint resources. Their subsequent displacement may have been greater than 20 km, with the points being transported after being reduced in thickness, quite possibly in final form.

The production sequence was different for the large-sized group. In the Maitreaux assemblage, which was manufactured from Turonian outcrop raw material, and in the assemblage from Monthaud, which is located near a Bajocian flint source, the shaping flakes are cortical. There is evidence for soft hammer percussion in practically the entire reducing sequence as shown by fragments at the Maitreaux site (Figure 8.8) resulting from breakage in the final phase. Shaping and sharpening by pressure retouch was performed to a lesser extent on the laurel leaves manufactured from Turonian outcrop raw material based on examination of the fragments discarded after use as projectiles. In contrast, pressure retouch was used to modify the entire edge and the entire surface of the point in the group of smaller laurel leaves made from Bajocian flint in the Monthaud shelter area.

Evidence for heat-treating, seen first in the Perigord (Bordes 1969), was afterwards recognized in other regions, and recently in Solutrean sites in Southern Iberia (Zilhão 1997; Tiffagom 1998). This procedure makes the material more suitable for pressure retouching, but also significantly increases the fragility of the final point. In France, evidence regarding how extensively heat-treating was used is not available. Although this technique was known, it was not systematically employed in the Creuse basin. Only Cenozoic and Bajocian, coarse-grained varieties of flint whose suitability for pressure retouch can be dramatically improved by this procedure, were heat-treated. However, analysis of bifacial points from several Solutrean sites in Spain and Portugal has shown that heat treatment was used systematically there.

In Portugal, at the sites of Vale Almoinha, Caldeirão, and Buraca Grande, a wide variety of flint was observed to have been used in the manufacture of laurel leaves (Table 8.2). The technological study of the production sequence indicates the use of flakes as blanks for shaping, with systematic use of heat treatment in the reduction process before or after the first phase of shaping by percussion with a soft hammer (Table 8.2, Figure 8.10). The

Table 8.2 Buraca Grande Level 9a

Raw Material	Distances	M-1	M-2	F-1	F-2	F-3	F-4	PF
J2-1	0 - km	1	1	13	16	25	29	3
C2s-1	30 - km	0	2	11	0	2	4	0
C2s-2	30 - km	0	0	1	0	0	0	1
Mc - 1	unknown	0	0	1	0	3	0	0
Mc - 2	10 - km	0	2	0	0	0	1	0
H-3 1	45 - km	0	0	1	0	0	0	0

M-1 = fragment of point fractured before heat treatment

M-2 = fragment of point fractured after heat treatment

F-1 = shaping flake without heat treatment

F-2 = first shaping flake after heat treatment.

F-3 = flakes with the two faces showing heat treated aspect

F-4 = pressure retouching flakes

PF= fragment related to projectile use

platforms for shaping flakes don't appear to have undergone any special preparation or grinding, which probably explains why most of the breakage occurred in this phase. The first phase of reduction was sometimes followed by a second heat treatment, evidenced by the different appearance of the material on the two sides of the shaping flakes. The refitting of shaping flakes on a foliate point at the Parpallo site have shown that the process of heat treatment had been used more than once on this tool (Tiffagom 1998). The final shaping and sharpening was performed by serial pressure retouch on the entire edge.

Evidence for the transportation of flakes or preforms at these sites is provided by a translucent coarse-grained flint whose geological origin is 30 km away from Buraca Grande Cave (Table 8.2). Shaping and intermediate heat treatment were performed at the campsite and at least one point was broken during the shaping process. Twenty preforms shaped by percussion, in some cases after heat treatment, recovered from the Monte da Fainha open-air site (Zilhão 1997, Figure 8.9) provide evidence for reserves being stock-piled.

Conclusions

These preliminary results establish that a variety of shaping and sharpening techniques was used to produce the apparently morphologically uniform Solutrean bifacial points found in southern Europe. Furthermore, although French laurel leaves, on which the definition of the Solutrean techno-complex in the Upper Palaeolithic sequence is based, have been considered to be typologically and technologically uniform, they have probably served a variety of functions as projectiles and knives. Based on the technological examination of discarded fragments, this assertion should be tested by microscopic use wear analysis on archaeological remains recovered from recent excavations.

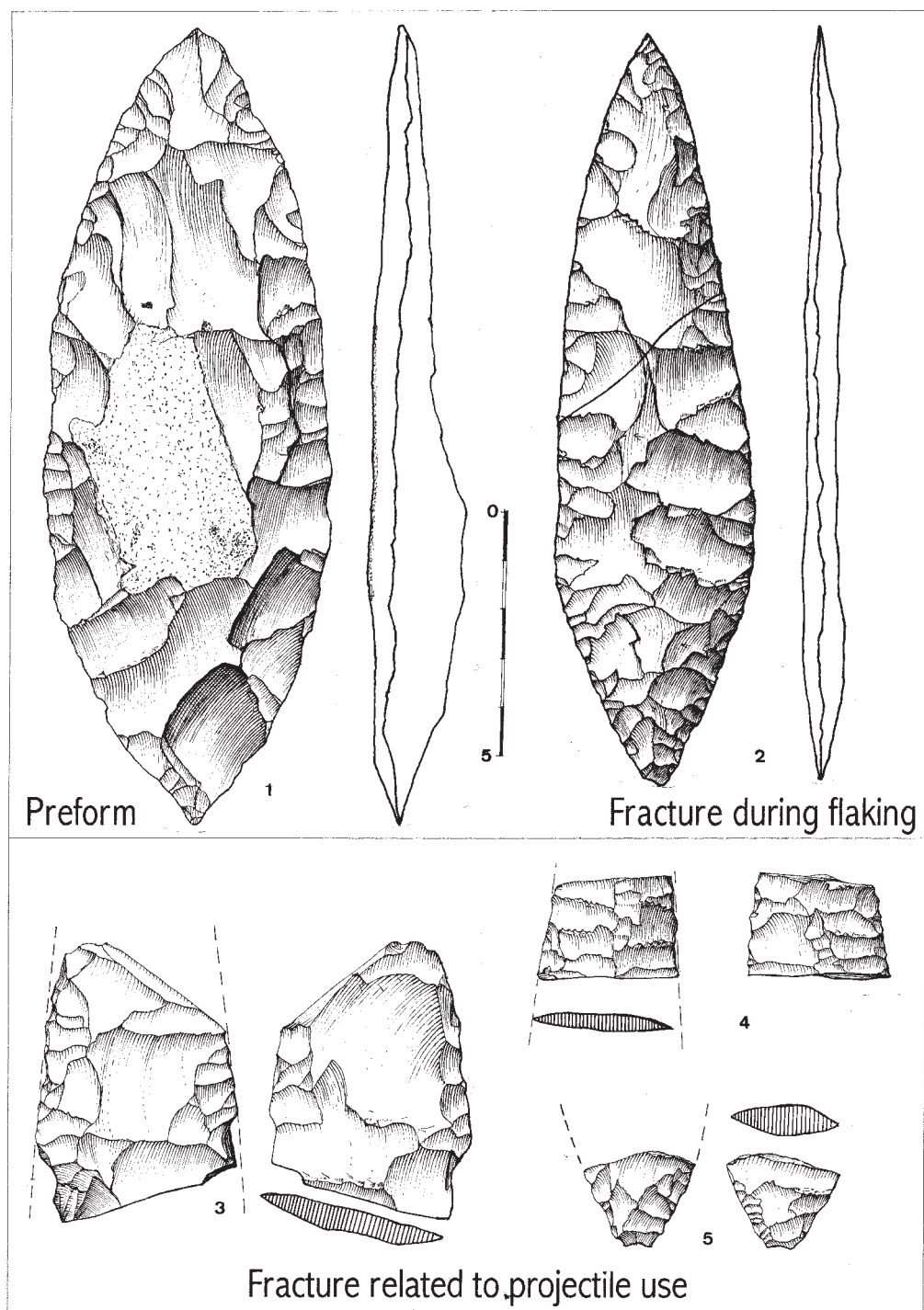


Figure 8.8 Small laurel leaf points from Creuse drainage basin settlements. 1: Preform from Les Maitreaux. 2: Points fractured during shaping by baton percussion, Les Maitreaux. 3 and 4: Mesial fragments related to projectile use, manufactured from upper Turonian flint, Monthaud Shelter. 5: Basal fragment related to projectile use made from lower Turonian flint, Fritsch shelter level 8e.

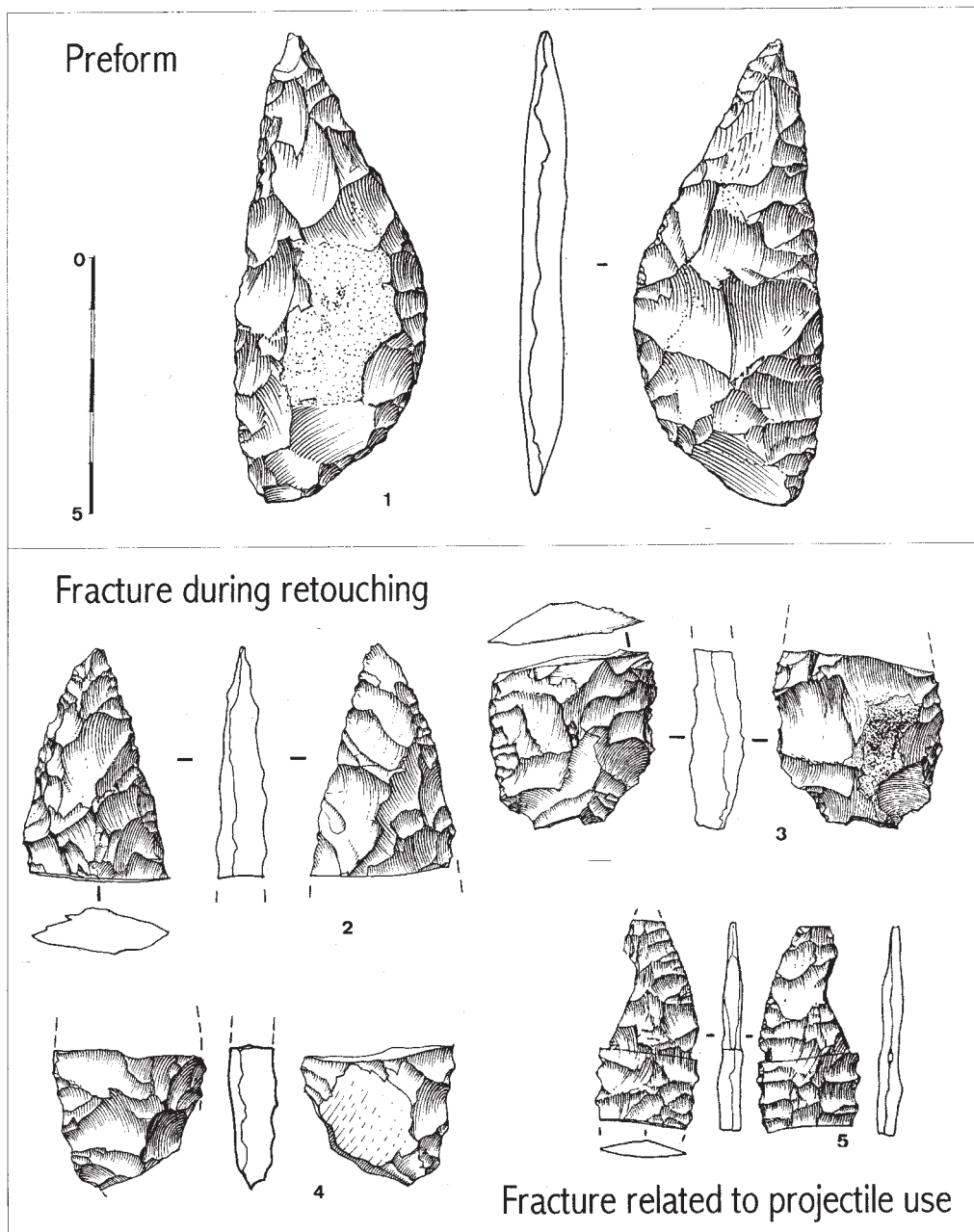


Figure 8.9 Small laurel leaves from Alentejo (1) and central Portugal (2-5). 1: Heat treated preform, Monte da Fainha. 2 and 3: Fragments obtained during pressure retouch after heat treatment, Lapedo Shelter. 4: Buraca Grande fragments obtained during pressure retouch after heat treatment. 5: Fragment related to projectile use, Vale Almoinha.

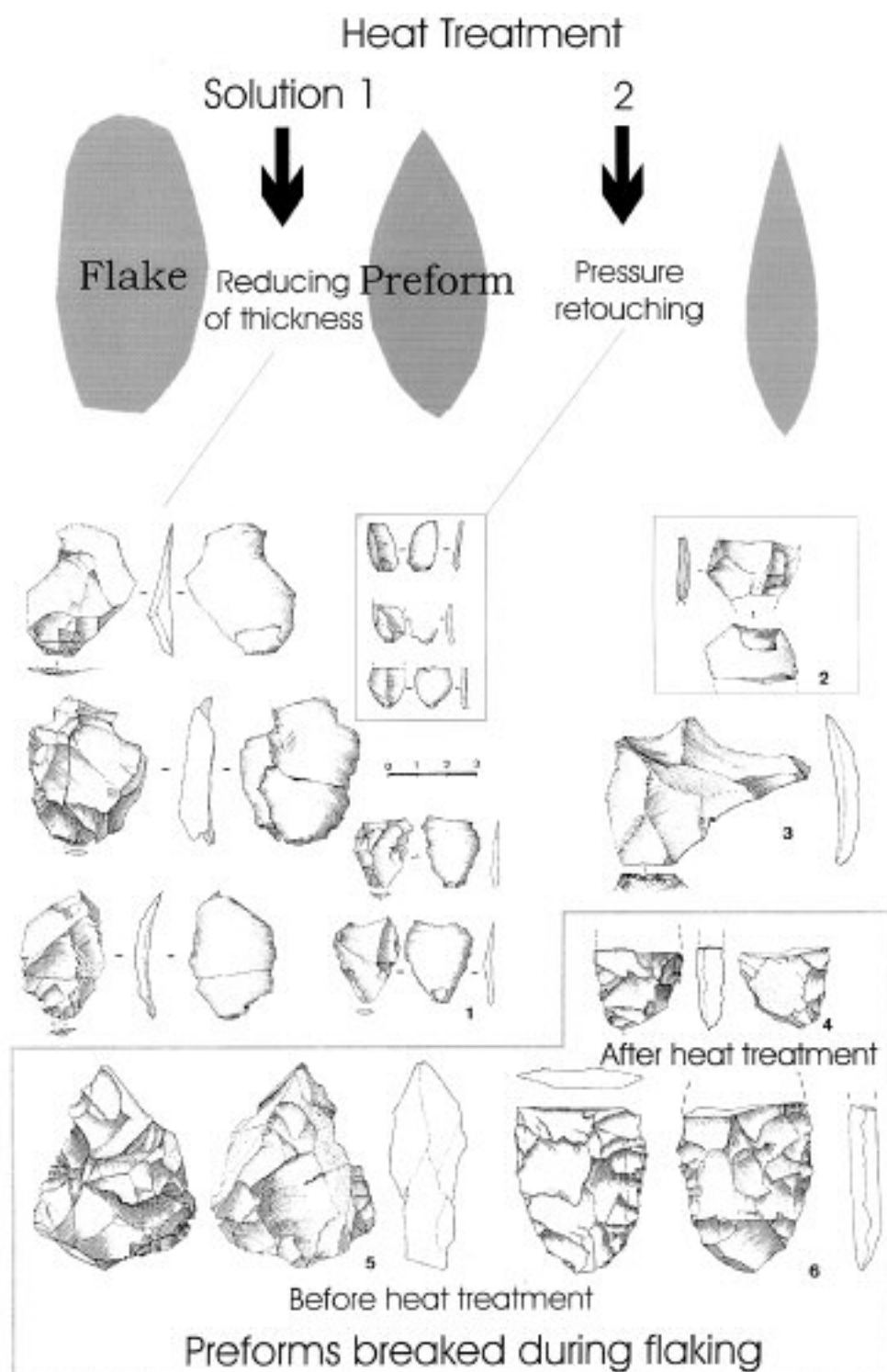


Figure 8.10 Use of heat treatment in the process of shaping and retouching of small laurel leaf points from Solutrean assemblages in Portugal. 1: Vale Almoinha. 2, 3 and 4: Buraca Grande level 9a, 5 and 6: Vale Almoinha.

Although there are differences visible between the two geographic areas examined in this chapter, there is also a high degree of homogeneity at a regional level. There is a strong similarity in production techniques and stages of manufacture among the sites on the edge of the French Massif Central. Also, the assemblages located in the Portuguese Estremadura bear a clear resemblance to those of the rest of southern Iberia. The geographic distribution of these homogeneities correlates with similarities in faunal resources. Similar regional trends, based on point typology and raw material supply territories, on the Cantabrian coast in Iberia, have been pointed out by Strauss (1977).

The role of environmental constraints on technological options remains difficult to define. The geographic distribution of large-sized laurel leaves is restricted to the regional groups on the border of the Massif Central and seems to comply with the constraints imposed by the availability of suitable raw material blanks with appropriate morphologies. This type of raw material exists in the Cretaceous and Tertiary geological formations of the Paris and Aquitaine sedimentary basins but seems to be rare elsewhere. However, this environmental constraint cannot entirely explain the variability in techniques because long blade production and large bifacial pieces created using pressure retouch are known from the Iberian Peninsula Chalcolithic (Forenbaier 1999). The systematic use of heat treatment in association with pressure retouch in the assemblages of Southern Iberia doesn't correspond to raw material availability, but rather to different strategies of seasonal group displacement and modalities of cave utilization in somewhat smaller territories in Iberia (Zilhão 1997; Ripoll Perello 1991).

Nevertheless, we must not downplay the consistency of behavior exhibited throughout the Solutrean techno-complex distribution area, as, for instance, in the selection of translucent varieties of flint among the available lithic resources. Such choices cannot be explained except by a network of long-distance social contacts extending beyond regional group limits. These preliminary findings need to be expanded upon through analysis of more assemblages to reduce the likelihood of bias being present in the available sample of Solutrean assemblages. In France, a high percentage of the archaeological sample available consists of sites where Solutrean points were discarded after hunting and short-term occupations of caves and rock shelters. Our perceptions of the resource exploitation modalities need to be improved by the detection and excavation of open-air sites associated with butchering and conservation activities and, most of all, knapping sites near flint resources.

References

- Allain, J.
1976 La fin du Paléolithique Supérieur en Région Centre. In *Le Magdalénien en Europe. Actes du Colloque de Mayence*, 1987. Liège: ERAUL 38.
- Aubry, T.
1991 L'Exploitation des Ressources en Matières Premières Lithiques dans les Gisements Solutréens et Badegoulien du Bassin Versant de la Creuse (France). Ph.D. dissertation, Bordeaux I University.
- Aubry, T., B. Walter, E. Robin, H. Plisson, and M. Benhabdelhadi
1998 Le Site Solutréen de Plein air des Maitreaux (Bossay-sur-Claise, Indre-et-Loire): Un Faciès Original de Production Lithique. *Paléo* 10:163–84.

Aubry, T.

- 1998 Olga Grande 4: Uma sequência do Paleolítico Superior no Planalto entre o Rio Còa e a Ribeira de Aguiar. *Revista Portuguesa de Arqueologia* 1:5–26.

Aubry, T., B. Walter, M. Almeida, M. Liard, and M. J. Neves

- 2000 Approche Fonctionnelle des Sites dit d'Atelier: l'Exemple des Occupations Solutréennes et Badegouliennes des Maitreaux (Indre-et-Loire, France). In *XXV^o Congrès Préhistorique de France, "Approche fonctionnelles en Préhistoire,"* Nanterre: Abstract and Program 24–25 November 2000.

Bayle, G.

- 2000 Étude Archéozoologique des Niveaux Solutréens de l'Abri Fritsch. D.E.A. dissertation, University of Paris I.

Bordes, F.

- 1969 Traitement Thermique du Silex au Solutrén. *Quatar* 18:25–55.

Cardoso, J.

- 1992 Contribuição para o Conhecimento dos Grandes Mamíferos do Plistocénico Superior de Portugal. Ph. D. dissertation, University of Lisbon.

Chadelle, J.-P., J.-M. Geneste, and H. Plisson

- 1991 Processus Fonctionnels de Formation des Assemblages Technologiques dans les Sites du Paléolithique Supérieur. Les Pointes de Projectile Lithiques du Solutrén de la Grotte de Combe Saunière (Dordogne, France). In *25 ans d'Etudes Technologiques en Préhistoire, XI^e Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*. Juans-les-Pins: APDCA.

Climap.

- 1976 The Surface of the Ice-Age Earth. *Science* 191:1131–37.

Demars, P.-Y.

- 1996 Le Solutrén de Laugerie-Haute (Dordogne). *Gallia Préhistoire* 37–1995: 1–53. Paris: CNRS Editions.

Duarte, C., J. Mauricio, P. Pettitt, P. Souto, E. Trinkaus, H. Vander Plicht, and J. Zilhão

- 1999 The Early Palaeolithic Human Skeleton from the Abrigo de Lagar Velho (Portugal) and Modern Human Emergence in Iberia. *Proceeding of the National Academy of Sciences, USA* 96:7604–9.

Ellwood, B. B., J. Zilhão, F. B. Harrold, W. Balsam, B. Burkart, G. J. Long, A. Debénath, and A. Bouzouggar

- 1998 Identification of the Last Glacial Maximum in the Upper Paleolithic of Portugal Using Magnetic Susceptibility Measurements of Caldeirão Cave Sediments. *Geoarchaeology: An International Journal* 13(1):55–71.

Forenbaher, S.

- 1999 *Production and Exchange of Bifacial Flaked Stone Artifacts during the Portuguese Chalcolithic*. Oxford: British Archaeological Reports.

Geneste, J.-M., and H. Plisson

- 1986 Le Solutrén de la Grotte de Combe Saunière I (Dordogne). Première Approche Paléothnologique. *Gallia Préhistoire* 29:9-27.
- 1993 Hunting Technologies and Human Behavior. Lithic Analysis of Solutrean Shouldered Points. In *Before Lascaux, the Complex Record of the Early Paleolithic*. H. Knecht, Pike-Tay, and White, eds. Boca Raton: CRC Press, Inc.

Larick, R.

- 1983 Circulation of Solutrean Foliate Points within the Perigord, SW France. In *The Uses of Flint and Chert*. Proceeding of the 4th International Symposium Held at Brighton, Polytechnics, 10-15 September 1983. Pp.217-29.

Pelegrin, J.

- 1981 Experiments in Bifacial Work: About "Laurel Leaves." *Flintknappers Exchanges (USA)* 4(1):4-7.

Rassila Vives, M., and L. Rodríguez.

- 1994 La Cronología Radiométrica del Solutrense en la Península Ibérica y su Correlación Crono-Climática. In *Monográfico: El Solutrense en la Península Ibérica*. Férvedes 1: 57-67.

Rassila Vives, M.

- 1994 *Monográfico: El Solutrense en la Península Ibérica*. Férvedes 1.

Ripoll Perrelo, E.

- 1991 Les Industries Solutréennes de la Cueva de Ambrosio (Vélez-Blanco) et Leur Rapport Avec les Sources de Matières Premières. In *Le Silex de sa Génèse à l'Outil*. M. R. Séronie-Vivien and M. Lenoir, eds. Paris: CNRS Cahiers du Quaternaire.

Smith, P.

- 1966 *Le Solutrén en France*. Bordeaux: Delmas.

Strauss, L. G.

- 1977 Pointes Solutréennes et Hypothèse de Territorialisme. *Bulletin de la Société Préhistorique Française* 74:206-12.
- 1983 *El Solutrense Vasco-Cantábrico una Nueva Perspectiva*. Centro de Investigación y Museo de Altamira.

Tiffagom, M.

- 1998 Témoignages d'un Traitement Thermique des Feuilles de Laurier dans le Solutrén Supérieur de la Grotte de Parpalló (Gandia, Espagne). *Paléo* 10:147-61.

Vialou, D., and A. Vilhena-Vialou

- 1990 Fressignes (Indre): Campement Solutréen au Nord du Massif Central. In *Les Industries à Pointes Foliacées du Paléolithique Supérieur Européen*. Krakow 1989. Pp. 335–345. Liège: ERAUL 42.

Zilhão, J.

- 1997 O Paleolítico Superior da Estremadura Portuguesa. Eds Colibri. Ph.D. dissertation, University of Lisbon, Portugal.



9

THE PITFALLS OF USING BIFACES AS CULTURAL MARKERS

Marcel Otte

Bifacial technology is the product of both cultural influences and convergence due to technological and environmental constraints. The effects of these two factors have not always been separated out in the literature. In homogeneous cultural contexts, traditional constraints justify the production of bifacial objects because it is a deeply codified stylistic expression. However, from one context to another, natural constraints (e.g., mechanical laws for the raw material) force the creation of similar forms: bifacial retouch of a point is only convergence. In the human sciences, it is up to us to identify the stylistic effects proper to a tradition and to isolate them from spontaneous “natural” effects. Only in this case can the bifacial tool have a traditional meaning.

Convergence

Pointed bifacial forms were produced by multiple independently developed technological processes across the time span of human history in which they were used. François Bordes (1968:230) has clearly demonstrated that many reduction processes, regardless of the type of support, used similar techniques to sharpen one end of the tool to form a point, thin the base, and create a symmetrical lenticular cross-section. The interaction between intention and technological constraints resulted in similarities in the final forms produced. Certain well-known, but incorrect, interpretations are actually based on the results of convergent processes. For example, although the “Proto-Solutrean” of Central Europe and the foliate point industries that appear at the beginning of the Upper Paleolithic are often linked together, they are in reality widely separated in both time and space (Freund 1952). However, it is possible to detect secondary stylistic variables and link them to specific cultural groups. These variables are discussed as they relate to the European Paleolithic.

Acheulean

Acheulean bifacial industries, prepared on nodules or cobbles, have precise geographic and chronological limits. They only appeared in Western Europe after 600,000 BP and never appeared in Central or Eastern Europe. In Asia, their distribution was limited to the center of Anatolia and to the vast southern region of China (Xie 1999). In other regions

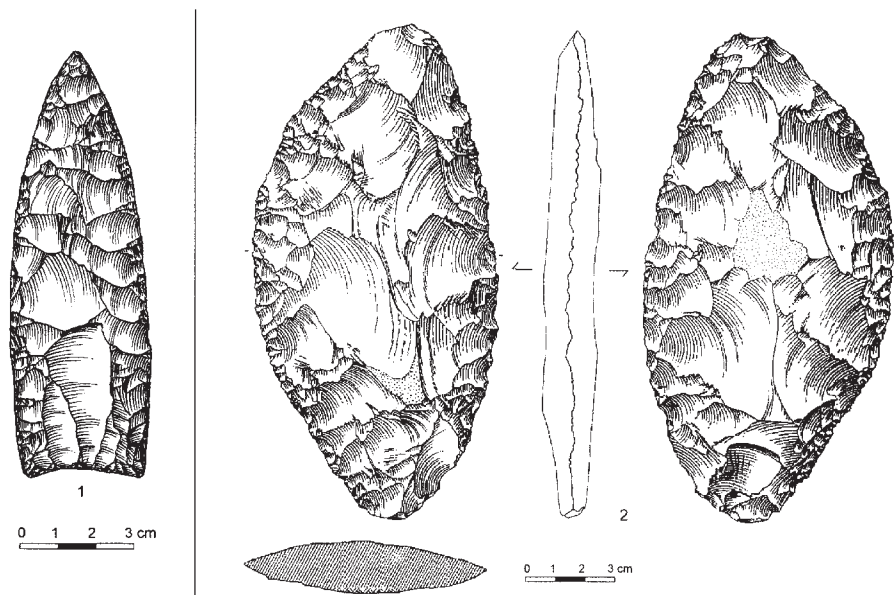


Figure 9.1 Example of convergent effects independently generating similar shapes (U.S. Clovis point and European Chalcolithic knife). Stylistic differences, however, provide clear cultural signatures. 1: Clovis point, USA (after Bordes 1984); 2: knife from Salinelles (Gard, France), Chalcolithic (after Briois 1991).

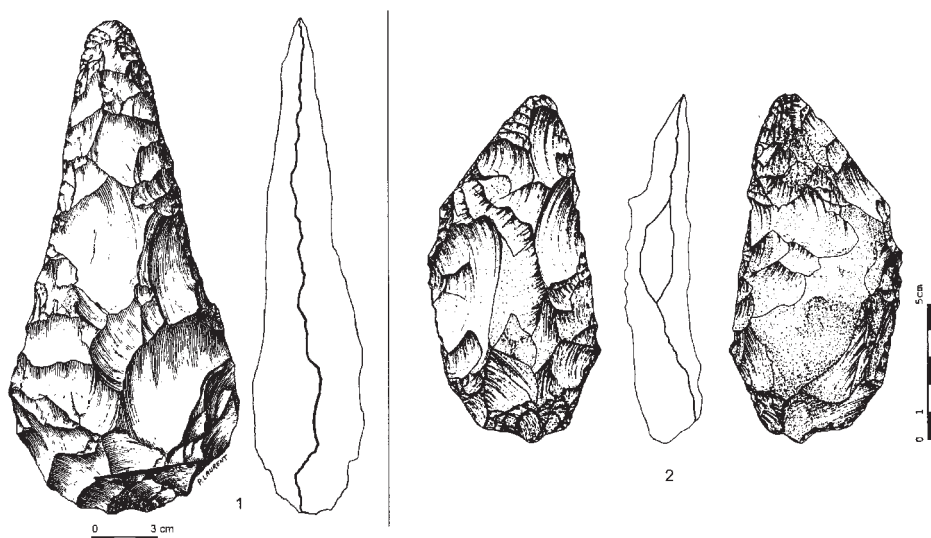


Figure 9.2 The bifacial technologies illustrated here do not share a common origin, but the name "Micoquian" has been responsible for much confusion regarding what industry they should be attributed to. On the left is an Acheulean biface (Lower Paleolithic), and on the right is a bifacial knife (Middle Paleolithic of Central Europe). These technologies overlap in some regions of France and this has generated confusion because it was not realized they were from separate traditions. These technologies have been used to argue that the Acheulean only appears in the west and that the "real" Micoquian people migrated to the West during the Middle Paleolithic. 1: "Micoquian" biface from Mantes (Yvelines, France), Upper Acheulean (after Bordes 1961); 2: bifacial knife-scraper from Vinneuf (Yonne, France) (after Gouédo 1999).

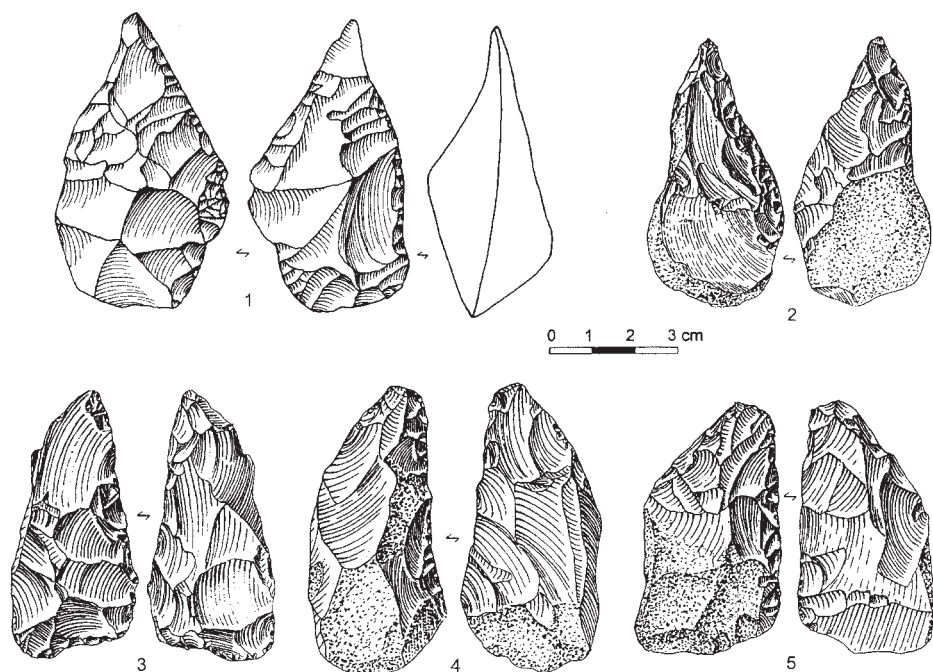


Figure 9.3 The unity of the Middle Paleolithic "Micoquian" is obvious, despite the vast geographical range of the industry. From La Micoque to Central Germany, assemblages show stylistic features which are clearly not the result of any convergence process or "Acheulean" tradition. Backed Micoquian knives; 1: La Micoque, France (after Ottevangner 1997); 2-5: Bockstein IIIa, Germany (after Wetzel & Bosinski 1969).

of Asia and in northern Europe, different technologies derived from earlier traditions (Tayacian, Taubachian) are found instead. A strong African ethnic influence is visible in these bifacial traditions, limited to southwestern Europe during its latest phase and to the Levant and the Caucasus during its early phase (Ubeidiya, Tsona; Lioubine 1989).

The use of the term *Acheulean* has been misapplied as a synonym for the "Lower Paleolithic" of Eastern Europe (Gladinin & Sitlivy 1990). Also, there are instances in which unfinished forms for Mousterian bifacial pieces have been interpreted as evidence for an Acheulean presence in Greece (Gowlett 1999). In Central Asia, elongated Levallois cores, which are, of necessity, "bifacial", have been confused with true Acheulean bifaces (Vishnyatsky 1996:15-18). Acheulean bifaces have been interpreted as evidence for a way of life, a culture, or even a specific population group. However, what they should really be associated with is the African continent (Otte 2000a).

Micoquian

The term *Micoquian* has also been used in a misleading manner. In France, following Bordes, this industry is often considered to be Late Acheulean. The site of La Micoque in the Dordogne actually contains Middle Paleolithic assemblages with bifacial retouch above a "Tayacian" level without bifaces, something that is completely foreign to the western Acheulean. Unlike the Acheulean, these assemblages contain tools, often on

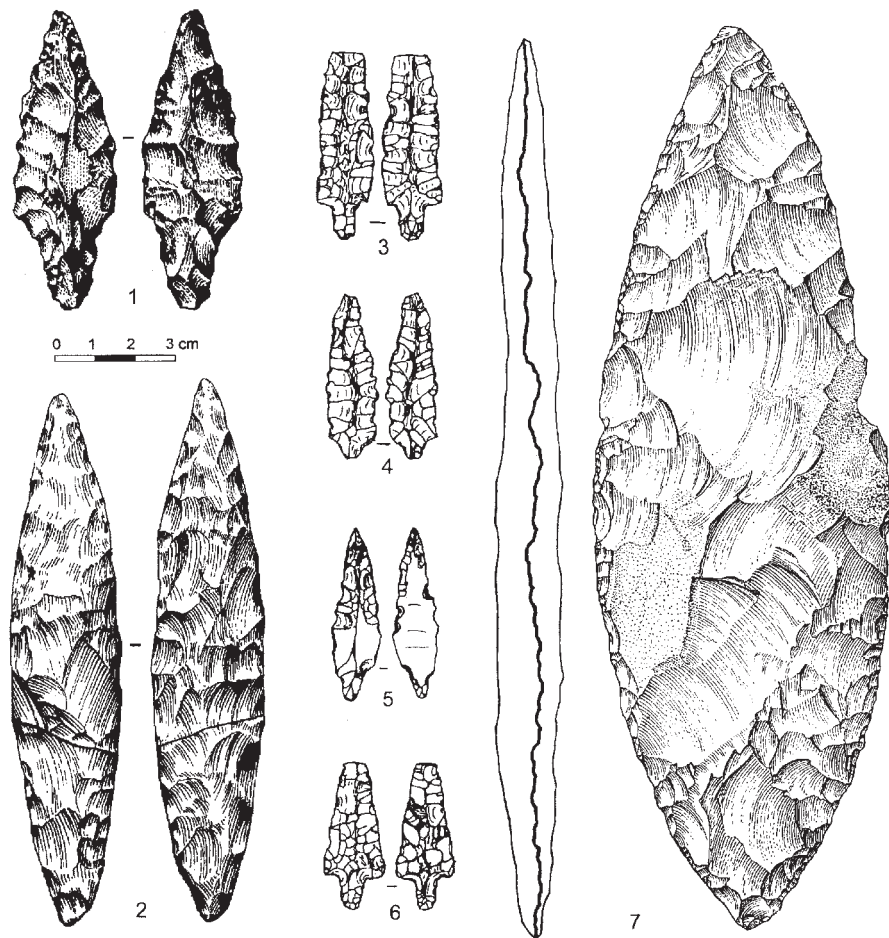


Figure 9.4 Another issue needs to be clarified here: a connection with Africa did exist during the middle Upper Paleolithic, as these Parpallo points (3-6) prove when compared to ones from nearby northern Morocco (1-2). They show that the same technologies were appearing at the same time on opposite sides of the Mediterranean. The French example (7) is a later development of this industry, only further west! Aterian bifacial pieces: 1: Dar es Soltan, 2: Tiourine, Morocco (after Camps 1974); 3-6: tanged points from Parpallo (Valencia, Spain), Solutrean (after Fullola Pericot 1979); 7: feuille de laurier from Le Fourneau-du-Diable (Dordogne, France), Upper Solutrean (after Smith 1966).

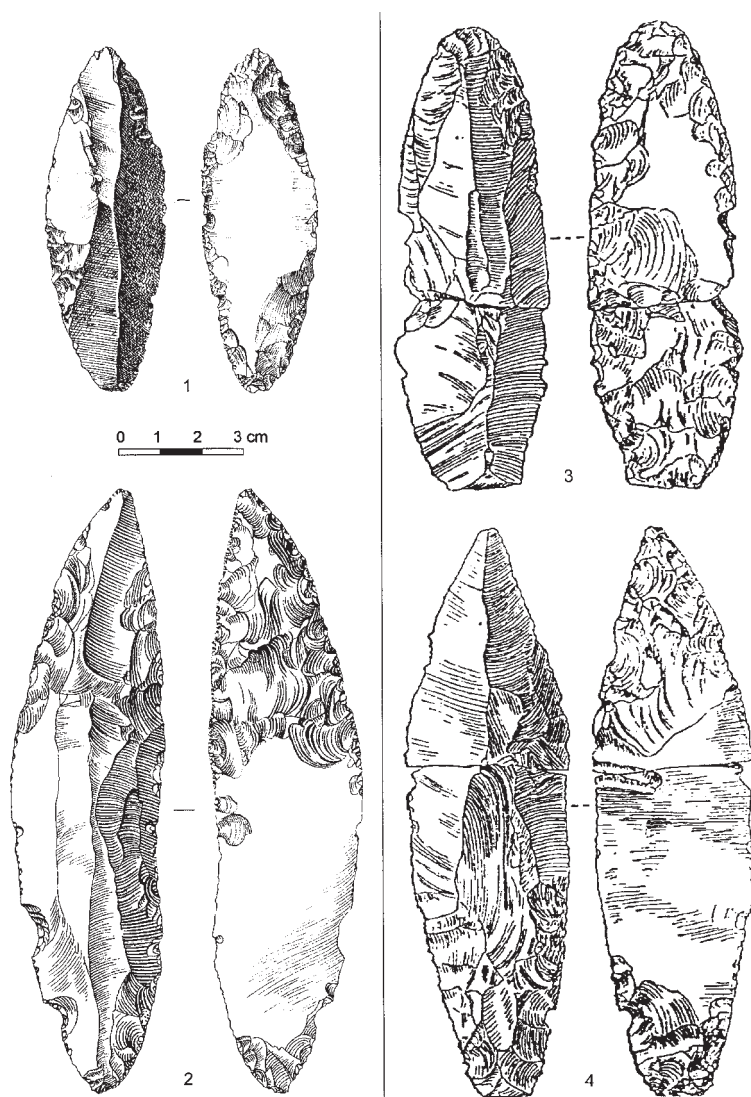


Figure 9.5 Leaf points industries in Northern Europe applied bifacial technology to blades, part of a cultural tradition which developed independently of any outside contact on the very margins of the continent during the Early Upper Paleolithic (around 38,000 BP). Although it has been called "Proto-Solutrean" by some authors, it has nothing in common with what happened 1,000 kilometers to the south and 15,000 years later! 1-2: Ranis 2, Germany (after Hülle 1977); 3-4: Pullborough, Great Britain (after Fox 1949).

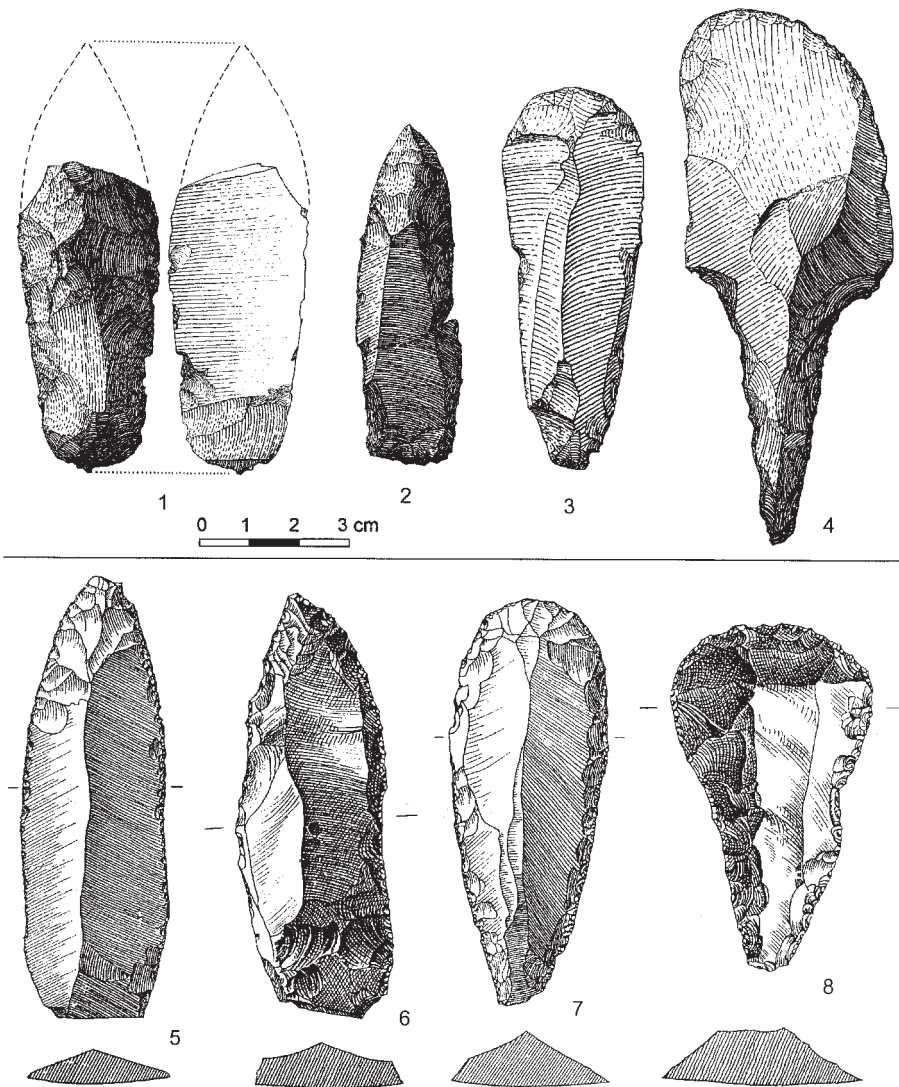


Figure 9.6 Pointed blades and tanged pieces have been found in the northern plains, occasionally using bifacial techniques. This is another "province" where the so-called "Proto-Solutrean" appears to have occurred in spite of a total absence of regional continuity: consequently convergence and migration are possible explanations. Pointed blades (1-2, 5-6), endscrapers on retouched blades (3, 7), tanged tools (4, 8); 1-4: Maisières-Canal, Belgium (after de Heinzelin 1973); 5-6: Ranis 3, Germany (after Hülle 1977).

flakes, with asymmetric profiles and alternate retouch. Also found in Belgium (Ulrix-Closset 1975) and in eastern France (Gouédo 1999), this industry demonstrates the penetration (and thus the migration) of Mousterian traditions proper to Central Europe (Bosinski 1967) into Western Europe.

Because of the ambiguous manner in which the term *Micoquian* is applied, it is used to support two opposing interpretations. It is clear, however, that the ephemeral and geographically limited western Acheulean has absolutely no link with the Mousterian industries with bifacial retouch in Central and Eastern Europe, which are, moreover, much more recent (Otte 2001).

If the term *Micoquian* is to be retained, it should be applied only to the industries of La Micoque, that is to say to the eastern Middle Paleolithic (Ottevanger 1997).

Northern Europe

Foliate point industries were manufactured on blades in Northern Europe at the beginning of the Early Upper Palaeolithic. Kent's Cavern and Pulborough in England, Ranis in Thuringia, Couvin in Belgium, and Jerzmanowice in Poland belong to this "northern movement," which probably grafted onto local Mousterian traditions. These industries are completely unrelated to western traditions, such as the Solutrean, and both sets of traditions developed products with similar forms as a result of convergence only. The current interpretation is to see the origin of the local Gravettian as coming from the foliate point industries, principally through Belgian Maisières type intermediate assemblages (Otte 2000b).

Solutrean and Aterian

During the development of the western Solutrean, a Gravettian component appeared, particularly in the early phase represented in France: the Proto-Solutrean and Early Solutrean. However, a clear break—geographical, technological, and chronological—appears during the course of this development. The purported "Middle" Solutrean is earlier in Spain than in France (Jordá Cerdá & Fortea Pérez 1976), which provides evidence for a southern influence. Additional evidence comes from the bifacial retouch that is found on foliate points. These tools are identical to those found in the Late Aterian of northern Morocco (Howe & Movius 1947), which comes just before the arid phase during which the Ibero-Maurusian first made its appearance. An African influence is clearly evident once again, just as it was in the case of the Acheulean (Otte 1997).

Regardless of how large a role convergence may have played in the development of these industries, a role that was rejected by Bordes, "cultural markers" permeate each technique in a manner more fundamental than do their technological similarities. It is clear that Acheulean, Solutrean, Micoquian, and northern foliate points all used the same processes in reducing the volume of these pieces. Each industry did so according to schemas so specific that it is impossible to confuse these traditions with each other, no more than one could confuse a bifacial point from the Bronze Age with a Clovis point, even though they share the same general "technological tendencies" (Leroi-Gourhan 1964).

References

Bordes, F.

1961 *Typologie du Paléolithique Ancien et Moyen*. Bordeaux: Delmas.

1968 *Le Paléolithique dans le Monde*. Paris: Hachette.

1984 *Leçons sur le Paléolithique*. Tome III : *Le Paléolithique hors d'Europe*. Paris: CNRS (Cahiers du Quaternaire 7).

Bosinski, G.

1967 *Die Mittelpaläolithischen Funde im Westlichen Mitteleuropa*. Köln-Graz: Böhlau Verlag (Fundamenta A 4).

Briois, F.

1991 Aspects Technologiques de la Taille du Silex en Plaquettes de Salinelles (Gard). In *25 ans D'études Technologiques en Préhistoire. Bilan et Perspectives*. Pp 357-365. Juan-les-Pins,:APCDA.

Camps, G.

1974 *Les Civilisations Préhistoriques de l'Afrique du Nord et du Sahara*. Paris: Doin.

Fox, C.

1949 Anniversary Address. *The Antiquaries Journal* 29(3-4): 192-93.

Freund, G.

1952 *Die Blattspitzen des Paläolithikums in Europa*. Bonn: Quartär-Bibliothek 1.

Fullola Pericot, J. M.

1979 *Las Industrias Líticas del Paleolítico Superior Iberico*. Valencia: Servicio de Investigacion Prehistorica (Serie de Trabajos varios 60).

Gladinin, V., and V. Sitlivy

1990 *The Acheulean in Central Europe*. Kiev: Naykova Doumka (in Russian).

Gouédo, J.-M.

1999 Le Technocomplexe Micoquien en Europe de L'ouest et Centrale; Exemples de Trois Gisements du sud-est du Bassin Parisien, Vinneuf et Champlost (Yonne), Verrières-le-Buisson (Essonne).Thèse de Doctorat, Université des Sciences et Technologies de Lille.

Gowlett, J. A. J.

1999 The Lower and Middle Palaeolithic, Transition Problems and Homind Species: Greece in Broader Perspective. In *The Palaeolithic Archaeology of Greece and Adjacent Areas*. G. N. Bailey, E. Adam, E. Panagopoulou, C. Perlès, and K. Zachos, eds. London: British School at Athens Studies.

Heinzelin, J. de

- 1973 *L'industrie du Site Paléolithique de Maisières-Canal*. Brussels: Institut royal des Sciences naturelles de Belgique (Mémoire 171).

Howe, B., and H. L. Movius, Jr.

- 1947 *A Stone Age Cave Site in Tangier: Preliminary Report on the Excavations at the Mugharet El Aliya, or High Cave, in Tangier*. Cambridge, MA: Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University 28(1).

Hülle, W. M.

- 1977 *Die Ilsenhöhle unter Burg Ranis / Thüringen. Eine paläolithische Jägerstation*. Stuttgart: Gustav Fischer Verlag.

Jordá Cerdá, F., and J. Fortea Pérez

- 1976 El Paleolítico Superior y Epipaleolítico Mediterráneo Español en el Cuadro del Mediterráneo Occidental. In *Chronologie et Synchronisme dans la Préhistoire Circum-Méditerranéenne, Colloquium II, IXth U.I.S.P.P. Congress (Nice, 1976)*. Pp. 99-127.

Leroi-Gourhan, A.

- 1964 *Le Geste et la Parole 2*. Paris: Albin Michel.

Lioubine, V.

- 1989 Paleolit Kavkaza. In *Paleolit Kavkaza i Severnoï Azii*. Leningrad: Academy of Sciences, pp. 9-142.

Otte, M.

- 1997 Contacts Trans-Méditerranéens au Paléolithique. In *El Món Mediterrani Després Del Pleniglacial (18.000-12.000 BP), Proceedings of the Colloquium in Banyoles (18-20 May 1995)*. J. M. Fullola and N. Soler, eds. Pp. 29-39. Girona: Museu d'Arqueologia de Catalunya, Sèrie monographica 17.
- 2000a L'Acheuléen comme Population. In *Toward Modern Humans: Yabrudian and Micoquian, 400-50 K Years Ago*. A. Ronen and M. Weinstein-Evron, eds. Oxford: British Archaeological Reports.
- 2000b Le Style Gravettien de Huccorgne. In *La Station de l'Hermitage à Huccorgne. Un habitat à la frontière septentrionale du monde gravettien*. L. G. Straus, M. Otte, and P. Haesaerts, eds. Pp. 197-202. Liège: ERAUL 94.

Otte, M. Le Micoquien et al.

- 2001 Le Micoquien et ses dérivés. In *Les Industries à Outils Bifaciaux du Paléolithique Moyen d'Europe Occidentale*. D. Cliquet, ed. Pp. 173-177. Actes de la table-ronde internationale organisée a Caen (Basse-Normandie-France), 14-15 October 1999, Liège: ERAUL.

Ottevanger, G

1997 *L'Industrie Lithique de la Micoque dans les Collections du Rei? Museum de Mannheim*. Mémoire de licence non publié, Université de Liège.

Smith, P. E. L.

1966 *Le Solutréen en France*. Bordeaux: Delmas.

Ulrix-Closset, M.

1975 *Le Paléolithique Moyen Dans le Bassin Mosan en Belgique*. Wetteren: Universa.

Vishnyatsky, L. B.

1996 *The Paleolithic of Central Asia and Kazakhstan*. St Petersburg: Evropeiskiy Dom (in Russian).

Wetzel, R. and G. Bosinski

1969 *Die Bocksteinschmiede im Lonetal* (Markung Rammingen, Kreis Ulm), 2. Stuttgart, Verlag Müller & Gräff (Veröffentlichungen des Staatlichen Amtes für Denkmalpflege Stuttgart, Reihe A, Heft 15).

Xie, G.

1999 A Discussion on the Handaxes from Bose. In *Abstracts of the International Symposium on Palaeoanthropology*, 12–16 October 1999, Beijing.



10

DEFORMATION MODELING: A METHODOLOGY FOR THE ANALYSIS OF HANDAXE MORPHOLOGY AND VARIABILITY

April Nowell, Kyoungju Park, Dimitris Metaxas, Jinah Park

A sophistication and proliferation in the number of studies focused on the evolution of human cognition have been witnessed in the last decade (Renfrew and Zubrow 1994; Nowell 2001; Donald 1991; Noble and Davidson 1993, 1996; Mithen 1996; Wynn 1998). As Paleolithic archaeologists, we naturally turn to stone tools to answer questions concerning the origins of language and symboling and the emergence of the modern mind. Not because, as some might think, this is all we have but rather because of the nature of lithic material. Because of their durability, lithic artifacts have at least a 2.5 million-year history and an immense geographic distribution (Barton 1990). These facts promote regional and temporal comparisons. Their abundance makes them amenable to statistical testing. In fact, the archaeological record is arguably far more complete than the paleontological record (Wynn n.d.). More importantly, lithics are the direct product of hominid behavior and thus may be able to provide archaeologists with information about technological and subsistence strategies, cultural differences and, possibly, even cognitive differences among our hominid ancestors.

Nowhere is the possible link between cognition and lithics made more explicit than in the case of handaxes. This is because of the general “notion that handaxe shape is an arbitrary imposition of form, on varied raw material, that reflects shared mental templates” (McPherron 2000:655). This suggests that “if this is so, then changes in handaxe shape through time may speak directly to evolving mental capacities” (McPherron 2000:655; see also McPherron 1994; Rolland 1986; Schlinger 1996:232). According to Jelinek (1977), Acheulian handaxes were the first “fully conceived implements whose final form is regularly patterned and in no way suggested by the shape or exterior texture of stone from which they were made.” This suggests that Acheulian hominids were able to conceive of a type. For many researchers, then, the handaxe is taken as the first evidence of a symbolic mental template¹ (e.g., Gowlett 1984, 1986, 1996).

¹ The term “mental template” is being used here in the conventional sense of the word—namely that it is a preconceived idea in the mind of the knapper of the exact type and shape of tool that he or she desires to knap. In other words, it is suggested by some that handaxe morphology is the direct result of a specific idea in the mind of the knapper of what that tool should look like.

In particular, archaeologists interested in the relationship between the evolving human mind and lithics (including handaxes) have focused on the variables of standardization and symmetry. These studies are based on a number of assumptions. First, it is believed that etic tool types can be identified in the archaeological record. Second, some assemblages are seen as more standardized and as having a higher frequency of symmetrical tools than others. Third, it is considered reasonable to link increasing standardization and symmetry in lithics to increasing intelligence, the use of symbols, and the appearance of language. Finally, it is held that archaeologists can, therefore, trace the origin and evolution of the human mind by documenting changes in standardization and symmetry in stone tools over time.

The identification of these variables in lithics (including handaxes) has led some researchers to infer information processing capabilities (Parker and Milbrath 1993; Roche 1993 as cited in Wynn 1995), an aesthetic sense (Edwards 1978; Schick and Toth 1993), mathematics (Gowlett 1984:183-186, 1996), complex procedural templates (Gowlett 1996; see also Mithen 1996:119), symboling and linguistic ability (Guilmet 1977; Holloway 1981; Deacon 1989:560; see also discussion in Noble and Davidson 2001), effortless reflexivity (Byers 1994), spatial cognition (Wynn 1989; Crompton and Gowlett 1993) and even modern human intelligence (e.g., Wynn 1991:203). However, in our haste to extend the boundaries of traditional archaeological inquiry, we have leap-frogged a crucial methodological step in many cases. Before we can even begin to discuss the implications of standardization and symmetry in lithics and to explore whether it is valid to link them to cognition, symboling, and language (Nowell 2000), we have to determine what variables are influencing the shapes that we study. Some of the issues involved in studying standardization and symmetry are discussed. An alternative method for analyzing handaxe morphology and variability is presented.

Standardization

Standardization and symmetry involve the imposition of form. In other words, an artifact's shape is the result of substantial human modification and is no longer strictly dictated by the shape of the blank from which it is made (Mellars 1989:347). In highly standardized assemblages, there is little or no morphological continuity between tool types. Standardization as a concept implies that tools are produced according to a model in the mind of the knapper—that there is some adherence to a particular set of linguistically based rules. However, it is far from clear that tool types in the Paleolithic are the products of symbolic mental templates (e.g. Dibble 1989; McPherron 2000; Davidson and Noble 1993; White 1995). Although we are not suggesting that early hominid knappers randomly removed flakes without any thought involved as even non-human primates achieve a surprising degree of standardization with termiting sticks (e.g., Sabater-Pi 1974), we are arguing that standardization and symmetry can be the result of one or several factors operating in the absence of symboling and language.

Following Sackett (1986, 1990), Chase (1991) identifies three separate levels of standardization that are often confounded. We would argue that these three levels apply to symmetry as well. The first level is symbolic. It is this category that we typically think of when we hear the words *standardization* and *symmetry*. It is at this level that stone tools truly are the product of symbolic mental templates—that there is a relationship created in the mind of the knapper between the concept of a type and the resultant tool. The term *symbolic* is employed to describe this relationship because we are referring to

arbitrary, non-iconic categories. Therefore, only artifacts that are the result of symbolic standardization can be used to study linguistic categories.

The second level of standardization and symmetry is imposed. Artifacts at this level are the result of traditions. Chase (1991) suggests that regional differences unrelated to the environment in chimpanzee termite, nest building, and the use of stone are examples of this level. Because this type of information can be transmitted through observation and imitation alone, there is no *a priori* reason to believe that language is involved. There is nothing symbolic at this level; there is no intent to communicate information. The key methodological issue for Chase (1991) is whether we can discern symbolic from imposed standardization in the archaeological record.

The most basic level of standardization is coincidental. It is at this level that variables such as raw material, blank morphology and selection, tool function, reduction, technology, and the imposition of typology drive the shapes that we see. If we do not isolate the effects of "coincidental" factors before turning to these other levels for our interpretations, we run the risk of reconstructing hominid capabilities in ways that are not meaningful behaviorally. Nowell (2000) presents a full discussion of the effects of coincidental factors. In this chapter, two examples of coincidental standardization using typology and reduction are briefly considered.

Typological Classes

One of the most insidious examples of coincidental standardization is the imposition of our own typological classes. Typologies are indispensable in that they condense information, provide archaeologists with a common framework for analysis, and often are the basis for dating a site. At the same time, they condition what we see. Using typology as an overlay on assemblage variability largely predetermines the number of types that will be recognized (see discussion in White 1982) and the degree of standardization to which those types conform.

One example of the effects of typology can be taken from a recently published study on stone tools and the mind (Gowlett 1996). Two graphs were used to demonstrate how handaxes produced at a particular site were more highly standardized than the flakes manufactured at this same site. However, it becomes clear that the degree of variability inherent in a type depends greatly on what pieces are included in the analysis.

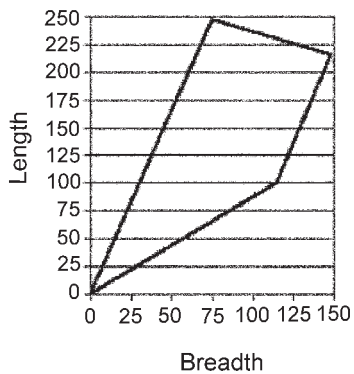
Simply by omitting artifacts that are 1.5 times as long as they are wide—what we would refer to as blades—in one graph (Figure 10.1) and adding artifacts that are roughly equal in length and breadth, namely cores, to the other graph (Figure 10.2), the pattern of variability is reversed.

Raw Material and Reduction

Reduction is another factor in coincidental standardization. When the morphology of a metal artifact is no longer desirable, it can be melted down and recast. The same cannot be said for lithic artifacts that carry the history of their use-lives with them. Artifacts in the archaeological record represent only the final forms of tools and the last uses to which they were put and not necessarily desired endproducts (Noble and Davidson 1993). Furthermore, location, nodule size, texture, thickness, and composition of raw material will determine not only the maximum dimensions of a tool and its discard length but also the amount and frequency a tool can be and needs to be resharpened. These properties of our material can complicate issues for archaeologists studying standardization.

A.

Flake Variability



B.

Biface Variability

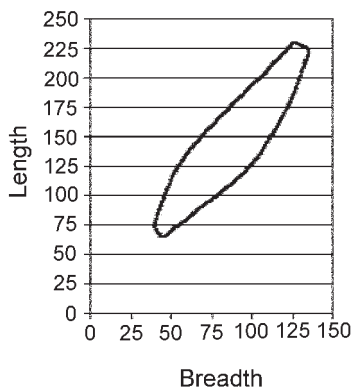
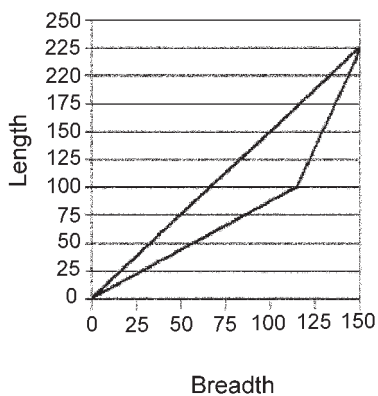


Figure 10.1 Comparison of variability between (A) flakes and (B) bifaces (after Gowlett 1996).

A.

Biface Variability



B.

Biface Variability

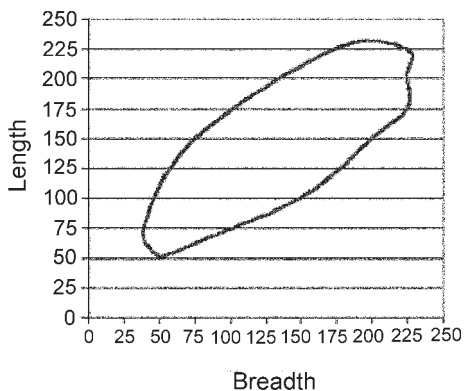


Figure 10.2 Patterns of variability reversed in (A) flakes and (B) bifaces.

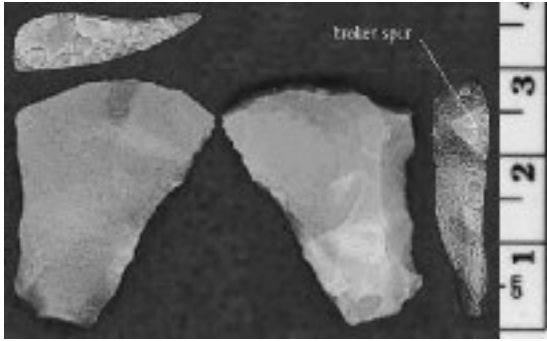


Figure 10.3

produced, these endscrapers begin their lives as flake knives and are manufactured with such a degree of variation that they are not even classifiable as endscrapers at this stage of their use-life (see Figure 10.3; Baker 1997).

These tools are resharpened in the shaft as use continues. Due to the constraints of hafting, the variability between these flake tools decreases dramatically until they become recognizable as belonging to this highly standardized class. Experimentation demonstrates that resharpening in the shaft produces a “spur” on one of the endscraper’s lateral margins. This spur is the type’s most diagnostic feature yet it only appears toward the end of the tool’s life cycle (Baker 1997).

In contrast to the Paleoindian endscraper, Paleoindian projectile points begin as symmetrical, highly standardized, and easily recognizable types. Throughout their use-lives, projectile points are broken and refurbished many times (Baker 1997). In this case, resharpening actually functions to increase the variation between types as it produces greater asymmetry about the longitudinal axis at both the base and the tip (Figures 10.3, 10.4A, and 10.4B; Baker 1997)

It can be seen from these brief examples that factors that are independent of hominid symboling and linguistic abilities can affect the morphology of lithic tools, including handaxes. A new method for studying shape and standardization in lithic artifacts that will aid in the isolation of these coincidental factors is presented.

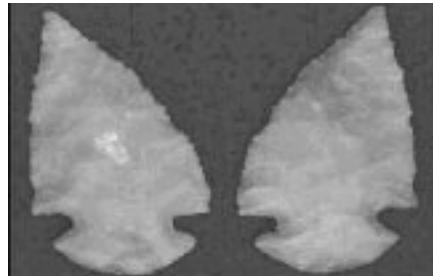
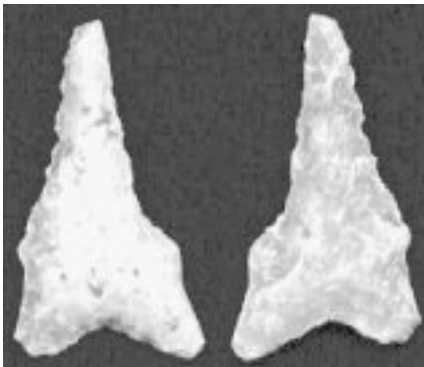


Figure 10.4 Two examples of Paleoindian projectile points. Ventral and dorsal views. In the case of this type of resharpening retouch leads to less standardization.

Deformable Models

In our program, simply called Lithics, a handaxe is scanned into a computer. The perimeter of the piece is outlined in NIH image. Each pixel of the outlined perimeter is then exported as X,Y coordinates into a spreadsheet.

These data are then analyzed using a deformable models-based approach (Metaxas 1996). These kinds of models are used in computer graphics, bioengineering, and robotics among other disciplines. They are often employed in cases in which object recognition is important (e.g., in the design of an ATM that will recognize a cardholder's features, or a robot that can distinguish between the crystalline structures of toxic and non-toxic minerals, or a computer that can compare a "normal" brain to an "abnormal" brain and outline the differences). In all of these cases, the goal is to compare objects present in the real world with a model or template located within the computer. The same kinds of questions are asked, as follows: how similar is the object to the model, on what basis is this similarity being judged, and what constitutes "enough difference" to classify the object as something other than the template? This type of technology is, therefore, appropriate for a study of standardization, be it of brains or stone tools.

A deformable model is based on the following principals. A deformable object or body experiences two types of motion—rigid body motion and non-rigid body motion. If p represents the points on a body at an initial point in time and p' represents these points after experiencing some deformation (M), the following equation is generated:

$$p' = M(p)$$

In the case of rigid body motion, p and p' are the same in the local coordinate frame—the distance between any two points on the body is not altered. By contrast, with non-rigid body motion, the shape of the object is deformed and the distance between any two points is affected accordingly. In this case "the operation M will modify the coordinates of the points in space. We can apply M either globally based on parameters, or locally without imposing constraints" (Park 1996:16; see also Metaxas 1996).

Parameter Fitting

The model employed here is a particular class of ellipse-based deformation model known as the "deformable model with parameter functions" or DMPF (Park 1996) and it involves parameter based discrimination of bodies. After a series of pilot tests it was determined that an ellipse could be adequately deformed to define the contour of flakes, bifaces, and retouched tools. Specifically, a template, in the form of a circle is created. This basic template is scaled and then deformed based on four parameters (see Figure 10.5): length at X-axis ($A1$); length at Y-axis ($A2$); tapering at proximal end (base); and tapering at distal end of tool (tip).

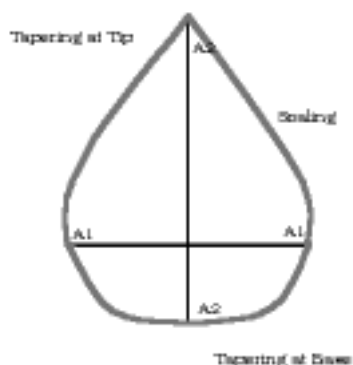


Figure 10.5

These parameters are largely derived from Bordes' metrical basis for biface classification (Debénath and Dibble 1994). Measurements of thickness are not considered here as the program considers handaxes in two dimensions only. Although it would be preferable to study handaxes three dimensionally, it is valid to study them in two dimensions as the majority of handaxe variability can be accounted for by length and width dimensions only (see discussion in Gowlett 1996; see also Bisson, 2000:8).

When the data points are first read into the program, a scaling parameter is applied to the X and Y coordinates of the points taken from each biface perimeter in order to normalize the handaxes. This results in the maximum length of all handaxes being the same. This is a crucial point because when studying standardization it is important to isolate variation due to shape alone. Maximum length (L) is calculated by measuring the distance between all possible sets of two points. The computer then finds the set that is the furthest apart and designates that distance as the "maximum length" and then uses that value to normalize the other points. For example, if the maximum length is found to be between the two points A (x_1, y_1) and B (x_2, y_2), the distance between A and B is the square root of $(x_2 - x_1)^2 + (y_2 - y_1)^2$ and every point is scaled by changing X (x_1, y_1) to $X(x_1/L, y_1/L)$. In other words, every point is scaled by $1/L$. No distortion of shape is introduced by this method.

The next program determines a suitable orientation for the handaxe. Scaling and orientation comprise the initial fitting stage of the program (Figure 10.6). McPherron (1994:77-83) tested five different methods of biface orientation using digitized images of drawings of bifaces in Bordes (1961). Following McPherron, a biface is oriented on a line that passes through its center of mass dividing its edge contour into two symmetrical halves. Center of mass can be located easily using the computer. According to McPherron (1994:80), the symmetry of the halves is evaluated by measuring the distances from the centerline to each edge at a number of intervals along the length at that line. The symmetry is expressed as the sum of the differences in each of these edge measurements. A perfectly symmetrical division of the biface will result in a sum of zero. Because this will seldom be the case, the line of maximum symmetry is the line that results in the lowest sum. Lines yielding a biface orientation with a width greater than the length are discarded in favor of the next best orientation. This method performs quite well with all forms and particularly improves the results of subtriangulars.



Figure 10.6

This line or axis of symmetry is labeled as Z by the program. When the handaxe points are first read into the computer, the X-Y axis is parallel to the program's window frame. During the initial fitting, the Y-axis is aligned with the Z-axis (see Figure 10.6) and the X-axis becomes perpendicular to the Y (and Z)-axis and is located at the position of the maximum width.

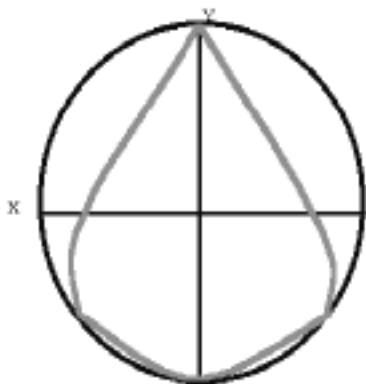


Figure 10.7

Once scaling and orientation of the biface is complete, the object is then compared with the template and the amount of stretching or deformation along the four parameters is calculated. At this point, the amount of tapering at the tip and base and the values for A1 and A2 are determined. The coordinates of each node are (X, Y) , where $X = A1(\theta) \cdot \cos(\theta)$ $(1+t[\theta])$ (t is the tapering parameter) and $Y = A2(\theta) \cdot \sin(\theta)$.

Symmetry values (Figure 10.7) along the X-axis and the Y-axis are also calculated at this stage in the analysis. In order to calculate symmetry, a circular template is created. The handaxe is placed on this template and divided into four quadrants. The template is then deformed to fit the perimeter of the handaxe using tapering at the proximal and distal ends as its parameters. The difference in deformation in each of the quadrants is used to give a general idea of how symmetrical an object is. More precise calculations of symmetry are possible using the local deformation data (see below).

Local Fitting

The next step in the program is to quantify edge contour shape. At this point, the program initiates local fitting (see Figure 10.8). Local deformation discerns how much each point along the parameter differs from the template. Global deformation modeling summarizes basic trends in biface shape, whereas local deformation modeling is much more sensitive to contour variation, generating more detailed information. Employing a method originally developed to model the human heart (see Park 1996), a series of A1 variables (or nodes) are calculated from the base of the handaxe to its tip. The program allows the user to determine the number of nodes to be calculated. For instance, by typing "HANDAXE 5" the computer records the curvature (the change in slope from one A1 to the next A1) every 5 degrees. If "HANDAXE 10" is entered changes in slope are recorded every 10 degrees. The results of the changes in slope are graphed.

Finally, a number of traditional measurements are calculated by the computer (the following terms are defined by Bordes [1961] and by Debénath and Dibble [1994:130]): biface length, which is "the maximum distance parallel to the long axis of symmetry of the piece"; maximum width, which is "measured perpendicularly to the length axis"; distance of the maximum width from the base along the width axis; width at midpoint of the length axis; and width at three quarters of the length from the base. These measurements are found by taking the raw values and multiplying them by the scaling parameter and pixel value (e.g., 72 px/in²). The values for these traditional variables, as well as the deformation modeling variables, are then read into a spreadsheet for each biface.

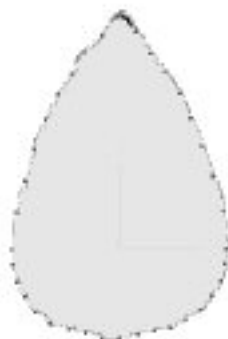


Figure 10.8 (black indicates minute area of discomformity between deformed template and true perimeter).

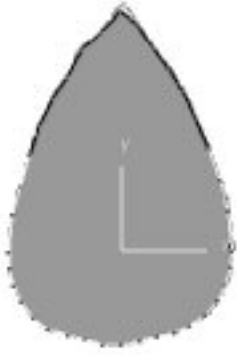


Figure 10.9 (Black is area of retouch)

Retouch

The program considers the effects of retouch on tool shape. Once the fitting is completed, an image of the tool, with areas of retouch indicated, is imported into the program. The fitted model is then superimposed upon the image. Using a mouse, the areas of retouch are selected (see Figure 10.9) and the corresponding coordinates are read into the computer. Because the fitted model has been scaled it is no longer the same size as the image from which it was created. To solve this problem, the model is temporarily

increased or decreased to fit the image and then returned to its original size with the extent of the retouch recorded. The image size must be 320 x 240 pixels/in (width x height). Each area of retouch is considered as a separate case. Comparisons can be made between areas of retouch on the same tool as well as between different tools. Retouch is compared in terms of overall length, location (using the center of the length of retouch), curvature (as measured by the angle created by two lines drawn perpendicular to the beginning and end of the retouch) and the percentage of the side that is retouched.

Graphs

Once parameter and local deformation are completed and, if applicable, areas of retouch considered, the computer generates five graphs. The graphs compare the left and right halves of the tool or flake across several variables. The first two graphs depict the series of A1's and A2's measured for each side of the artifact. The third graph depicts measurements taken from the origin of the graph to the perimeter of the artifact. The exact number of the radii depends on the number of nodes to be measured as defined by the user. The fourth graph illustrates differences in the length of the radii between the artifact's left and right sides along these nodes. Bolded areas of the radius graph correspond to the location and extent of areas of retouch on the artifact. The summary data presented in these four graphs permit a rapid assessment of similarity (i.e., symmetry) between the left and right halves of the artifact. The fifth graph documents the difference in degree of the angle of curvature of the retouched areas. All of the data depicted in the graphs are read into a spreadsheet.

Although there have been previous attempts to characterize shape in handaxes using both traditional measurements (e.g., Barton 1990; Wynn and Tierson 1990) and computer modeling (Saragusti et al. 1998), the methodology presented here allows for the complete description of shape in terms of parameters that provide both local and global measurements of shape variation. In addition, whereas previous studies have tended to focus on shape variation within one tool class only, such as handaxes or scrapers, this modeling program is appropriate for the study of any retouched tool or blank. Furthermore, some earlier studies (e.g., Saragusti et al. 1998) were based solely on measures of symmetry. Finally, it is becoming increasingly difficult to remove artifacts from their country of origin for study. This methodology represents a way of completing or supplementing on-site research. The price of high-quality digital cameras is declining whereas the storage capacity of laptops is spiraling, especially now that CD-ROM writers are becoming standard equipment. Studies employing the methodology presented here are

increasingly practical. The only issue is that the program runs on an SGI computer at the moment. This is standard equipment in most engineering departments but unusual for anthropology departments.

Pilot Studies and Their Results

Nowell (2000, in prep.) presents the application of this methodology to an archaeological collection. However, two pilot studies using geometric shapes were designed to test the program's accuracy and reliability and the results of these studies are presented here. First, five circles of differing diameters (see Figure 10.10) were used to test whether or not the computer analyzed variability due to *shape alone* ($r=2.5$ cm, 5.0 cm, 10.0 cm, 15.0 cm, 20.0 cm). Second, five ellipses of varying shapes (see Figure 10.11) were used to see if the computer would generate results consistent with elongation in either the X or Y axes depending on the case (Tables 10.1–10.4). Let us first consider the circles. The initial template created by the computer is a perfect circle in which A1 east, A1 west, A2 north, and A2 south will be 0.500000 (see Table 10.1). Accordingly, we would expect two results. First, if the computer program is analyzing shape alone then all circles, regardless of diameter, should have identical results across these variables. Second, these results should not vary significantly from the initial template measurements since the five sample circles are by definition perfect circles as well. In Table 10.1, we can see that both of these predictions are borne out.

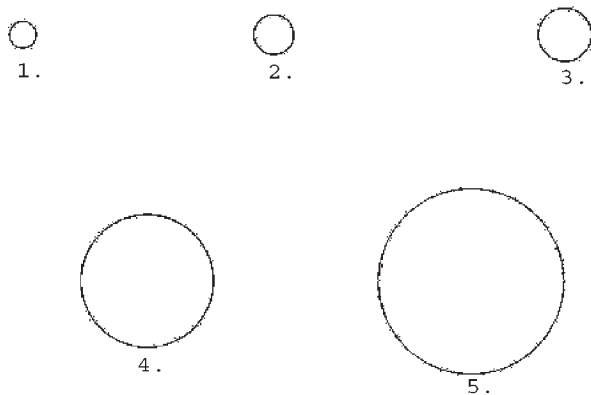


Figure 10.10 Circles used in pilot study. (a) $r=2.5$ cm (b) $r=5.0$ cm (c) $r=10$ cm (d) $r=15.0$ (e) $r=20$ cm.

There are a number of other observations that can be made as well. First, all the circles exhibit the same amount of tapering at the base and tip, which is what we would expect for similar shapes. Second, X-symmetry and Y-symmetry for a perfect circle would each be 1.000000. The sample circles conform to this prediction as well. Third, changes in slope were measured every 10 degrees along each circle and the results are consistent for each circle. Finally, where we would expect the circles to diverge from each other is for measurements of width at midpoint and maximum length (see Table 10.2). Of course, in a perfect circle width at midpoint and maximum length will be identical.

From the ellipse data, the same situation is seen from a different perspective. Each ellipse was drawn so that either the maximum width (ellipse 1–3) or the maximum length (ellipse 4–5) measures 1200 mm depending on the direction of elongation (see Figure 10.11). In this case, we would expect that if the computer is truly analyzing shape

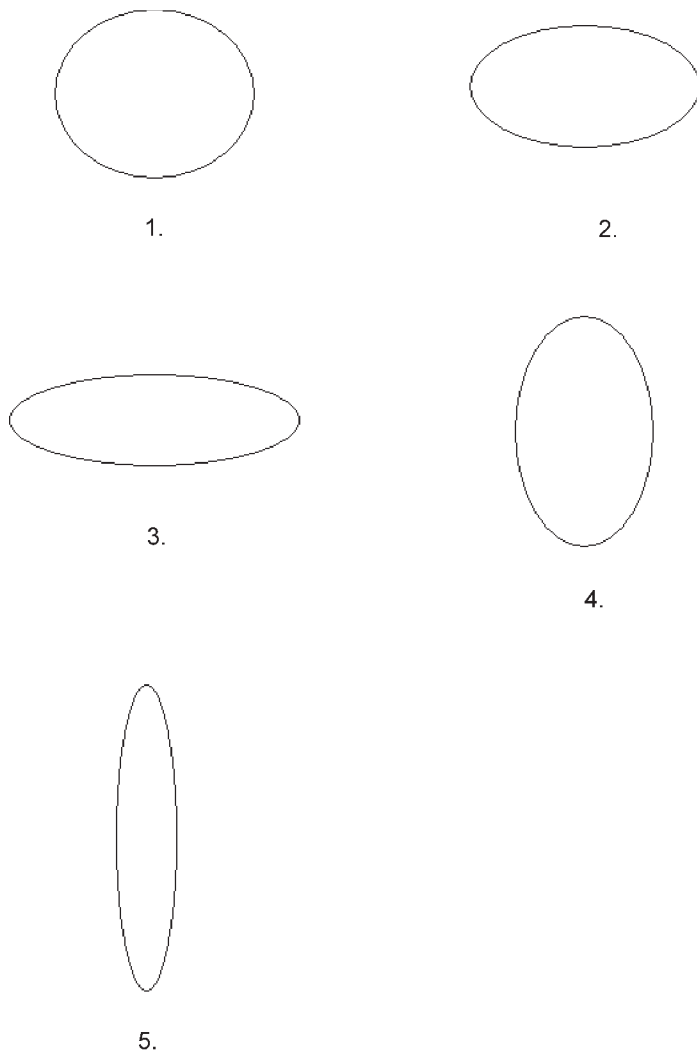


Figure 10.11 Ellipses used in pilot study(ellipses redrawn here, not to scale).

alone then the maximum lengths or widths of the ellipses will be identical (see Table 10.3), whereas the other variables will vary in predictable ways (see Table 10.4). The results conform to this prediction.

First, of the five, ellipse 1 is the most oval shaped. This is reflected in its A1 and A2 variables. They are similar to each other and approach the 0.5 measurement of a perfect circle. Ellipse 2 is more elongated along the X-axis and more compressed along the Y-axis than Ellipse 1. This is clearly reflected in its A1 and A2 variables. Ellipse 3 is the most elongated along the X-axis and the narrowest along the Y-axis of all five ellipses. Again, this is reflected in the A1 and A2 variables. Conversely, ellipses 4 and 5 are elongated in the direction of the Y-axis, with ellipse 5 being the most elongated. The morphology of these shapes is also clearly described by the A1 and A2 variables. Second, ellipses 3 and 5

Table 10.1 Pilot Study Conducted on 5 Circles of Varying Diameters Demonstrates Consistency of Results Across a Number of Variables

	Circle 1 (r=2.5 cm)	Circle 2 (r=5.0 cm)	Circle 3 (r=10.0 cm)	Circle 4 (r=15.0 cm)	Circle 5 (r=20.0 cm)
A1 east	0.50005	0.50005	0.499782	0.50005	0.499782
A1 west	0.50005	0.50005	0.499781	0.50005	0.499781
A2 north	0.507555	0.492349	0.492897	0.49235	0.492894
A2 south	0.492357	0.507563	0.507552	0.507552	0.507555
Taper. (Tip)	-0.00017	-0.00016	-0.00013	-0.00017	-0.00013
Taper. (Base)	0.000115	0.000116	0.000176	0.000114	0.000167
X-Sym	1.000000	1.000000	0.999997	1.000000	0.999998
Y-Sym	0.970058	0.970024	0.971125	0.970029	0.971113

indicates that the computer is analyzing shape only and controlling for size

Table 10.2 Lithics Accurately Calculates Width at Midpoint and Maximum Length for Circles of Different Diameter

	Width At Midpoint	Max. Length
Circle 1	5.000005	4.999995
Circle 2	10.00001	9.999996
Circle 3	19.99999	20
Circle 4	29.99999	29.99999
Circle 5	40	40

Table 10.3 Five Ellipses Standardized for Size

	Ellipse 1	Ellipse 2	Ellipse 3	Ellipse 4	Ellipse 5
Max Width	1199.88	1199.88	1199.88	799.9201	399.9601
Max Length	1000.00	600.00	200.00	1200.00	1200.00

Either maximum length or width was set to 1200 mm depending on the direction of the elongation.

Table 10.4 Results of Ellipse Pilot Data Demonstrate that Even Though the Ellipses Have Been Standardized for Size Because of Their Morphological Differences the Results Along a Number of Variables Differ in Predictable Ways

	Ellipse 1	Ellipse 2	Ellipse 3	Ellipse 4	Ellipse 5
A1 east	0.54343	0.645905	0.748253	0.396866	0.250835
A1 west	0.544279	0.646091	0.748253	0.396792	0.251126
A2 north	0.44747	0.320442	0.125528	0.584097	0.688295
A2 south	0.460557	0.33078	0.129737	0.601398	0.7081
Tapering (Tip)	-0.000083	0.003092	0.002304	-0.00388	-0.02012
Tapering (Base)	0.000375	0.004063	0.002342	0.00018	-0.01816
X- Symmetry	0.998441	0.999712	1	0.999813	0.998843
Y-Symmetry	0.971586	0.968747	0.967553	0.971232	0.97203

are the most elongated along the X-axis and Y-axis, respectively. As a result, the value and direction (either positive or negative) for tapering at the “tip” of each figure is the same as the value for its “base”. Predictably, ellipses 1–3 fall in between. Finally, the ellipses are perfectly symmetrical figures in the direction of both the X and Y axes. This is reflected in the X- and Y-symmetry scores that are at, or near, 1.0 for each figure.

Conclusion

Many researchers have effectively argued that standardization and symmetry are relevant to the study of human behavioral and cognitive evolution. A method for studying these variables in lithics was presented and the results of two pilot studies were discussed. However, it was argued that in many instances symmetry and standardization can be the result of coincidence and not symbolic factors. In our haste to establish an “archaeology of mind” we must be mindful not to fall prey to methodological traps of our own making. If we can explain standardization and symmetry in lithics through raw material, blank morphology and selection, tool function, reduction, technology and the imposition of typology (Nowell 2000), then we have no *a priori* reason for turning to higher levels of inference. At the very least, we need to eliminate these factors as explanations before we use stone tools to draw conclusions concerning hominid cognitive abilities. Otherwise, we run the risk of uncovering symbols of our own creation in the behavioral record of our hominid ancestors.

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References

Baker, T.

1996 <http://www.ele.net/refurbish/rfrbinfo.htm>

1997 <http://www.ele.net/pes/pesintro.htm>

Barton, M. C.

1990 Beyond Style and Function: A View from the Middle Paleolithic. *American Anthropologist* 92:57–73.

Bisson, M. S.

2000 Nineteenth Century Tools for Twenty-First Century Archaeology? *Journal of Archaeological Method and Theory* 7(1):1–48.

Bordes, F.

1961 *Typologie du Paleolithique Ancien et Moyen*. Bordeaux: Delmas.

Byers, A. M.

1994 Symboling and the Middle-Upper Paleolithic Transition: A Theoretical and Methodological Critique. *Current Anthropology* 35:369–99.

Chase, P. G.

- 1991 Symbols and Paleolithic Artifacts: Style, Standardization and the Imposition of Arbitrary Form. *Journal of Anthropological Archaeology* 10:193–214.

Crompton, R., and J. Gowlett

- 1993 Allometry and Multidimensional Form in Acheulian Bifaces from Kilombe, Kenya. *Journal of Human Evolution* 25:175–200.

Davidson, I., and N. William

- 1993 Tools and Language in Human Evolution. In *Tools, Language and Cognition in Human Evolution*. K. Gibson and T. Ingold, eds. Pp. 363–88. Cambridge: Cambridge University Press.
- 2001 *The Mind's Eye: Multidisciplinary Perspectives on the Evolution of Human Intelligence*. A. Nowell, ed. Pp. 187–196. Ann Arbor: International Monographs in Prehistory.

Deacon, H. J.

- 1989 Late Pleistocene Paleoecology and Archaeology in the Southern Cape, South Africa. In *The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans*. P. Mellar and C. Stringer, eds. Pp. 547–64. Edinburgh: Edinburgh University Press.

Débenath, A., and H. L. Dibble.

- 1994 *Handbook of Paleolithic Typology*. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Dibble, H. L.

- 1989 The Implications of Stone Tool Types for the Presence of Language during the Lower and Middle Paleolithic. In *The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans*. P. Mellars and C. Stringer, eds. Pp. 415–32. Edinburgh: Edinburgh University Press.

Donald, M.

- 1991 *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*. Cambridge, MA: Harvard University Press.

Edwards, S. W.

- 1978 Nonutilitarian Activities in the Lower Paleolithic: A Look at the Two Kinds of Evidence. *Current Anthropology* 19:135–39.

Gowlett, J. A.

- 1984 Mental Abilities of Early Man: A Look at Some Hard Evidence. In *Hominid Evolution and Community Ecology*. R. Foley, ed. Pp. 167–92. London: Academic Press.
- 1986 Culture and Conceptualization: The Oldowan-Acheulian Gradient. In *Stone Age Prehistory*. G. N. Bailey and P. Callow, eds. Pp. 243–60. Cambridge: Cambridge University Press.

- 1996 Mental Abilities of Early Homo: Elements of Constraint and Choice in Rule Systems. In *Modeling the Early Human Mind*. P. Mellars and K. Gibson, eds. Pp. 191–216. Cambridge: McDonald Institute.
- Guilmet, G.M.
- 1977 The Evolution of Tool-Using and Tool-Making Behavior. *Man* 12:33–47.
- Holloway, R.
- 1981 Culture, Symbols and Human Brain Evolution. *Dialectical Anthropology* 5:287–303.
- McPherron, S. P.
- 1994 A Reduction Model for Variability in Acheulian Biface Morphology. Ph.D. dissertation, University of Pennsylvania.
- 2000 Handaxes as a Measure of Mental Capabilities of Early Hominids. *Journal of Archaeological Science* 27:655–64.
- Mellars, P.
- 1989 Major Issues in the Emergence of Modern Humans. *Current Anthropology* 30:349–85.
- Metaxas, D.
- 1996 *Physics-Based Deformable Models: Applications to Computer Vision, Graphics and Medical Imaging*. The Kluwer International Series in Engineering and Computer Science. Boston: Kluwer.
- Mithen, S.
- 1996 *The Prehistory of the Mind*. London: Thames and Hudson.
- Noble, W., and I. Davidson
- 1996 *Human Evolution, Language and Mind*. Cambridge: Cambridge University Press.
- Nowell, A.
- 2000 The Archaeology of Mind: Standardization and Symmetry in Lithics and Their Implications for the Study of the Evolution of the Human Mind. Ph.D. dissertation, University of Pennsylvania.
- 2001 *In the Mind's Eye: Multidisciplinary Perspectives on the Evolution of Human Intelligence*. Ann Arbor: International Monographs in Prehistory.
- In prep *Deformation Modeling and the Lithic Assemblages of Tabun Cave*.
- Park, J.
- 1996 Model-Based Shape and Motion Analysis: Left Ventricle of a Heart. Ph.D. dissertation, University of Pennsylvania.
- Parker, S., and C. Milbrath
- 1993 Higher Intelligence, Propositional Language and Culture as Adaptations for Planning. In *Tools, Language and Cognition in Human Evolution*. K. Gibson, and T. Ingold, eds. Pp. 314–33. Cambridge: Cambridge University Press.

Renfrew, C., and Z. Renfrew

- 1994 *The Ancient Mind: Elements of Cognitive Archaeology*. Cambridge: Cambridge University Press.

Rolland, N.

- 1986 Recent Findings from La Micoque and Other Sites in South-Western and Mediterranean France: Their Bearing on the 'Tayacian' Problem and Middle Paleolithic Emergence. In *Stone Age Prehistory*. G. N. Bailey and P. Callow, eds. Pp.121-51. Cambridge: Cambridge University Press.

Sackett, J.

- 1986 Approaches to Style in Lithic Archaeology: A General Model. *Journal of Anthropological Archaeology* 1:59-112.
- 1990 Style and Ethnicity in Archaeology: The Case for Isochrestism. In *The Uses of Style in Archaeology*. M. Conkey and C. Hastorf, eds. Pp.32-43. Cambridge: Cambridge University Press.

Saragusti, I., S. O. Katzenelson, and D. Avnir

- 1998 Quantitative Analysis of Archaeological Science. *Journal of Archaeological Science* 25 (8):817-825.

Schick, K., and N. Toth

- 1993 *Making Silent Stones Speak*. New York: Touchstone.

Schlanger, N.

- 1996 *Understanding Levallois: Lithic Technology and Cognitive Archaeology*. Cambridge: Cambridge University Press.

White, M.

- 1995 Raw Materials and Biface Variability in Southern Britain: A Preliminary Examination. *Lithics* 145:1-20.

White, R.

- 1982 Rethinking the Middle/Upper Paleolithic Transition. *Current Anthropology* 23:169-89.

Wynn, T.

- 1989 *The Evolution of Spatial Competence*. Urbana: University of Illinois Press.
- 1991 *Tools, Grammar and the Archaeology of Cognition*. Cambridge: Cambridge University Press.
- 1995 Handaxe Enigmas. *World Archaeology* 27:10-23.
- 1998 Symmetry and the Evolution of the Mind. Paper Presented at the Hang Center For Cognitive Science Workshop on the Evolution of the Mind, Sheffield.

Wynn, T., and F. Tierson

- 1990 Regional Differences in Later Acheulian Handaxes. *American Anthropologist* 92:73-84.



11

RETHINKING THE ROLE OF BIFACIAL TECHNOLOGY IN PALEOINDIAN ADAPTATIONS ON THE GREAT PLAINS

Douglas B. Bamforth

Paleoindian groups on the Great Plains, and in North America generally, are widely seen as having moved unpredictably within very large areas, and this pattern of land use is thought to have made a sophisticated and flexible biface-based technology advantageous. In this view, bifaces are said to have been designed to serve first as cores and later as preforms to be reduced into finished tools. However, this reconstruction has been assumed rather than demonstrated to be correct, and it conflicts with data from assemblages reported throughout the Plains. Descriptions of these assemblages indicate most Paleoindian tools were made on core-struck rather than biface-struck flakes and that virtually all Paleoindian bifaces were designed for reduction directly into tools. Taphonomic problems suggest that many supposed “tools” made on biface-thinning flakes may have been produced naturally. Analysis of the assemblage from the Allen site, a Paleoindian camp in southwestern Nebraska, provides a more detailed assessment of many of these issues. Overall, the available data indicate that Paleoindian technology is best viewed primarily as a core/flake industry.

Bifacial tools are particularly common in North American Paleoindian assemblages. Technically sophisticated stoneworking like that evident on bifaces from the Fenn and Richey-Roberts caches (Frison 1991; Gramly 1993) or on Folsom age “ultra-thin” bifaces (Root 1994) testifies to the extraordinary skill of many Paleoindian artisans. Drawing on Goodyear’s (1979 [reprinted 1989]) famous arguments, archaeologists view Paleoindians as “high-tech foragers” (Kelly and Todd 1988:239) who produced long-use life, multifunctional implements, including bifaces, that were designed to be recycled from one form to another. Many Paleoindian stone tools are thought to have been manufactured near sources of high-quality raw material and transported, often over very long distances, as essentially finished pieces; bifaces are argued to have been partially reduced for transport and used first as cores and later as blanks for finished knives or projectile points.

This chapter examines the evidence supporting the possibility that Paleoindian bifaces on the Plains were designed for use as both cores and tools (Bamforth [2002] discusses the evidence pertaining to the high-tech forager hypothesis in general). One aspect of this reconstruction is explored—the use of bifaces as both cores and as tools. The high-tech forager hypothesis in general, and the assertions it makes about bifacial technology, tends to be treated uncritically and more or less monolithically, and, as they are used in the literature, it offers us few tools for coping with variability in the archaeological record that does not fit them. Despite the widespread acceptance of this view,

the evidence underlying it tends to be at a high level of abstraction and studies that systematically assess it at the assemblage level are rare. This chapter addresses these issues by exploring the implications of this view for patterning at the assemblage level, by considering published descriptions of post-Clovis (11,000 to 8000 radiocarbon years BP) Plains Paleoindian assemblages, and by examining one such assemblage, from the Allen site in southwestern Nebraska, in some detail.

Cores, Bifaces, and Assemblage-Level Expectations

Although long-distance transport of stone and lateral recycling of finished tools are widely seen as fundamental to Paleoindian technology, the use of bifaces as cores is central to many analyses (Bement 1999; Ingbar 1992; Hofman 1991, 1992; Kelly and Todd 1988; MacDonald 1968). This makes drawing out the implications of such use for analysis is particularly important.

Production of any bifacial tool produces large numbers of waste flakes, some of which are potentially useful. However, casual selection of a minority of the flakes produced while making a tool is not the pattern that is hypothesized for the Paleoindian period: such selection would not distinguish Paleoindian groups from Lower Paleolithic archaic humans at Hoxne in England (Keeley 1980) or from the nearly sedentary late Holocene Chumash of the central California coast (Bamforth 1986, 1991). Instead, the Paleoindian pattern is seen as systematic production of large bifacial cores to provide the bulk of the blanks for tool production, and the subsequent reduction of these cores into smaller bifacial tools.

There are a number of *a priori* objections to such a reconstruction, particularly because core reduction and bifacial tool reduction represent fundamentally different kinds of flaking strategies. The goal of core reduction is to produce useful flakes from a parent nodule of stone; although standardized cores often result from this, standardization is an incidental by-product of the way in which flakes are produced. In contrast, the goal of biface reduction is to shape the parent piece of stone into a particular form; although standardized flakes often result from this, standardization here is an incidental by-product of the strategy needed to shape and thin the biface. A technology in which these contradictory goals are combined as the centerpiece of the pattern of tool production is thus somewhat unexpected, although certainly not impossible (also see Bamforth 1991:230; Lothrop 1989:112-3).

Furthermore, most flakes driven from mid- to late-stage bifacial preforms are small and thin and have extremely acute and fragile edges; most potentially useful biface reduction flakes are removed early in the reduction sequence. Mid- to late-stage biface thinning flakes do indeed have high edge-to-weight ratios (Boldurian 1991; Kelly and Todd 1988). However, they are not well suited for most tasks: they are difficult to hold and manipulate for any but fairly delicate work, their edges cannot sustain use on hard materials, and their use as hand-held implements can be nearly as damaging to the user as to the material being worked. Problems like these do not prevent biface thinning flakes from being used, but they do suggest that such flakes are not likely to serve as the basis for an overall technological strategy. For example, among the Chumash, such flakes seem to have been casual and briefly used adjuncts to a basic technology based on bifaces and core-struck flakes (Bamforth 1991).

Assemblage-Level Expectations

A priori arguments like these, of course, do not replace archaeological evidence, and viewing the high-tech forager argument as a statement about the life histories of Paleoindian artifacts helps to clarify the evidence that is needed to examine it. In this view, Paleoindian bifaces originated in a form that was large enough to produce useable flakes. These flakes were then used for a variety of purposes and, at some point in the reduction continuum, bifaces were shaped into knives or projectile points.

A reconstruction like this is clearly as much about linkages among artifacts as it is about kinds of artifacts, and it can be assessed only by specifically searching for evidence pertaining to both of these. With this in mind, the high-tech forager model of Paleoindian biface use has a number of implications for assemblage patterning (also see Lothrop 1989). For example, use of bifaces first as cores and then as tools should result in high frequencies of tools made on biface-struck flakes and in clear evidence for reduction of bifacial cores into bifacial tools. Bifaces produced at initial reduction sites should be large enough to have served as the cores that produced the blanks used to make non-bifacial tools; non-bifacial cores, as well as debris from the reduction of such cores, should be rare or absent.

Technical Issues

Three general kinds of technical problems complicate any attempt to gather data on these aspects of assemblage patterning: (1) distinguishing between bifacial cores and bifacial tools, (2) identifying the original forms or blanks of heavily retouched tools, and (3) distinguishing between the effects of human use and retouch and natural post-depositional processes.

Standards for distinguishing between bifacial cores and bifacial tools are rarely made explicit (but see Wyckoff 1996), and the possibility that a single object can be both obviously complicates this problem. Ultimately, identifying an object as a core depends on demonstrating that flakes from it were used as tools. However, the distinction above between reduction designed to produce useful flakes and reduction designed to produce a useful tool provides general guidelines that also help to solve this problem.

In general, production of a bifacial tool requires attention to plan-view and cross-sectional symmetry, regularity of edge angles, and carefully and regularly spaced flakes. Cross-sections should be thin relative to their width, and more regular and closely spaced flake scars should be associated with relatively thinner pieces. Particularly in the later stages of reduction, such production produces relatively large numbers of flakes. Considerations like these are always important to successful biface production, but they are particularly critical in production of fluted points (in which the configuration of the fluted surface strongly affects breakage rates) and very thin bifaces. In contrast, bifacial cores should show an overall bifacial pattern of flaking, but should bear large flake scars that do not carefully shape surfaces. Such cores should also show irregular edge angles and configurations, may show striking platforms that are not centered in the midline of the piece, and will often be thick relative to their width and asymmetrical in plan-view and/or cross-section.

The second problem is perhaps more difficult. It is relatively common, particularly in biface reduction, for later stages of flaking to remove all traces of previous stages, and recycling tools from one form into another is likely to have similar effects. In many cases, then, it can be impossible to identify all of the stages in an individual artifact's life histo-

ry. Examining such histories, then, will require information from debitage and systematic analyses of the traces of blanks preserved on tools. When core-struck flake blanks retain their striking platforms, it is often possible to identify the general class of core from which they were removed (cf. Frison and Bradley 1980; Lothrop 1989), and this is particularly critical in addressing the degree to which ancient humans used biface-struck flakes as blanks for tools.

Finally, it is necessary to explicitly address the role played by natural taphonomic processes (e.g., trampling by both humans and animals) in the formation of lithic assemblages. It is very clear that such processes can mimic the results of both tool use and intentional human retouch (Bamforth 1998; McBrearty et al. 1998) and that archaeologists often have difficulty distinguishing human from non-human alterations to stone artifacts (Young and Bamforth 1990). The fragile edges of biface reduction flakes are obviously particularly susceptible to this problem (see, for example, Keeley 1980:165). As I note below, there is some evidence that this problem may affect the available Paleoindian data.

Plains Paleoindian Assemblage Patterning

The variety of bifaces represented in post-Clovis Paleoindian sites on the Plains along with published analyses of the kinds of blanks used for tools are my primary focus. This section emphasizes sites other than large bison kills because, although such kills record an important component of Paleoindian subsistence activity and have dominated most archaeologists' views of the Paleoindian period on the Plains, kill site assemblages are comprised primarily of projectile points and thus provide a particularly incomplete view of overall toolkit patterning. A second section examines the collection from one site, the Allen site, in detail.

Diversity in Paleoindian Bifaces

Bifacial Cores

A variety of bifacial and non-bifacial cores, often including unpatterned or multidirectional cores, are present in Paleoindian assemblages throughout the Plains (Boldurian 1991; Bradley 1982; Frison and Bradley 1980; Knudson 1983; Root 1994; Thurmond 1990), although, as Bamforth and Becker (2000) discuss, cores of any kind are relatively rare.

Bifacial cores fall roughly into two groups. The first of these includes a very small number of very large, thin pieces (i.e., Boldurian 1991:287; Wyckoff 1996). The rarity of these is perhaps best illustrated by the fact that Bamforth and Becker (2000) tabulate 520 cores from 27 published Plains Paleoindian assemblages (238 of these from nine Folsom assemblages), including only those artifacts that could be placed within a clear assemblage context. This total includes no examples of these large bifacial pieces. In fact, no example of this class of cores has been recovered in situ, none can be examined within an overall assemblage context, and none can be dated with any certainty to the Paleoindian period (LeTourneau 2000:164-185); however, one such core, "Frank's biface" from the Mitchell Locality at Blackwater Draw in eastern New Mexico (Stanford and Broilo 1981; Boldurian 1990, 1991), was recovered from the surface of one of the sites in the sample.

Although this class of cores has received substantial attention in the Paleoindian literature, a second group of less technically sophisticated bifacial cores is somewhat more

common in Paleoindian assemblages (i.e., Boldurian 1991:287-91; Davis 1962: 42-3; Knudson 1983: Figures 37 and 38; Root 1994). These latter examples are smaller, show less technically difficult flaking patterns, and have higher width/thickness ratios than the pieces in the first category. Identifying "exhausted" cores can be difficult, but the thinness of the first class of cores (width/thickness ratios in the vicinity of 4.0 to 5.0) and the relatively small size of the artifacts in the second class suggest that all of these were discarded because they were no longer useful.

Other Bifaces

In contrast to the rarity of bifacial cores, bifacial tools and discarded preforms for these tools are extremely common in Paleoindian assemblages. Excluding projectile points, finished bifaces suggest at least three distinct trajectories of production. The largest group of these has lenticular cross-sections, width/thickness ratios of roughly 3.0 to 4.0, pointed tips, and squared or rounded bases (Boldurian and Cotter 1999; Bradley 1982; Frison and Bradley 1980; Davis 1962; Knudson 1983; Root 1994; Wilmsen and Roberts 1984). These are likely to have been used as general-purpose knives. In addition to these, several Folsom sites (Boldurian and Cotter 1999:80-3; Jodry 2000; Root 1994) have produced a small number of ultra-thin bifaces, distinguished by flat rather than lenticular cross-sections and width/thickness ratios ranging from just over 6.0 to nearly 20.0. Jodry (1998) suggests that these may have been specialized women's knives used to cut meat into thin strips for drying.

Unfinished bifaces are much more common than finished pieces. These can sometimes be difficult to place in the context of specific production trajectories because of a likely overlap in size between small preforms for bifacial knives and large preforms for bifacial projectile points. This is particularly true in the case of fluted-point preforms: Boldurian and Hubinsky (1994), following Judge (1973), argue that these are large enough to have been used as hafted knives prior to their final reduction into finished points. Bradley and Frison (1987) argue that Cody points often passed through a long series of reduction steps that began with fairly large bifacial preforms, and Hartwell (1995) identifies bifacial preforms in the Ryan's Site cache from west Texas as unfinished Plainview points.

Eliminating unfinished bifaces with widths below 3.0 to 4.0 centimeters and lengths below 6.0 to 7.0 centimeters as probable projectile point preforms leaves a large sample of artifacts that likely represent unfinished examples of the first class of bifacial knife just noted (Bamforth and Becker [2000] tabulate 1665 of these from 27 Paleoindian assemblages). Similarities between the pre-fluting stages of Folsom point production and the middle stages of bifacial knife production complicate this identification somewhat. In addition to these, Folsom sites regularly produce discarded bifaces that failed during fluted point production (i.e., Boldurian 1991; Bradley 1982; Frison and Bradley 1980; Root 1994; Tunnell 1977). Mid-stage knife preforms can in some cases be difficult to distinguish from mid-stage fluted point preforms. However, both of these items are included in the class of material thought to have been used as cores prior to being reduced to finished tools, minimizing the importance of this problem. Bobtail Wolf has produced a very small number of late-stage preforms for ultrathin bifaces (Root 1994:149), and the modes of edge and platform preparation evident on these artifacts clearly indicate that these represent a production trajectory that is distinct from other bifaces.

Blanks for Bifaces and Other Tools

Analysts do not always identify the kinds of blanks used for tool manufacture. However, with the exception of Bobtail Wolf, studies that have examined this issue uniformly report that Paleoindian bifaces (both projectile points, including fluted points and knives) are made on flakes, and published illustrations of finished and unfinished points and bifaces confirm this in many cases where analysts do not report blank types (Amick 1995; Boldurian and Cotter 1999; Boldurian and Hubinsky 1994; Bradley 1982; Flenniken 1978; Hester 1972; Hughes and Willey 1978; Knudson 1983; Tunnell 1977). It is rarely possible to identify the form of core that these blanks were removed from, but remnant flake scars on four fluted point preforms from Blackwater Draw (Boldurian and Hubinsky 1994) are consistent with use of flake blanks driven from large bifacial cores. Hofman et al. (1990) also identify 13 such flakes in the assemblage from Shifting Sands. At Bobtail Wolf, very thin tabular cobbles and plates of Knife River flint are available locally, and Folsom flintknappers used either these or large flakes for virtually all of their bifaces, apparently including ultra-thin bifaces (Root 1994:148).

Flenniken (1978:474-5) argues from measurements of the Folsom points in the Lindenmeier collection and from experimental replication that the flakes used as blanks for Folsom points should have been twice the size of the finished piece. The dimensions of the Lindenmeier points thus imply blanks approximately 7.0 cm long, 4.0 cm wide, and 0.8 cm thick. Consistent with this estimate, Bradley (1982:Figure 3.2a) identifies a blank at the Agate Basin site approximately 6.0 cm long, 4.0 cm wide, and 0.7 cm thick, and the flakes struck from large bifacial cores at Shifting Sands (Hofman et al. 1990:Table 11.1) are, on average, very close to this size (also see Boldurian 1991). There is also some evidence suggesting that suitable Folsom point preforms fall into a narrow range of thicknesses. Root (1994:173) suggests that the finished ultra-thin bifaces at Bobtail Wolf, with thicknesses averaging roughly 0.6 cm, may have been too thin to flute.

Non-bifacial tools have attracted less detailed attention in the Paleoindian literature. However, the available data indicate that such tools were often, and sometimes predominantly, made on blanks struck from non-bifacial cores. For example, nearly 80% of the tools from the Hanson site and roughly half of the tools at Agate Basin were made on core-struck rather than biface-struck flakes (Bradley 1982:184-5; Frison and Bradley 1980:30). Similarly, Boldurian (1991:292; see Boldurian 1990) argues that "opportunistic reduction of simple percussion cores" produced many of the tools at Blackwater Draw. At Bobtail Wolf, only 30 out of a total of 452 flake-based tools (6.6%) are on flakes struck from bifaces, and bifacial cores make up a small proportion of the total number of cores in the collection (Root 1994:147-8, 179).

This last conclusion is particularly interesting in light of the links proposed between efficient raw material use and reliance on bifacial cores: apparently Folsom-age surface collections from Blackwater Draw include five bifacial cores but no non-bifacial cores, despite the fact that tools made from non-bifacial cores were used and discarded there. Boldurian (1990, 1991) suggests that this results from production of core-struck tools at other sites, but debitage from this site indicates that cores were flaked there, implying that non-bifacial cores passed through Blackwater Draw without being discarded. This possibility is also supported by the common occurrence of core reduction debris in other Paleoindian debitage assemblages in which cores themselves are either rare or absent: such debris often makes up a substantial portion, and sometimes the majority, of these assemblages (Frison and Bradley 1980; Hemmings 1987; Ingbar 1992; Ingbar and Larson 1996; Root 1994).

Table 11.1 Frequencies of Worked Stone at the Allen Site

Artifact Category	Number of Artifacts
Bifaces	114
Points	9
Point Preforms	17
Beveled Tools ^a	18
Cores	19
Edge-Modified Flakes	74
Perforators	3
Other/indeterminate	6
Chunk	1

^a Holder and Wilke (1949) and Bamforth (1991) refer to these as "trapezoidal scrapers."

Note: These frequencies differ from, and supersede, those presented by Bamforth (1991); earlier totals were derived from preliminary analysis of the assemblages.

Summary

There are several clear patterns in these data. Bifacial cores are present in Paleoindian assemblages, but (1) they are by no means the only core form represented, (2) flakes struck from them do not dominate as blanks for tool production, and (3) no artifact from any Paleoindian site anywhere on the Plains has been shown to have been made on an exhausted bifacial core. Instead, such cores occur as discarded pieces recovered with other discarded production waste from habitation or workshop areas. Non-bifacial cores are far more common than bifacial forms and the relatively few systematic studies of Paleoindian debitage uniformly report high frequencies of core-struck flakes. Preforms for bifacial tools seem to have been transported in a form poorly suited for their use as cores, and fluted point preforms in particular were almost certainly too thin to have regularly produced useful flakes.

The flakes that preforms did produce have exactly the kinds of fragile edges that are most likely to accumulate non-use edge damage. It is significant that the classes of "tools" associated with biface thinning flakes—utilized flakes, notches, denticulates, graters, "raclettes" (Boldurian 1990; Bradley 1982; Hofman 1992; Lothrop 1989)—are exactly the forms that are most readily produced by non-use forces like trampling (Bamforth 1998; Debenath and Dibble 1994; McBrearty et al. 1998). The common association of Paleoindian sites with buried soils (i.e., Root and Emerson 1994) implies that Paleoindian-age lithic assemblages were on or very near the ancient ground surface for extended periods of time prior to being buried, making it extremely likely that post-depositional processes like trampling have affected them.

Relatively little of this accords well with the high-tech forager hypothesis. It is important to bear in mind that there are no studies from the Plains that have attempted to test the accuracy of this hypothesis, and therefore that many analyses do not provide the spe-

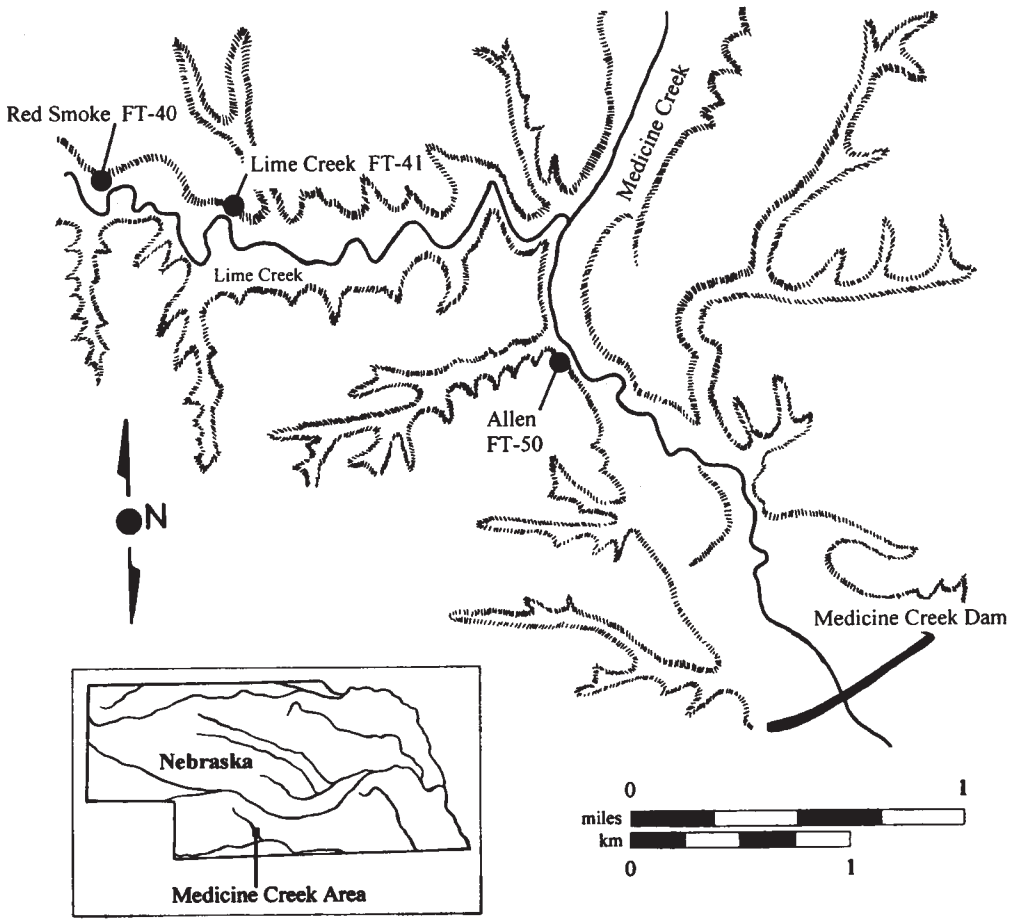


Figure 11.1 Location of the Allen Site and other paleoindian sites in the Medicine Creek Drainage.

cific kinds of information such a test requires. Some of the gaps in the data are likely to be the result of a lack of attention to these issues, and additional work will likely identify patterns that better fit this reconstruction. Even bearing this in mind, though, a number of lines of evidence are strongly discordant with traditional expectations, and additional analyses are unlikely to alter this. Analysis of the assemblage from the Allen site in southwestern Nebraska carried out specifically to examine these issues confirms this conclusion.

The Allen Site

The Allen site is located on the main channel of Medicine Creek, a tributary of the Republican River, near the town of Cambridge, Nebraska (Figure 11.1). It was identified along with several other very deeply buried sites in 1947; three of these sites (Allen, Red Smoke, and Lime Creek) were partially excavated by the Nebraska State Museum between 1948 and 1954 (Davis 1954, 1962; Holder and Wike 1949; Bamforth [n.d.]). A recent program of radiocarbon dating firmly fixes the age of all of the material from Allen, and most of the material from Red Smoke and Lime Creek, to between shortly after 11,000 RCYBP and shortly before 8000 RCYBP.

The Allen site excavations produced some 11,000 unmodified flakes, 259 pieces of worked stone (216 with specific provenience), 12 hammerstones, eight ground stone tools, 76 bone tools (including needles and awls), 3600 identifiable bones, thousands of additional unidentifiable bone fragments, and 20 hearths. Analysis of the flaked stone, the portion of the collection at issue here, incorporated typological and technological analysis of the worked stone (including identification, where possible, of the types of blanks

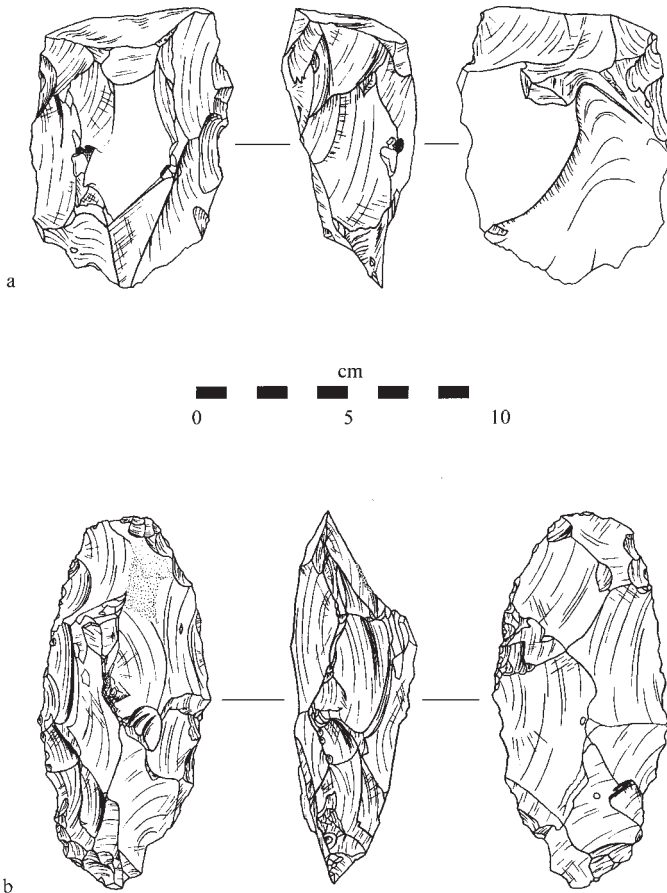


Figure 11.2 Bifacial cores from the Allen site.



Figure 11.3

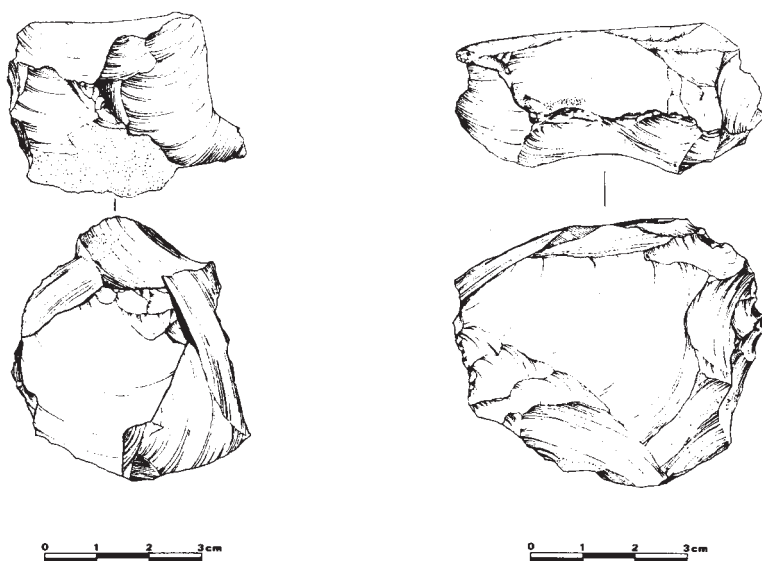


Figure 11.4

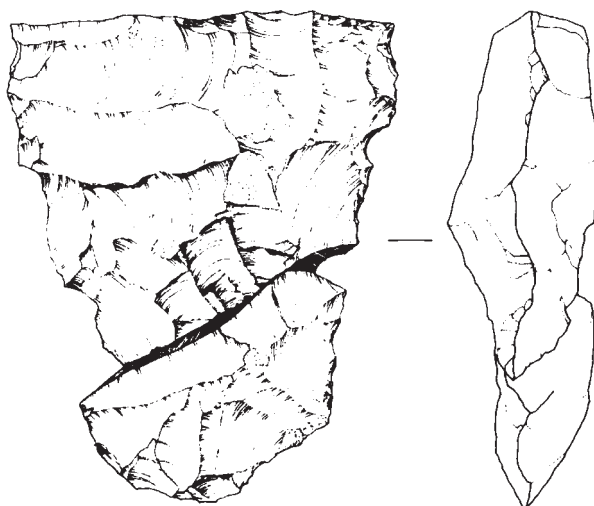
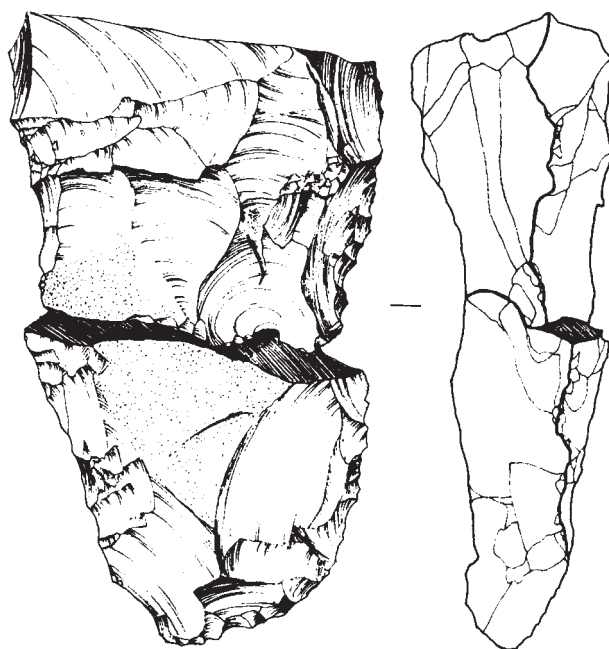


Figure 11.5

on which tools were made), recording of a series of descriptive variables on a sample of the debitage, microwear analysis, and a comprehensive attempt to refit as much of the collection as possible. Although my emphasis here is not on Paleoindian use of raw material, it is important to note that more than 99% of the Allen site lithic assemblage is made from Smoky Hills jasper, a material that outcrops extensively very close to the site.

Allen Site Bifaces

Bifacial Cores (and Other Cores)

The Allen site collection contains one definite and one probable bifacial core (Figure 11.2). One bifacially flaked piece is clearly the exhausted slug of a bifacial core. One face of this piece shows large, opposed scars originating at the lateral edges that formed a fairly flat surface. This surface was then used as the platform for a series of flake removals that resulted in a thick, triangular cross-section; one unsuccessful attempt was made to remove a flake using the point of the triangle opposite the major striking platform as a new platform. A second piece is also probably the end result of a nearly identical pattern of bifacial core reduction, but much of the surface used as the primary striking platform has broken away along a natural fracture in the stone, and its identification is thus somewhat tentative. The strategy used for at least the last rounds of flake removals on both of these pieces—use of a single platform to remove overlapping flakes around the perimeter of the core—is essentially the same as that used in polyhedral core reduction; this is the dominant strategy used for the majority of the cores in the collection.

There are 19 cores in the Allen site collection. They can be divided into a group of eight larger pieces (mean weight 252.9 g) and 11 smaller pieces (mean weight 52.7 g). Although the larger cores (with the exception of the two cores discussed just previously) show a pattern of single platform/polyhedral block core reduction (Figure 11.3), the smaller cores show no clearly defined reduction pattern, and often bear traces of bipolar flaking (Figure 11.4). These two groups of cores also differ in raw material quality: the smaller cores are uniformly made from high-quality stone, whereas most of the larger cores are made from more granular stone.

Other Bifaces

The assemblage includes a total of 114 finished and unfinished bifaces (Figure 11.5). These fall into Stages 1 through 4 in Callahan's (1979) classification, with Stage 4 being the finished tool. Only seven of the 114 fall into Stage 4, suggesting that bifaces may have been reduced on-site to Stage 3 and transported in that form for completion elsewhere. Table 11.1 presents summary data on biface sizes and width/thickness ratios by stage.

Blanks for Bifaces and Other Tools

Unsurprisingly, most tools in the assemblage (94 of 126, or 74.6%) whose original blanks are identifiable are made on flakes; the remainder is made on thin tabular pieces of jasper. Among bifaces, the proportion of tabular blanks is somewhat higher (13 of 30, or 43.3%, of identifiable biface blanks are tabular). Bifaces other than the two bifacial cores are clearly far too small to have served as cores for the retouched tools made on flake blanks: the mean width for retouched pieces in the Allen site collection that were definitely made on flakes is 47.1 mm (SD = 15.5, N = 75), mean length is 58.4 mm (SD = 17.0, N = 56), and mean thickness is 13.7 mm (SD = 7.4, N = 91), and these artifacts are nearly as large as the discarded bifaces in the collection (compare with the values in

Table 11.1, p. 215). Most retouched pieces lack their striking platforms; however, 85% of those with intact platforms were made on core-struck, not biface-struck, blanks.

Refitting, Debitage, and Reduction Strategies

Importantly, despite the frequency of bifaces in the retouched portion of the assemblage, refitting of the Allen site material reveals a very different pattern of production and transport: although the core/biface ratio in the retouched portion of the collection is 0.15, cores outnumber bifaces in refitted reduction sequences from the site by 1.17 to 1. Many more cores passed through the site than were discarded there, making it clear that the groups who inhabited the Allen site transported cores rather than only finished or partially finished tools (Bamforth and Becker [2000] discuss this in detail).

Summary

The Allen site assemblage shows few of the patterns predicted by the traditional view of Paleoindian bifaces. The Paleoindian occupants of the site appear to have manufactured bifaces for reduction directly into finished knives and relied on cores, usually single platform block cores, for the great majority of their non-bifacial tools; they seem to have produced bifacial cores infrequently, and there is no evidence that such cores were ever themselves reduced into tools. The frequency of these tools coupled with the low frequency of cores in the site assemblage fits the pattern that has often been interpreted as evidence for a strategy of segmented production (Ingbar 1994; Lothrop 1989; Nelson 1991), in which tools were produced in one place and transported without cores for use at other locations, minus the cores. However, the refitted sequences indicate that, at least at the Allen site, this is an illusion: cores are rare at Allen not because they were not produced and worked on-site, but because they were not discarded there.

Discussion

The overall patterns in the published data, and the detailed information from the Allen site, do not closely match the assemblage level expectations that the high-tech forager hypothesis implies. Although future work may provide evidence that is more consistent with the high-tech forager model, some of the patterns in the available data are so clear that they are unlikely to be altered substantially by additional work.

The overall data suggest strongly that Paleoindian technology is best described as largely, although certainly not exclusively, a core/flake industry. The evidence supporting this includes the kinds of cores recovered from Paleoindian sites, the regular occurrence of core reduction debris even on sites on which no cores have been found, and very frequent use of core-struck flake blanks for reduction into a wide variety of tools. The refitting data from Allen, showing that many more cores were flaked at the site than were discarded there, suggest that cores are often invisible in Paleoindian sites because many of these sites were occupied for a period of time that was shorter than the useful life of a core. Bamforth and Becker (2000) discuss this in detail, and show that some regions of the Plains appear to produce cores more frequently than other regions, implying that patterns of site occupation (or, perhaps, reoccupation) may have varied substantially across the Plains.

Paleoindian cores that have been recovered take a wide variety of forms. This variety includes bifacial cores, but these are known only as apparently exhausted production

Table 11.2 Mean Dimensions for Stage 2, 3, and 4 Bifaces from the Allen Site (Complete Measurements Only)

	Stage		
	2	3	4
Length			
Mean	63.5	68.1	82.9
SD	18.0	15.3	4.5
N	15	11	2
Width			
Mean	48.8	43.1	40.9
SD	7.9	9.3	10.9
N	23	34	5
Thickness			
Mean	20.0	14.7	11.3
SD	6.0	4.6	4.0
N	43	42	8
L/W Ratio	2.40	2.93	3.62

debris. Bifacial knives were certainly important tools, in the sense that Paleoindian flintknappers often made them, but high frequencies of discarded mid- and late-stage bifacial preforms at many sites suggest strongly that such knives were often reduced at or near raw material sources and transported in finished form, a habit that makes them exceptionally poorly designed as sources of useful flakes. The flakes that were almost universally used as the blanks for Folsom fluted points appear to have been particularly thin (slightly less than 1.0 cm) and thus almost completely unsuitable as cores.

Paleoindians must surely have used fluted point or bifacial knife preforms as occasional *ad hoc* sources of useable flakes. However, this is a very different pattern than the high-tech forager hypothesis proposes. It is almost certain that current inventories of "tools" made on biface thinning flakes include objects, and perhaps many objects, that were modified not by humans but by natural processes. Paleoindian archaeology is not alone in having to cope with this problem (i.e., Debenath and Dibble 1994:101, 104, 112), but serious consideration of its implications for our data is lacking. No one would consider analyzing a Paleoindian faunal assemblage without considering taphonomic problems; Paleoindian lithic assemblages need to be approached with the same considerations in mind.

The Allen site data in particular do not fit well with widely accepted links between reconstructed patterns of tool production and group movements. The occupants of the Allen site clearly transported bifaces and other tools; however, the bifaces appear to have been reduced at the site almost to finished form, and the tiny sample of non-local debitage clearly indicates transport of that material almost entirely as nearly finished bifaces that were too small to serve as cores and that would have been ruined by attempts to do so. The refitting data from the site make it clear that cores were worked but not discarded there, and hence must have been transported. The presence of exhausted but not recycled cores in the collection suggests that, like every other class of flaked stone artifact represented at the Allen site, cores were rarely, if ever, used for multiple purposes (Bamforth [n.d.] discusses the Allen site lithic assemblage in detail).

Conclusions

What, then, is the role of bifacial technology in Paleoindian lifeways? Although the available data are imperfect, this question can be answered from two perspectives. The first is that bifaces from the Allen site and from many, although perhaps not all, other Paleoindian sites were designed primarily for reduction into knives and points and were only incidentally used as cores. That is, bifaces formed an important part of Paleoindian technology, but they were not the centerpieces of that technology.

However, from another perspective, the question is misguided: the data, limited though they are, suggest that bifaces played different roles in Paleoindian lifeways in different times and places. The Allen site pattern persists throughout the entire period of site occupation, but other kinds of bifacial technology are more limited in time or space: ultra-thin bifaces seem to be characteristic only of the Folsom period and it is possible, although currently undocumented, that large bifacial cores were more characteristic of Folsom rather than of later Paleoindian occupations. Although the focus here is on Folsom and later Paleoindian assemblages, it is worth noting that occasional discoveries of Clovis-age caches of large, very well-made bifaces along with fluted points that are too large to have been functional suggest that some bifacial technology may have to be understood in symbolic or social rather than utilitarian terms. Gratuitously high levels of flintknapping skill thus may be more characteristic of the earlier (fluted point) than the later portions of the Paleoindian period.

Paleoindian flaked stone technology in North America is clearly distinctive in at least some ways from flaked stone technology in other times and places. Despite this, though, considering technological patterning systematically at the level of whole site assemblages rather than concentrating on a limited portion of the inventory of Paleoindian material culture suggests two points. First, the widespread view of Paleoindian technological organization is inconsistent with important bodies of data, particularly with data derived from debitage, a class of material that is widely neglected in Paleoindian lithic analysis, and from systematic refitting, which is rare in North American lithic analysis in general. Refitting at the Allen site shows especially clearly that the inventory of artifacts discarded at a site cannot automatically be assumed to provide a picture of the inventory and organization of artifacts used at that site; this assumption is fundamental to Paleoindian archaeology and, indeed, to virtually all archaeology. If we cannot refit in all cases, and clearly we cannot, at least we can more thoroughly analyze collections of debitage in search of contrasts between the technological patterns they indicate and the patterns suggested by the retouched pieces that so dominate our research. Second, the widespread emphasis of research on the most spectacular of these retouched pieces, particularly projectile points and the extremely rare and exceptionally large or thin bifaces, and not on the more mundane majority of Paleoindian tools, obscures the overall character of Paleoindian technological organization, which in many ways is not dramatically different from the organization of many later stone technologies. A focus on systematic analysis of whole assemblages will provide us with a more detailed, and more accurate, picture of Paleoindian lifeways. As patterns of geographic and temporal variation within the Paleoindian period become more widely recognized, such analysis will better prepare us to make sense out of them.

Acknowledgments

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References

Amick, D.

- 1995 Patterns of Technological Variation Among Folsom and Midland Projectile Points in the American Southwest. *Plains Anthropologist* 40:23–38.

Bamforth, D.B.

- 1986 Technological Efficiency and Tool Curation. *American Antiquity* 51:38–50.
 1991 Technological Organization and Hunter/Gatherer Mobility: A California Example. *American Antiquity* 56:216–34.
 1998 *Test Excavations at 5GA872, the Windy Ridge Quartzite Quarry*. Report Submitted to the USDA Forest Service, Routt National Forest, Steamboat Springs, CO.
 2002 High-Tech Foragers? Folsom and Later Paleoindian Technology on the Great Plains. *Journal of World Prehistory* 16:55–98.
 n.d.a. The Paleoindian Occupation of the Medicine Creek Drainage, Southwestern Nebraska. In *Seventy Years of Archaeology at Medicine Creek*. D. Roper, ed. Tuscaloosa: University of Alabama Press, in press.
 n.d.b. *The Allen Site: A Paleoindian Camp in Southwestern Nebraska*. In preparation.

Bamforth, D.B., and Becker, M.

- 2000 Core/Biface Ratios, Mobility, Refitting, and Artifact Use-Lives: A Paleoindian Example. *Plains Anthropologist* 45:273–90.

Bement, L.

- 1999 *The Cooper Site*. Norman: University of Oklahoma Press.

Boldurian, A.

- 1990 Lithic Technology at the Mitchell Locality of Blackwater Draw. *Plains Anthropologist* Memoir 24.
 1991 Folsom Mobility and Organization of Technology: A View from Blackwater Draw, New Mexico. *Plains Anthropologist* 36:281–96.

Boldurian, A., and J. Cotter

- 1999 *Clovis Revisited: New Perspectives on Paleoindian Adaptations from Blackwater Draw, New Mexico*. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Boldurian, A., and S. Hubinsky

- 1994 Preforms in Folsom Lithic Technology. *Plains Anthropologist* 39:445-64.

Bradley, B.

- 1982 Flaked Stone Technology and Typology. In *The Agate Basin Site*. G. Frison and D. Stanford, eds. Pp. 181-208. New York: Academic Press.

Bradley, B., and G. Frison

- 1987 Projectile Points and Specialized Bifaces from the Horner Site. In *The Horner Site*. G. Frison and L. Todd, eds. Pp. 199-232. New York: Academic Press.

Callahan, E.

- 1979 The Basics of Biface Manufacture in the Eastern Fluted Point Tradition. *Archaeology of Eastern North America* 7:1-180.

Davis, E. M.

- 1954 Culture History of the Central Great Plains Prior to the Introduction of Pottery. Ph.D. dissertation, Harvard University.
- 1962 *Archaeology of the Lime Creek Site in Southwestern Nebraska*. Special Publication of the Nebraska State Museum No. 3.

Debenath, A., and H. L. Dibble

- 1994 *Handbook of Paleolithic Typology*, Volume 1: *Lower and Middle Paleolithic of Europe*. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Flenniken, J.

- 1978 Reevaluation of the Lindenmeier Folsom: A Replication Experiment in Lithic Technology. *American Antiquity* 43:473-80.

Frison, G.

- 1991 *Prehistoric Hunters of the High Plains*, 2 ed. New York: Academic Press.

Frison, G., and B. Bradley

- 1980 *Folsom Tools and Technology at the Hanson Site*. New York: Academic Press.

Goodyear, A.

- 1989 A Hypothesis for the Use of Cryptocrystalline Raw Materials Among Paleoindian Groups of North America. In *Eastern Paleoindian Lithic Resource Use*. C. J. Ellis, and J. C. Lothrop, eds. P. 109. Boulder, CO: Westview Press.

Gramly, R.

- 1993 *The Richey Clovis Cache*. Buffalo: Persimmon Press Monographs in Archaeology.

Hartwell, W.

- 1995 The Ryan's Site Cache: Comparisons to Plainview. *Plains Anthropologist* 40:165-84.

Hemmings, E. T.

- 1987 The Homer Site Debitage. In *The Horner Site*. G. Frison and L. Todd, eds. Pp. 435-442. New York: Academic Press.

Hester, J.

- 1972 *Blackwater Locality No. 1*. Fort Burgwin Research Center: Southern Methodist University.

Hofman, J.

- 1991 Folsom Land Use: Projectile Point Variability as a Key to Mobility. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*. A. White and S. Holen, eds. Pp. 335-56. University of Kansas Publications.
- 1992 Recognition and Interpretation of Folsom Technological Variability on the Southern Plains. In *Ice Age Hunters of the Rockies*. D. Stanford and J. Day, eds. Pp. 193-224. Denver: Denver Museum of Natural History.

Hofman, J., D. Amick, and R. Rose

- 1990 Shifting Sands: A Folsom-Midland Assemblage from a Campsite in Western Texas. *Plains Anthropologist* 35:221-54.

Holder, P., and J. Wike

- 1949 The Frontier Culture Complex, a Preliminary Report on a Prehistoric Hunter's Camp in Southwestern Nebraska. *American Antiquity* 14:260-66.

Hughes, J., and P. Willey

- 1978 *Archaeology at Mackenzie Reservoir*. Archaeological Survey Report 24. Austin: Texas Historical Commission, Office of the State Archaeologist.

Ingbar, E.

- 1992 The Hanson Site and Folsom on the Northwestern Plains. In *Ice Age Hunters of the Rockies*. D. Stanford and J. Day, eds. Pp. 169-92. Denver: Denver Museum of Natural History.
- 1994 Lithic Raw Material Selection and Technological Organization. In *The Organization of North American Prehistoric Chipped Stone Technologies*. P. Carr, ed. Pp. 9-34. Ann Arbor: International Monographs in Prehistory.

Ingbar, E., and M. L. Larson

- 1996 Spatial Analysis of the Northwestern Block Excavation. In *The Mill Iron Site*, G. Frison, ed. Pp. 15-24. Albuquerque: University of New Mexico Press.

Jodry, M.

- 1998 The Possible Design of Folsom Ultra-Thin Bifaces as Fillet Knives for Jerky Production. *Current Research in the Pleistocene* 15:75-77.

Judge, J.

- 1973 *Paleoindian Occupation of the Rio Grande Valley*. Albuquerque: University of New Mexico Press.

Keeley, L.

- 1980 *Experimental Determination of Stone Tool Uses*. Chicago: University of Chicago Press.

Kelly, R., and L. Todd

- 1988 Coming into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53:231-44.

Knudson, R.

- 1983 *Organizational Variability in Late Paleoindian Assemblages*. Reports of Investigations No. 60. Pullman: Laboratory of Anthropology, Washington State University.

LeTourneau, P.

- 2000 Folsom Toolstone Procurement in the Southwest and Southern Plains. Ph.D. dissertation, Anthropology Department, University of New Mexico.

Lothrop, J.

- 1989 The Organization of Paleoindian Lithic Technology at the Potts Site. In *Eastern Paleoindian Lithic Resource Use*. C. Ellis, and J. Lothrop, eds. Pp. 99-137. Boulder, CO: Westview Press.

MacDonald, G.

- 1968 *Debert: A Paleo-Indian Site in Central Nova Scotia*. Buffalo: Persimmon Press.

McBrearty, S., L. Bishop, T. Plummer, R. Dewar, and N. Conard

- 1998 Tools Underfoot: Human Trampling as an Agent of Lithic Artifact Edge Modification. *American Antiquity* 63:108-131.

Nelson, M.

- 1991 The Study of Technological Organization. *Archaeological Method and Theory* 3:57-100.

Root, M.

- 1994 Analysis of Stone Tools and Flaking Debris. In *Archaeology of the Bobtail Wolf Site (32DU955a): 1993-1994 Progress Report*. M. Root, and A. Emerson, eds. Pp. 147-90. Center for Northwest Archaeology, Department of Anthropology, Washington State University.

Root, M., and A. Emerson, eds.

- 1994 *Archaeology of the Bobtail Wolf Site (32DU955a): 1993-1994 Progress Report*. Center for Northwest Archaeology, Department of Anthropology, Washington State University.

Thurmond, J.

- 1990 Late Paleoindian Utilization of the Dempsey Divide on the Southern Plains. *Plains Anthropologist* 25.

Tunnell, C.

- 1997 Fluted Point Production as Revealed by Lithic Specimens from the Adair-Steadman Site in Northwest Texas. In *Paleoindian Lifeways*, E. Johnson, ed. Pp. 140-168. The Museum Journal. Lubbock: West Texas Museum Association.

Wilmsen, E., and F. Roberts

- 1984 *Lindenmeier, 1934-1974: Concluding Report on Investigations*. Smithsonian Contributions to Anthropology No. 24.

Witthoft, J.

- 1952 A Paleoindian Site in Eastern Pennsylvania, an Early Hunting Culture. *Proceedings of the American Philosophical Society* 96:464-95.

Wyckoff, D.

- 1996 The Westfahl and Engle Bifaces: Isolated Finds of Large Bifaces on the Southern Plains. *Plains Anthropologist* 41:287-96.

Young, D., and D. Bamforth

- 1990 On the Macroscopic Identification of Used Flakes. *American Antiquity* 55:403-409.



12

TETHERED TO STONE OR FREEDOM TO MOVE: FOLSOM BIFACE TECHNOLOGY IN REGIONAL PERSPECTIVE

Jack L. Hofman

Unlike the toolkits of low-tech foragers, distance does not directly or consistently impact high-tech hunting toolkits, which are brought into use only during specific targeted hunting events. Depletion of Folsom hunting toolkits was probably not consistent on a regular or daily basis, but episodic and punctuated with intensive use periods. Thus, it was more the amount of required bison and other products, as well as the number of hunting events, which determined the size and essential composition of the hunters' toolkits rather than the time or distance from a lithic source. Folsom people on bison hunting forays knew their toolkit requirements and could have been prepared to move without concern for fixed lithic resources until it was time to gear up for another hunting period. This model holds implications for patterning in the distribution of Folsom artifacts on a regional scale.

Introduction and the Problem

Folsom biface technology is characterized by three kinds of bifaces and biface reduction strategies that usually, but not always, reflect distinctive reduction trajectories. These are bifacial cores (Stanford and Broilo 1981; Boldurian 1991; Hofman 1992; Collins 1999; Wyckoff 1999), ultrathin bifacial knives (Root et al. 1995; Root et al. 1999; Jodry 1998), and bifacial point preforms and projectile points (Frison and Bradley 1980; Wilmsen and Roberts 1978; Judge 1973; Tunnell 1977; Ingbar 1992, 1994; Boldurian and Hubinsky 1994; Nami 1999; Wyckoff 1999). These are interrelated and complementary components of the Folsom techno-functional toolkit, which also included a variety of formal and expedient unifacial tool forms such as scrapers, graters, and flake knives. Many of the unifacial tools were made from flakes derived from the three bifacial reduction systems noted above. Some Folsom projectile points were manufactured from flake blanks and some of these are recognizable by remnants of the original flake blank's surface, but the flake blanks for Folsom point manufacture were sometimes also derived from bifacial cores. All these reduction trajectories in the Folsom technological system required very high quality crypto-crystalline material for successful production, staging, and maintenance of the key elements.

Large Folsom and probable Folsom age bifacial cores (Figure 12.1) are documented from New Mexico, Texas, Colorado, and Nebraska, the most well known example being

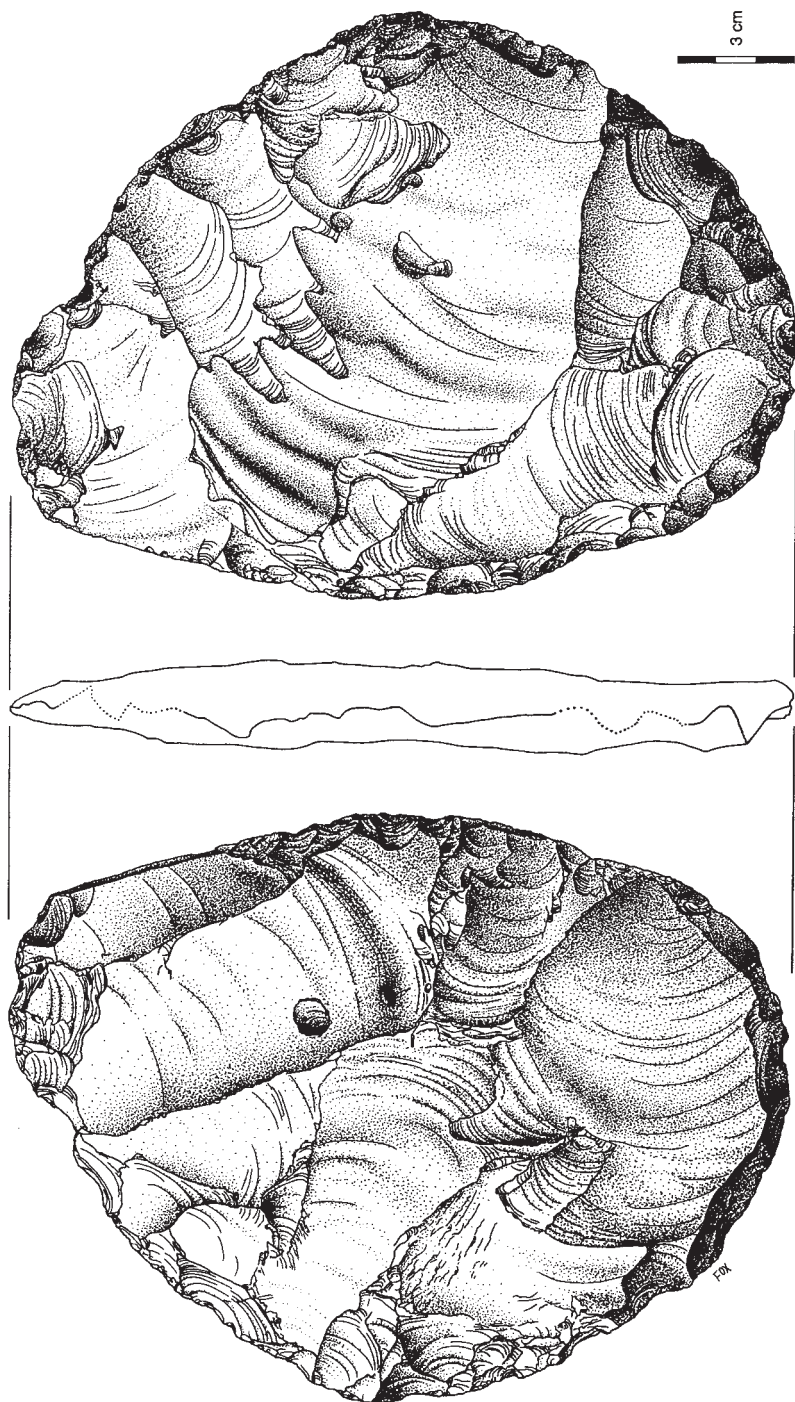


Figure 12.1 Large Paleoindian bifacial core made from Flat Top chalcodony from southwestern Nebraska.

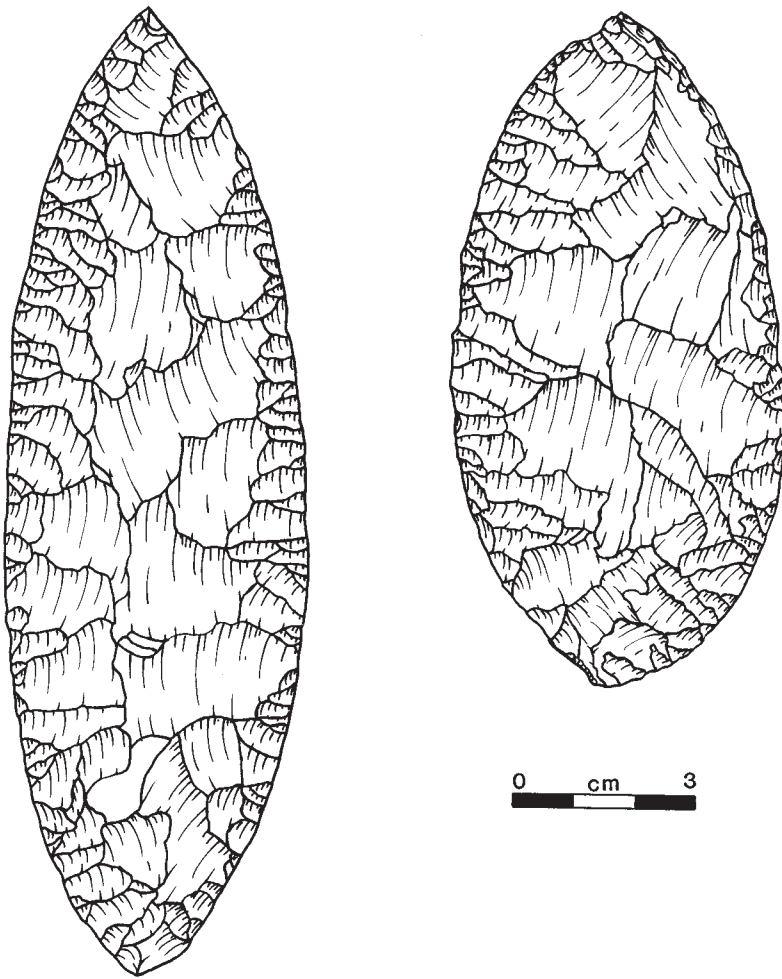


Figure 12.2 Examples of ultra-thin bifaces of Folsom age from western Texas.

Frank's Biface (Stanford and Broilo 1981; Boldurian 1991; Hofman 1992). Although such large bifacial cores are themselves quite rare, the large flakes derived from them are much more common and better documented (Hofman et al. 1990; Ingbar and Hofman 1999; Jodry 1987). These large flakes apparently served a variety of functions during their life histories, and in some cases were reduced to manufacture Folsom point preforms and points.

Ultrathin bifaces (Figure 12.2) were apparently specialized butchering tools (Root et al. 1999; Jodry 1998, 1999), and represent a significant element of Folsom assemblages from Texas to North Dakota. The large flat flakes derived from ultrathin manufacture were also used as objective pieces for formal and expedient unifacial tools (Root et al. 1999; Collins 1999). From one perspective, ultrathins can be recognized as a specialized

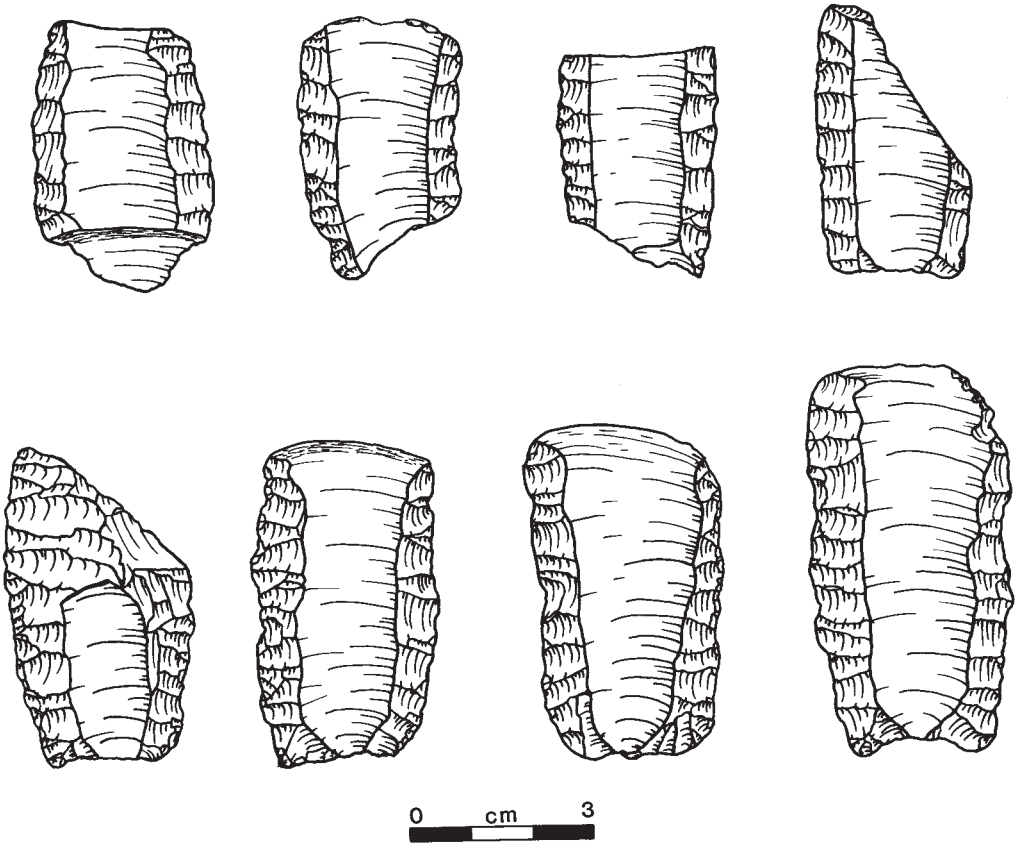


Figure 12.3 Bifacial Folsom projectile point preforms from western Nebraska.

bifacial core form, although the end product or goal was apparently not limited to flakes but directed toward a specialized knife form. Reduced (heavily reworked) ultrathins or fragments may have served as blanks for the manufacture of Midland points (Wilke 2000), the unfluted counterpart to Folsom points in some assemblages (Amick 1995; Hofman 1992; Hofman et al. 1990). Unlike many hafted projectile points (Ahler 1971; Goodyear 1974), Folsom points were apparently rarely utilized for cutting or for any use other than service as a projectile tip. Because of this, alternative (non-projectile point) knife forms and butchery tools, including ultrathins, were important in the Folsom technological sys-

tem. The same was true for late prehistoric bow-and-arrow-using Plains bison hunters who employed four-beveled bifacial knives, perhaps in much the same manner as Folsom people used ultrathins.

Bifacial preforms for Folsom projectile point manufacture (Figure 12.3) commonly served as a source for flake blanks and the preforms themselves were highly serviceable as functional implements (Judge 1973; Boldurian and Hubinsky 1994; Root et al. 1999; Wyckoff 1999). Therefore, although a majority of Folsom tools in those assemblages that contain more than projectile points are unifacial tools made on flakes, most of these flakes were apparently derived from several types of bifacial "cores." It is reasonable to argue, then, that bifaces and bifacial technology were an integral and key component of the overall Folsom lithic technological system.

The focus here is on the continued investigation of regional patterning in Folsom biface technology, particularly as exemplified by the occurrence of distinctive Folsom point preforms and projectile points. Several decades of research in the Southern Plains region of New Mexico, Texas, and Oklahoma have resulted in the definition of strong patterns in the occurrence of specific lithic material types across an extensive region (Amick 1994, 1996, 1999; Bodurian and Cotter 1999; Broilo 1971; Bement 1999; Collins 1999; Hester 1972; Hofman 1991, 1992, 1999a; Largent et al. 1991; Tunnell 1977; Wyckoff 1999). One pattern of interest is the apparent unidirectional or outward movement of Edwards chert from the central Texas area to west and northwest Texas, eastern New Mexico, and western Oklahoma. Edwards chert commonly constitutes more than 50% of the chipped stone assemblages from Folsom sites within 400 km of the Edwards source area (Hofman 1999a). By contrast, it is rare to find "non-local" Folsom artifacts in the Edwards source area or on its margins, even though the distribution of Edwards-dominated Folsom assemblages encompasses other quality lithic sources areas known to have been used by Folsom people (e.g., Tecovas jasper and Alibates flint from the Texas Panhandle). This pattern is documented based on site assemblages and many isolated finds and is argued to reflect the long-term lithic and land use patterns of Folsom people in the Southern Plains region (Hofman 1999a).

This patterning has resulted in a variety of explanatory models (Amick 1996, 1999; Bement 1999; Boldurian and Cotter 1999; Broilo 1971; Hofman 1991, 1992, 1999a; Ingbar and Hofman 1999). I have suggested that Southern Plains Folsom people had a generally redundant, although not annually fixed, pattern of movement, which incorporated the Edwards chert source area, bison hunting on the High Plains and dissected low plains, and use of wood and a variety of other resources along drainages in the eastern prairie and the prairie-savanna ecotone. On the west, the foothills-mountain/prairie ecotone provided a similarly diverse resource area and potential seasonal refuge. Unfortunately, we have relatively little evidence on the Folsom record from the Upper Pecos, Canadian, and upper Cimarron river region of northeastern New Mexico at the present time. These movements and activities sometimes included use of other lithic sources, but these were of relatively minor significance on a regional scale. Movements to the west of the Edwards chert source area onto the Southern High Plains generally did not encounter alternative high-quality lithic sources and hunting excursions into that region would have required Folsom people to carry an ample supply of lithics with them to complete the expected range of activities.

Tethered to Stone and Freedom to Move

The Folsom economy is argued to have emphasized bison hunting (Bamforth 1988; Hofman and Todd 2000; Hofman 1996; Kelly and Todd 1988; Stanford 1999), and their technological organization and land-use practices were tied to a mobile hunting economy balanced between multiple key variables. These included bison condition, location and movements, wood for technological needs (e.g., Osborn 1999), water, protected settings in periods or seasons of severe weather (Hofman 1988, 1999a), other social groups (e.g., MacDonald 1999; Hofman 1994a; Surovell 2000), and of course lithics.

It is argued that Folsom hunters were highly sophisticated in their knowledge of bison behavior and habits (Kelly and Todd 1988; Hofman and Todd 2000; Frison 1987), and, using their technological system of which the distinctive lithic artifacts were only a limited portion, in hunting tactics (Ahler and Geib 2000; Hofman 1999b; Osborn 1999). It is assumed that Folsom people could closely estimate the amount of tool stone and other technological requirements needed to complete the successful kill and butchery of the number of bison required to sustain them through weeks or months. This is perhaps analogous to extended sea mammal hunting trips, using either boats or breathing holes, wherein the technological requirements are known well in advance and the wherewithal for replenishing damaged equipment must be carried with the individual hunter or task group. Similarly, bison were a predictable resource, but the exact location and time of a successful kill could not be known in advance. Immediately after a kill, the focus had to be on processing the carcasses rather than on lithic procurement, and commonly suitable lithic materials would not have been available in the vicinity. For the Southern Plains and much of the Great Plains as a whole, quality lithic sources are localized, limited in extent, and many bison kills would have occurred in locations distant from known quality lithic sources.

In such situations, the gearing-up process would have been based on the amount of required weaponry and equipment needed to provide the required number of animals, regardless of the time, distance, or number of kill events involved. The amount of equipment needed would have been linked directly to the technological and economic requirements of the group which would have determined, and been determined by, the number of bison required.

The organization of Folsom technology liberated Folsom groups from concern for locating or using alternative lithic sources during their pursuit of bison, their key economic and technological resource. They gained the freedom to move or hunt bison without concern for lithics because of the creative, conservative, and focused use of a highly curated and flexible technocomplex. This technological flexibility or freedom was enabled by use of high-quality fixed lithic sources to which the groups consistently returned, just as they had to return to other critical resources, including water and wood.

This model suggests directional movement of lithics away from key source locations toward bison hunting areas. Return movements would have de-emphasized lithics in favor of other critical products and equipment. Hunting equipment may have seen limited service after a successful series of hunts. If Folsom groups repeatedly utilized one or more high-quality lithic sources in this manner, their long-term pattern of land use would have resulted in lithic distribution patterns suggesting one-way movement, even if people moved in complex patterns which had them eventually or recurrently returning to the original lithic source location.

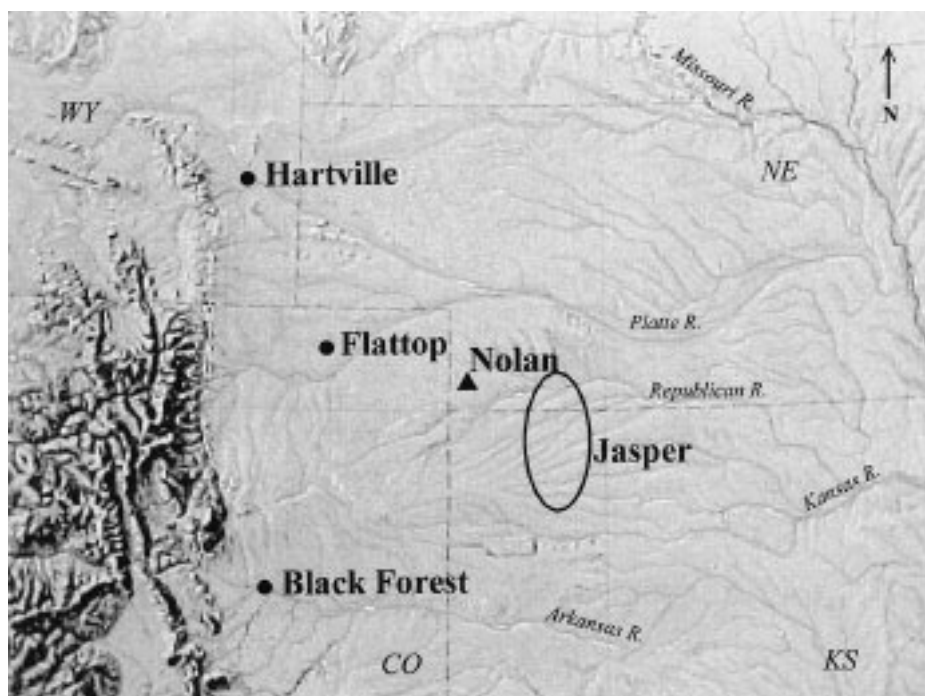


Figure 12.4 Location of the Nolan site (25CH4) in Chase County, Nebraska in relation to lithic source areas and Folsom sample areas in northeastern Colorado and southwestern Nebraska.

Thoughts of Taylor's (1964:199) concept of "tethered nomadism" are provoked. Concerning desert-dwelling foragers in Coahuila, Taylor writes, "Thus we envisage a nomadism demanded by the natural characteristics of terrain and food supply yet tied, like a picketed horse, to the locus (or loci) of socially recognized and socially sanctioned water rights." This concept of tethered nomadism and water territoriality is in no manner directly applicable here, because of technological and economic differences. For this study, the notion is of a technology linked to, and liberated by, a reliable source of quality stone for a hunter-gatherer group focused on a critical, highly mobile, and only generally predictable resource. To evaluate whether the Southern Plains Folsom pattern of primary dependence upon a single lithic material source area is a recurrent or more widespread Folsom pattern, evidence from the Central Plains region of northeast Colorado and western Nebraska is considered.

Nolan, Flattop, and the Central Plains Pattern

The Nolan site (25CH4) in Chase County, western Nebraska, was discovered in the early 1930s by Cornelius Gardner and was the scene of active artifact collecting during the following decades. His collection, donated to the University of Nebraska State Museum, is one of the few extant collections from the site and provides the basis for much of the following discussion (Hofman n.d.). Nolan is a large erosional blow out or wind-deflated basin in a dune field, located near the Nebraska-Colorado border east of Yuma County, Colorado (Figure 12.4). The site is situated on an upland interfluvium in the

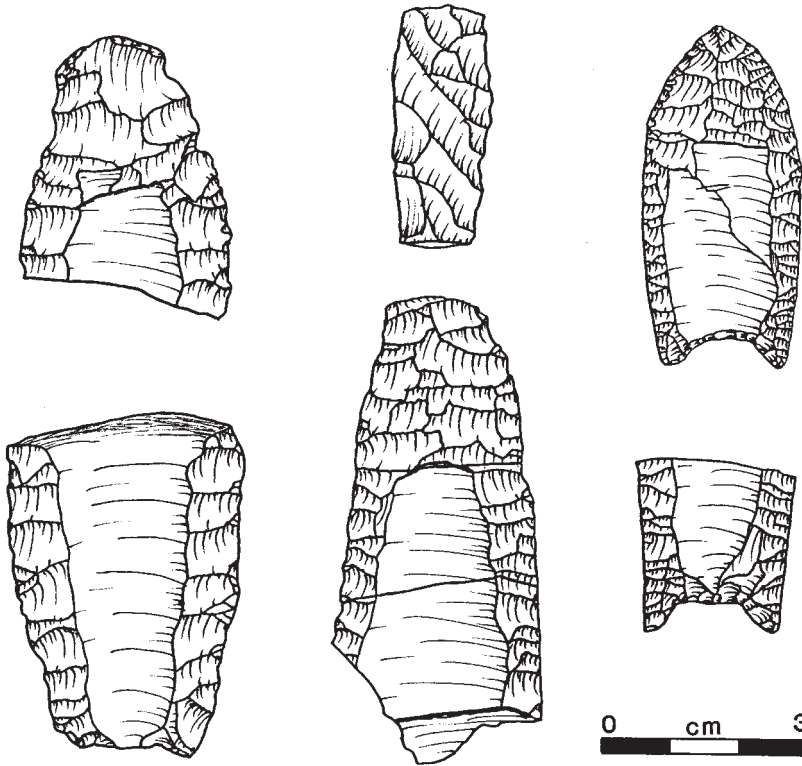


Figure 12.5 Folsom points and preforms from the Nolan site (25CH4) in Chase County, Nebraska.

Republican River basin, which drains east central Colorado, and south of the Frenchman Fork of the Republican River, which heads in Logan County, northeastern Colorado. In 1946, minimal archaeological and paleontological testing was conducted at the site by C. Bertrand Schultz and his crew after they completed work at the Lipscomb Bison Quarry in the Texas Panhandle.

The Folsom assemblage from Nolan suggests hunting, processing, and retooling activities, perhaps associated with bison hunting and processing in a dune field or an interdune pond setting. The identified Folsom assemblage from Nolan (Table 12.1; Figures 12.5 and 12.6) includes Folsom points ($n = 13$), Folsom preforms ($n = 9$), channel flakes ($n = 5$), graters ($n = 8$), tips or perforators ($n = 2$), endscrapers, many of which are spurred ($n = 44$), spokeshaves and notches ($n = 4$), other scrapers ($n = 44$), flake knives ($n = 44$), wedges ($n = 4$), burins ($n = 2$), denticulates ($n = 1$), bifaces ($n = 3$), flakes and spalls ($n = 27$), and one abrader. Some of these artifacts are possibly derived from Cody and other Paleoindian components at the site.

One striking characteristic of the Nolan artifact assemblage is the dominance of Flattop chalcodony, a variety of White River Group silicate. The known source location is Flattop Butte, which is northwest of Sterling in Logan County, Colorado (Hoard et al.

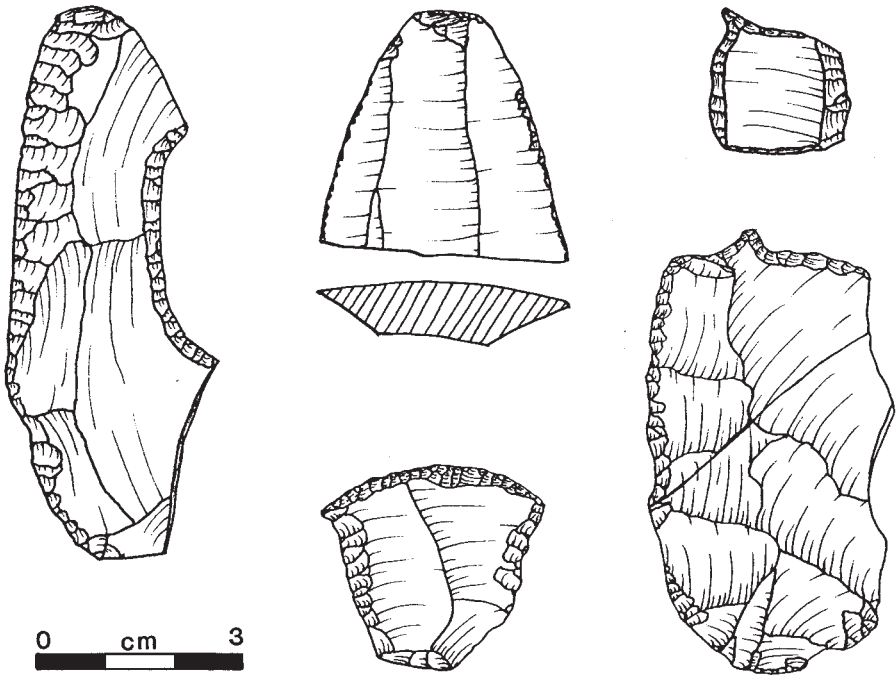


Figure 12.6 Selected Folsom artifacts from the Nolan site.

1992, 1993; Hofman and Toft n.d.; Jensen 1973; Greiser 1983). Additional sources occur at Table Mountain in eastern Wyoming (Koch and Miller 1996), West Horse Creek in southwestern South Dakota (Nowak and Hannus 1984), and as secondary deposits (Ahler 1977). The closest primary source of White River Group chalcedony to Nolan is Flattop Butte, 150 km to the west, and the artifacts from the site compare well with the Flattop materials.

Other cultural components represented in the Nolan site surface collection include non-Folsom Paleoindian, some Mesoinian, and late prehistoric diagnostics. The Folsom assemblage from the site must, therefore, be segregated on typological and technological criteria. As noted, the Folsom artifacts are made predominantly from Flattop chalcedony, but additional lithic types are represented by some Paleoindian artifacts from eastern Wyoming made from Hartville Uplift materials (Miller 1991), Black Forest petrified wood from east central Colorado (Jodry 1999), and a very small number of artifacts made from more distant materials including Alibates flint, Edwards chert, Knife River flint, and Permian Florence chert. In addition, a significant minority of the collection is made from Niobrara or Republican River jasper (Hofman n.d.).

Table 12.1 Folsom Assemblage from the Nolan Site by Lithic Material

Type	WRGS	HV	FW	NJ	AL	KRF	ED	OTHER	Totals
Folsom Points	9			2				2	13 (6.2%)
Preforms	8			1					9 (4.3%)
Channels	4	1							5 (2.4%)
Gravers	5	1		1				1	8 (%3.8)
Perforators		2							2 (1%)
Endscrapers	28	3	7	1	1	1	1	2	44 (21%)
Spokeshaves	4								4 (2%)
Scrapers	19	2	1	14			1	7	44 (21%)
Flk Knives	38		2	3				1	44 (21%)
Wedges	3							1	4 (2%)
Burins	2								2 (1%)
Denticulates				1					1 (0.5%)
Bifaces	2			1					3 (1.4%)
Flakes	12		8	6				1	27 (12.8%)
Totals	134	9	18	30	1	1	2	15	210
Percent	63.8	4.3	8.6	14.3	0.5	0.5	1	7	

Key: WRGS = Flat Top and White River Group silicates; HV = Hartville Uplift materials; FW = silicified fossilized wood; NJ = Niobrara jasper; AL = Alibates flint; KRF = Knife River flint; ED = Edwards chert; OTHER includes unidentified agates, jaspers, cherts, chalcedony, quartzites, and Tongue River silicified sediment (2 scrapers), one end scraper of Burlington-Crescent, and one endscraper of Permian chert.

Primary sources for this jasper occur to the east and southeast of Nolan in the Republican and Saline river basins, including the Medicine Creek area in Frontier County, Nebraska about 125 km to the east and extending south to the Graham, Trego, and Gove counties area on the Saline River in northwestern Kansas (Wedel 1986; Hofman 1990). Use of Niobrara jasper at Nolan was more intensive in later Paleoindian times than during the Folsom period. Among the 26 non-Folsom Paleoindian projectile points from Nolan are 10 (38%) made of Niobrara Jasper. This is consistent with the evidence for intensive use of this jasper in Paleoindian components at Medicine Creek sites to the east (Davis 1953, 1962; Bamforth 1991).

By contrast, out of 43 Folsom-age artifacts (24 Folsom points, 14 Folsom preforms, and 5 Midland points) from Chase and Dundy counties, Nebraska, only 6 (14%) were made from Niobrara jasper (Table 12.2). This sample includes the Nolan site artifacts and all other Folsom points, Folsom preforms, and Midland points in Chase and Dundy counties. Dundy County is located immediately to the south of Chase and also borders Colorado. So, despite the fact that Nolan is slightly closer to the Niobrara jasper source area than to Flattop, the assemblage is dominated by Flattop materials with minimal evidence for use of Niobrara jasper at the site or in the region. This is not simply a site-specific or unique pattern, as indicated by the total available Folsom evidence from Chase and Dundy counties. For Nebraska as a whole, a total of 257 Folsom points, preforms, and Midland points have been recorded, and only 26 (10%) of these were manufactured from Niobrara jasper. They are most commonly reported from Harlan County ($n = 8$), slightly east of the primary source area, and about 250 km east of Nolan.

Folsom points and preforms from the Flattop Butte area west of the South Platte River in Logan County, Colorado include 57% ($n = 47$) manufactured from Flat Top and White River Group silicates (Table 12.3). Hartville materials from eastern Wyoming are well represented ($n = 7$, 15%), and several Niobrara jasper points ($n = 3$, 6%, no preforms) are documented. If we include Sedgwick County Folsom material, which is mostly from the South Platte River in extreme northeastern Colorado, with the Logan County sample, the pattern changes little with 57% Flat Top and White River Group silicates ($n = 32$), 10% Hartville Uplift materials ($n = 12$), 17% unidentified and other materials ($n = 11$), 8% Black Forest and other silicified woods ($n = 5$), and only 5% ($n = 3$) Niobrara jasper points (Table 12.4). Folsom preforms are represented by all materials except Niobrara jasper. This supports the pattern seen at Nolan in which artifacts manufactured from Flat Top and White River Group silicates were being carried to the east at a much greater frequency than Niobrara jasper pieces were being moved to the west during Folsom times.

To the south of Flattop and the South Platte River, Yuma and Washington counties in eastern Colorado encompass much of the area drained by the Republican River and its tributaries. Yuma County, Colorado is immediately west of Chase County, Nebraska where the Nolan site is located. A sample of 118 Folsom artifacts (100 Folsom points, 13 Folsom preforms, and 5 Midland points) has been documented primarily from upland settings comparable with Nolan. This sample, too, is dominated by Flat Top and White River Group silicates ($n = 49$, 42%), with a significant proportion of unsourced chalcedonies and other unknown lithics (Table 12.5). There is minimal representation of Alibates and Knife River flint, Tecovas jasper, and other materials. Hartville is represented by only 7 pieces (6%), whereas Black Forest silicified wood is well represented by 20 pieces (17%). Niobrara jasper is represented by 11 points (9%), with no preforms. This is comparable with the proportion seen for the state of Nebraska as a whole, and slightly less than at Nolan (14%). The Yuma-Washington counties area is in the same drainage basin as primary

Table 12.2 Folsom artifacts from Chase and Dundy Counties, Nebraska, by Lithic Material

Types	WRGS	HV	FW	NJ	OTHER	Totals
Folsom	15	1	0	3	5	24 (56%)
Pre/Chan	12	1	0	1	0	14 (32%)
Midland	1	0	0	2	2	5 (12%)
Totals	28 (65%)	2 (5%)	0 (0%)	6 (14%)	7 (16%)	43

Key: WRGS = Flat Top and White River Group silicates; HV = Hartville Uplift materials; FW = silicified fossilized wood; NJ = Niobrara jasper; OTHER = other materials; PRE/CHAN = preforms and channel flakes.

sources for Niobrara jasper, but a significant amount of Niobrara jasper simply did not move west from the source area. Interestingly, the frequency of Black Forest wood in the Yuma and Washington counties is relatively high, even though the primary source area is about 120 to 200 km to the southwest (Figures 12.4 and 12.7). The frequency of Hartville materials, however, is notably lower than for areas north of the South Platte River. The Kansas Folsom sample has equal proportions, approximately 10%, of both Flattop chalcedony and Niobrara jasper, even though sources of the latter are common in the north-western portion of the state (Hofman 1994b).

North and west of the Nolan site and the Chase-Dundy counties area, a sample of 53 Folsom points and preforms is documented for the South Platte River valley in Keith, Lincoln, and Deuel counties, Nebraska (Table 12.6). This South Platte River sample has equal proportions of Flat Top and White River Group silicates and Hartville Uplift materials (n = 14, 26% of each). Also well represented is fossil wood (n = 7, 13%), some of which may be from the Black Forest area. Niobrara jasper Folsom material is represented by only three pieces (6% of the sample), two preforms from the eastern end of the sample area and one point base from the central county (Keith). Again, Niobrara jasper does not constitute a significant part of Folsom samples to the west and northwest of the source area. The increased significance of Hartville Uplift materials from the South Platte River to the north in Nebraska is also a strong pattern. It is well represented in Folsom samples across the Sand Hills region into central Nebraska (e.g., Holen and Hofman 1999).

Conclusions

A strong directional pattern in the movement of Flat Top and White River Group silicates from the Flattop Butte source area to the east and southeast is indicated; however, evidence is lacking for comparable western movement of significant lithic materials such as Niobrara jasper to the west during the same period (Figure 12.7). This is despite that fact that Folsom groups repeatedly used Niobrara jasper. I suggest that Folsom groups did not move in one direction more than the other, simply that the procurement, transport, and use of lithic components of their technology was typically directional. On the return trips, lithics were of much less concern. Unidirectional movement of lithics need not imply unidirectional movement of people, but in the case of Folsom on the Great Plains probably reflects a recurrent long-term pattern of movement from lithic source areas to

Table 12.3 Folsom Artifacts from Logan County, Colorado, by Lithic Material

Types	WRGS	HV	FW	NJ	OTHER	Totals
Folsom	17	6	2	2	2	29 (62%)
Preforms	8	1	0	0	4	13 (28%)
Midland	2	0	1	1	1	5 (11%)
Totals	27 (57%)	7 (15%)	3 (6%)	3 (6%)	7 (15%)	47

Key: See Table 12.2.

Table 12.4 Folsom artifacts from Logan and Sedgwick Counties, Northeastern Colorado, by Lithic Material

Types	WRGS	HV	FW	NJ	OTHER	Totals
Folsom	21	9	2	2	4	38 (60%)
Preforms	9	3	2	0	6	20 (32%)
Midland	2	0	1	1	1	5 (8%)
Totals	32 (51%)	12 (19%)	5 (8%)	3 (5%)	11 (17%)	63

Key: See Table 12.2.

Table 12.5 Folsom Artifacts from Yuma County Area, Colorado, by Lithic Material

Types	WRG	HV	FW	NJ	OTHER	Totals
Folsom	42	6	14	11	27	100 (85%)
Pref/Chan	6	1	4	0	2	13 (11%)
Midland	1	0	2	0	2	5 (4%)
Totals	49 (42%)	7 (6%)	20 (17%)	11 (9%)	31 (26%)	118

Key: See Table 12.2.

Table 12.6 Folsom Artifacts from South Platte River Area, Keith, Lincoln, and Deuel Counties, Northwestern Nebraska, by Lithic Material

Types	WRGS	HV	FW	NJ	OTHER	Totals
Folsom	15	11	6	1	2	35 (66%)
Preforms	9	3	1	2	3	18 (34%)
Totals	14 (26%)	14 (26%)	7 (13%)	3 (6%)	5 (9%)	53

Key: See Table 12.2.

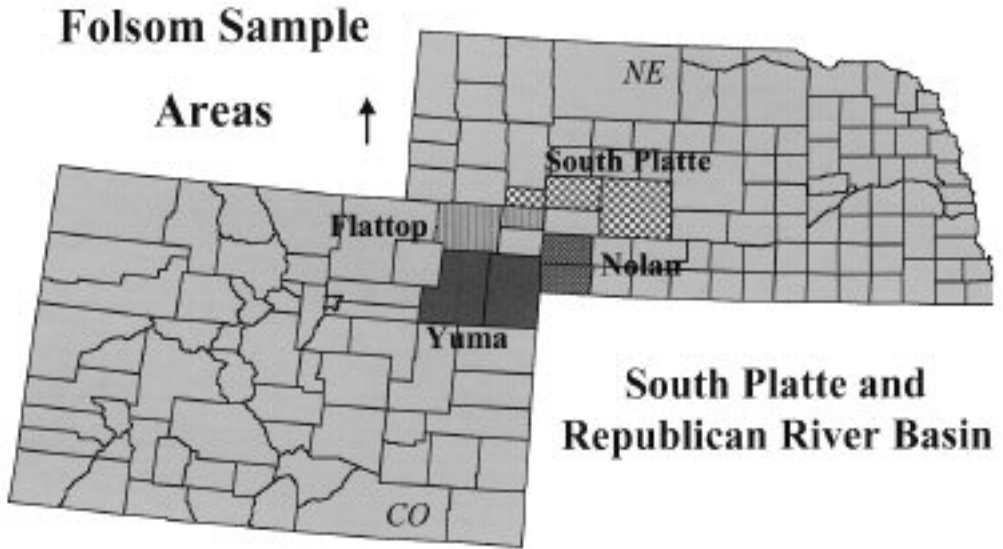


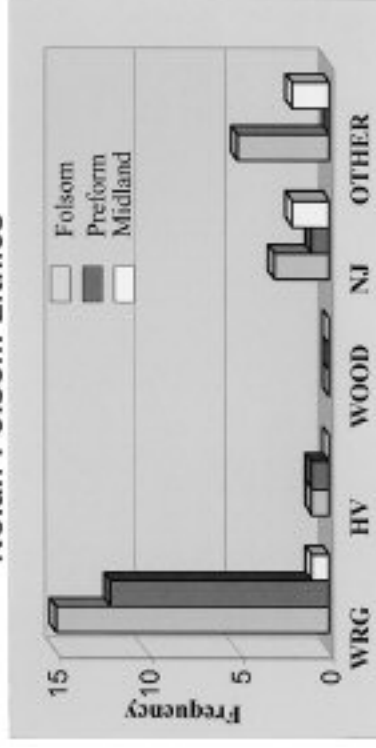
Figure 12.7 Geographic summary of lithic material representation in Folsom samples from northeastern Colorado and southwestern Nebraska.

bison hunting areas. The systematic study of Folsom technology is the focus here, but not because it epitomizes or represents “typical” technology representative of all Paleoindian groups. It does, however, provide an important comparative reference for investigation of the considerable variability within Paleoindian assemblages and lithic utilization patterns throughout the region.

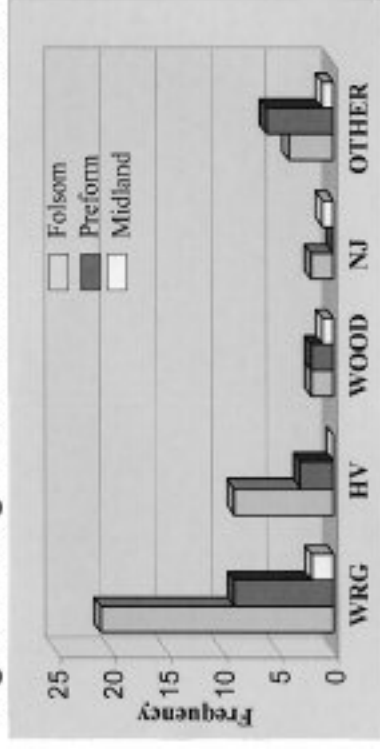
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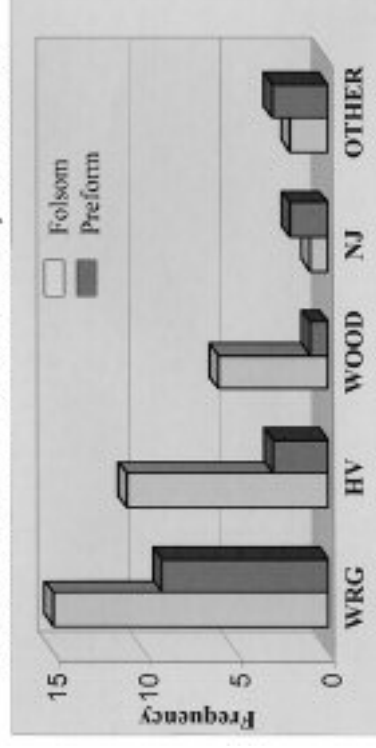
Nolan Folsom Lithics



Logan & Sedgwick Counties Folsom Lithics



South Platte Folsom Lithics, Nebraska



Yuma County Folsom Lithics

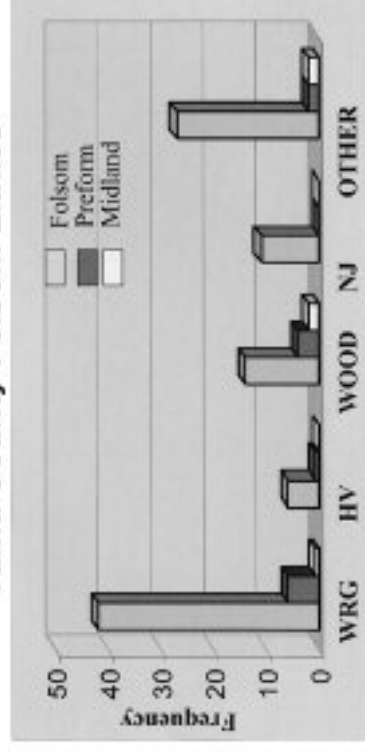


Figure 12.8 Summary of Lithic Material for Nolan, Logan and Sedgwick Counties, South Platte and Yuma County.

References

Ahler, S.A.

- 1971 *Projectile Point Form and Function at Rodgers Shelter, Missouri*. Memoir 8. Columbia: Missouri Archaeological Society.
- 1977 Lithic Resource Utilization Patterns in the Middle Missouri Sub-Area. In *Trends in Middle Missouri Prehistory*. W. R. Wood, ed. Pp. 132-50. Memoir 13. Plains Anthropologist.

Ahler, S.A., and P. Geib

- 2000 Why Flute? Folsom Point Design and Adaptation. *Journal of Archaeological Science* 27:799-820.

Amick, D. S.

- 1994 Folsom Diet Breadth and Land Use in the American Southwest. Ph.D. dissertation, University of New Mexico.
- 1995 Patterns of Technological Variation Among Folsom and Midland Projectile Points in the American Southwest. *Plains Anthropologist* 40:23-38.
- 1996 Regional Patterns of Folsom Mobility and Land Use in the American Southwest. *World Archaeology* 27:411-426.
- 1999 Regional Approaches to Unbounded Systems, the Record of Folsom Land Use in New Mexico. In *The Archaeology of Regional Interaction, Religion, Warfare, and Exchange Across the American Southwest and Beyond*. M. Hegmon, ed. Pp. 119-147. Boulder: University Press of Colorado.

Bamforth, D. B.

- 1988 *Ecology and Human Organization on the Great Plains*. New York: Plenum Press.
- 1991 Population Dispersion and Paleoindian Technology at the Allen Site. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*. A. Montet-White and S. R. Holen, eds. Ppp. 357-374. Publications in Anthropology 19. Lawrence: University of Kansas.

Bement, L. C.

- 1999 *Bison Hunting At Cooper Site, Where Lightning Bolts Drew Thundering Herds*. Norman: University of Oklahoma Press.

Boldurian, A. T.

- 1991 Folsom Mobility and Organization of Lithic Technology: A View from Blackwater Draw, New Mexico. *Plains Anthropologist* 36:281-95.

Boldurian, A., and J. L. Cotter

- 1999 *Clovis Revisited: New Perspectives on Paleoindian Adaptations from Blackwater Draw, New Mexico*. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Boldurian, A., and S. M. Hubinsky

- 1994 Preforms in Folsom Lithic Technology: A View from Blackwater Draw, New Mexico. *Plains Anthropologist* 39:445-465.

Collins, M. B.

- 1999 Clovis and Folsom Lithic Technology on and Near the Southern Plains: Similar Ends, Different Means. In *Folsom Lithic Technology*. D. S. Amick, ed. Pp. 12-38. Archaeological Series 12. Ann Arbor: International Monographs in Prehistory.

Davis, E. M.

- 1953 Recent Data from Two Paleo-Indian Sites on Medicine Creek, Nebraska. *American Antiquity* 18(4).
 1962 *Archaeology of the Lime Creek Site in Southwestern Nebraska*. Lincoln: University of Nebraska State Museum.

Frison, G. C.

- 1987 Prehistoric, Plains-Mountain, Large-Mammal, Communal Hunting Strategies. In *The Evolution of Human Hunting*. M. H. Nitecki and D. Y. Nitecki, eds. Pp. 177-211. New York: Plenum Press.

Frison, G. C., and B. A. Bradley

- 1980 *Folsom Tools and Technology at the Hansen Site, Wyoming*. Albuquerque: University of New Mexico Press.

Goodyear, A. C.

- 1974 *The Brand Site, a Techno-Functional Study of a Dalton Site in northeast Arkansas*. Research Series 7. Fayetteville: Arkansas Archeological Survey.

Greiser, S. T.

- 1983 A Preliminary Statement about Quarrying Activity at Flattop Mesa. *Southwestern Lore* 49(4):6-14.

Hester, J. J.

- 1972 *Blackwater Draw Locality No. 1: A Stratified Early Man Site in Eastern New Mexico*. Ranchos de Taos: Fort Burgwin Research Center.

Hoard, R. J., S. R. Holen, M. D. Glascock, H. Neff, and J. M. Elam

- 1992 Neutron Activation Analysis of Stone from the Chadron Formation of a Clovis Site on the Great Plains. *Journal of Archaeological Science* 19:655-65.

Hoard, R. J., J. R. Bozell, S. R. Holen, M. D. Glascock, H. Neff, and J. M. Elam

- 1993 Source Determination of White River Group Silicates from Two Archaeological Sites in the Great Plains. *American Antiquity* 58:698-710.

Hofman, J. L.

- 1988 Folsom Research in Western Oklahoma: Rethinking the Folsom Occupation of the Southern Plains. In *Transactions of the 23rd Regional Archaeological Symposium for Southeastern New Mexico and Western Texas*. Pp. 6–30.
- 1990 Paleoindian Mobility and Utilization of Niobrara or Smoky Hill Jasper on the Southern Plains. *The Kansas Anthropologist* 9(2):1–13.
- 1991 Folsom Land Use: Projectile Point Variability as a Key to Mobility. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*. A. Montet-White, and S. R. Holen, eds. Pp. 335–355. Lawrence: University of Kansas Publications in Anthropology 19.
- 1992 Recognition and Interpretation of Folsom Technological Variability on the Southern Plains. In *Ice Age Hunters of the Rockies*. D. J. Stanford and J. S. Day, eds. Pp. 193–224. Niwot: University Press of Colorado.
- 1994a Paleoindian Aggregations on the Great Plains. *Journal of Anthropological Archaeology* 13:341–70.
- 1994b Kansas Folsom Evidence. *Kansas Anthropologist* 15(2):31–43.
- 1996 Early Hunter-Gatherers of the Central Great Plains: Paleoindian and Mesoindian (Archaic) Cultures. In *Archaeology and Paleoeology of the Central Great Plains*. Pp. 41–100. Arkansas Archeological Survey Research Series 48. Fayetteville: Arkansas Archeological Survey.
- 1999a Unbounded Hunters: Folsom Bison Hunting on the Southern Plains Circa 10,500 B.P., the Lithic Evidence. In *Le Bison: Gibier et Moyen de Subsistance des Hommes du Paleolithique aux Paleoindiens des Grandes Plaines*. J. Brugal, F. David, J. G. Enloe, and J. Jaubert, eds. Pp. 383–415. Antibes: Editions APDCA.
- 1999b Folsom Fragments, Site Types, and Assemblage Formation. In *Folsom Lithic Technology*. D. S. Amick, ed. Pp. 122–143. Ann Arbor: International Monographs in Prehistory.
- n.d. Folsom Activity at the Nolan Site (25CH4) in Southwestern Nebraska. In preparation.

Hofman, J. L., D. S. Amick, and R. O. Rose

- 1990 Shifting Sands: A Folsom-Midland Assemblage from a Campsite in Western Texas. *Plains Anthropologist* 35:221–53.

Hofman, J. L., and L. C. Todd

- 2000 Tyranny in the Archaeological Record of Specialized Hunters. In *People and Wildlife in Northern North America, Papers in Honor of R. D. Guthrie*. S. Craig Gerlach and M. S. Murray, eds. Oxford: BAR International Series.

Hofman, J. L., and M. Toft

- n.d. The Luft Site and Folsom Use of Flattop Chalcedony in Northeastern Colorado. In preparation.

Holen, S. R.

- 2001 Climate Change and Human Adaptation at the Pleistocene-Holocene Boundary: Clovis Mobility and Lithic Procurement on the Central Great Plains of North America. Ph.D. dissertation. University of Kansas, Lawrence.

Holen, S. R., and J. L. Hofman

- 1999 Folsom Evidence from the Nebraska Sand Hills: The Elfgren Site. *Current Research in the Pleistocene* 16:38-40.

Ingbar, E. E.

- 1994 Lithic Material Selection and Technological Organization. In *The Organization of North American Prehistoric Chipped Stone Tool Technologies*. P. J. Carr, ed. Pp. 45-56. Ann Arbor: International Monographs in Prehistory.

Ingbar, E. E., and J. L. Hofman

- 1999 Folsom Fluting Fallacies. In *Folsom Lithic Technology*. D. S. Amick, ed. Pp. 98-110. Ann Arbor: International Monographs in Prehistory.

Jensen, R. E.

- 1973 *A Preliminary Report on the Point of Rocks Archeological Survey, 1971*. Publications in Anthropology 5(2):157-233. Lincoln: Nebraska State Historical Society.

Jodry, M. A.

- 1987 Stewart's Cattle Guard Site: A Folsom Site in Southern Colorado. Master's thesis. University of Texas, Austin.
- 1998 The Possible Design of Folsom Ultrathin Bifaces as Fillet Knives for Jerky Production. *Current Research in the Pleistocene* 15:75-7.
- 1999 Folsom Technological and Socioeconomic Strategies: Views from Stewart's Cattle Guard and the Upper Rio Grande Basin, Colorado. Ph.D. dissertation. American University, Washington, DC.

Judge, W. J.

- 1973 *Paleoindian Occupation of the Central Rio Grande Valley in New Mexico*. Albuquerque: University of New Mexico Press.

Kelly, R. L., and L. C. Todd

- 1988 Coming into the Country. *American Antiquity* 53:231-44.

Koch, A., and J. Miller

- 1996 *Geoarcheological Investigations at the Lyman Site (25SF53) and Other Cultural Resources Related to Table Mountain Quarry Near the Nebraska/Wyoming Border*. Lincoln: Report for Nebraska Department of Roads, Project HES-92-1(113).

Largent, F. B., Jr., M. R. Waters, and D. L. Carlson

- 1991 The Spatiotemporal Distribution of Folsom Projectile Points in the State of Texas. *Plains Anthropologist* 36(137):323-41.

MacDonald, D.

- 1999 Modeling Folsom Mobility, Mating Strategies, and Technological Organization in the Northern Plains. *Plains Anthropologist* 44:141-61.

Miller, J. C.

- 1991 Lithic Resources. In *Prehistoric Hunters of the High Plains*, 2 ed. G. C. Frison, ed. Pp. 449–78. San Diego: Academic Press.

Nami, H. G.

- 1999 The Folsom Biface Reduction Sequence: Evidence from the Lindenmeier Collection. In *Folsom Lithic Technology*. D. S. Amick, ed. Pp. 82–97. Ann Arbor: International Monographs in Prehistory.

Nowak, T. R., and A. L. Hannus

- 1985 Lithic Raw Materials from the West Horse Creek Quarry Site (39SH37). *South Dakota Archaeology* 8 and 9:98–114.

Osborn, A. J.

- 1999 From Global Models to Regional Patterns: Possible Determinants of Folsom Hunting Weapon Design, Diversity, and Complexity. In *Folsom Lithic Technology*. D. S. Amick, ed. Pp. 188–213. Ann Arbor: International Monographs in Prehistory.

Root, M. J., J. D. William, L. K. Shifrin, and E. Feiler

- 1995 Folsom Point and Biface Manufacture in the Knife River Flint Quarry Area. *Current Research in the Pleistocene* 12:65–68.

Root, M. J., J. D. William, M. Kay, and L. K. Shifrin

- 1999 Folsom Ultrathin Biface and Radial Break Tools in the Knife River Flint Quarry Area. In *Folsom Lithic Technology*. D. S. Amick, ed. Pp. 144–168. Ann Arbor: International Monographs in Prehistory.

Stanford, D. J.

- 1999 Paleoindian Archaeology and Late Pleistocene Environments in the Plains and Southwestern United States. In *Ice Age People of North America*. R. Bonnicksen and K. L. Turnmire, eds. Pp. 281–339. Corvallis: Oregon State University Press.

Stanford, D. J., and F. Broilo

- 1981 Frank's Folsom Campsite. *Artifact* 19(3–4):1–11.

Surovell, T. A.

- 2000 Early Paleoindian Women, Children, Mobility, and Fertility. *American Antiquity* 65(3):493–508.

Taylor, W. W.

- 1964 Tethered Nomadism and Water Territoriality: An Hypothesis. 35th *Congreso Internacional de Americanistas, Actas y Memorias* 2:197–203. Mexico.

Tunnell, C. D.

- 1977 Fluted Projectile Point Production as Revealed by Lithic Specimens from the Adair-Steadman Site in Northwest Texas. In *Paleoindian Lifeways*. E. Johnson, ed. Pp. 140–168. Lubbock: Texas Tech University.

Wedel, W. R.

- 1986 *Central Plains Prehistory*. Lincoln: University of Nebraska Press.

Wilke, P. J.

- 2000 Bifacial Flake-Core Reduction Strategies and Other Aspects of Paleoindian Lithic Technology. Paper presented at the 65th Annual Meeting of the Society for American Archaeology. Philadelphia.

Wilmsen, E. N., and F. H. H. Roberts, Jr.

- 1978 Lindenmeier: 1934–1974: Concluding Report of Investigations. *Smithsonian Institution Contributions to Anthropology* 24. Washington, DC: Smithsonian Institution.

Wyckoff, D. G.

- 1999 Southern Plains Folsom Lithic Technology: A View from the Edge. In *Folsom Lithic Technology*. D. S. Amick, ed. Pp. 39–64. Ann Arbor: International Monographs in Prehistory.



13

TIME AS SEQUENCE, TYPE AS IDEAL: WHOLE-OBJECT MEASUREMENT OF BIFACE SIZE AND FORM IN MIDWESTERN NORTH AMERICA

Michael J. Shott

Common ways to measure and describe bifaces reduces them to linear dimensions—useful but as limited as are stick-figure depictions of people. Whole-object methods better represent form and reveal otherwise imperceptible variation. I examine size and form in triangular arrowheads from single-component assemblages in the central Illinois Valley forming a rough time series of A.D. 600–1400. Biface types that archaeologists define are considered approximations of ideal types, possessing historical, social, and practical meaning. In our poor approximation to whole-object measurement, types partition a time-dependent continuum of metric variation; they are abstractions, not real categories. Sometimes, how we look influences what we see.

The North American archaeological record is distinguished by its great abundance and diversity of bifaces. In a scant 13,000 years, perhaps more bifaces were made here than in all of Europe or Africa in Paleolithic times. Comparatively, North America is Biface Central. Such abundance is both a blessing and a curse. The blessings are obvious, but the wide variation in biface size and form hinder description and comparison. Variation is a good thing, but too much of it is a bad thing. Herein lies the curse.

This study concerns biface classification in time-ordered assemblages from the American Midwest. Bifaces cannot be studied without speaking of types, however defined and recognized. Ironically, types seem hard to define but easy to recognize, so the tendency is to slight typological theory and method in favor of the empirical business of creating types. Types are erected to impose order on the great diversity of the archaeological record, to ease description and comparison, and to reveal essential kinds that pattern by time, ethnicity, function, or other dimensions. It is scarcely possible to function as social beings without classifying people, things, and experiences. It is equally impossible to practice archaeology without classifying relevant parts of evidence and experience. My subject is bifaces, a category that itself engages typological assumptions about its reality and validity. Bifaces are real things; the category biface is a valid way to make distinctions among the manifest variety of things in the archaeological record. We cannot escape classification.

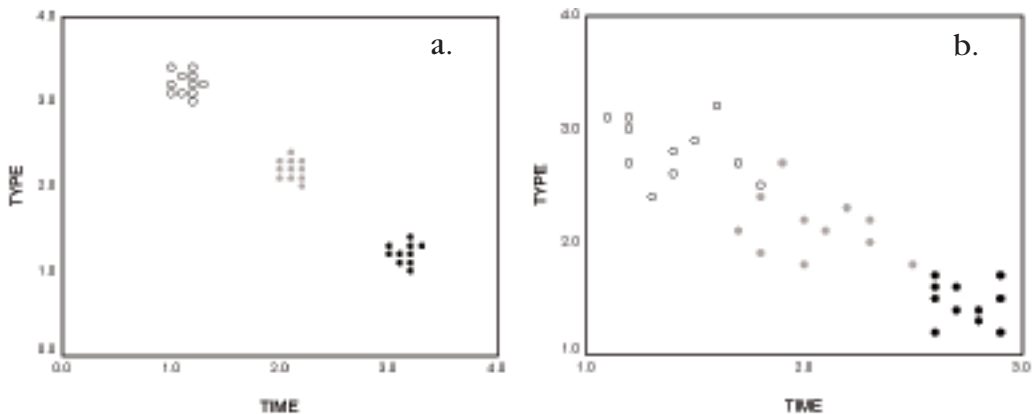


Figure 13.1 Patterns of object variation in time. (a) Ideal typological pattern, in which types appear as discrete, cohesive sets of objects. (b) Continuous pattern in which both discreteness and cohesion are weak.

Pottery and Lithic Classification

Pottery and bifaces are the most popular subjects of archaeological classification, and we often bring the same assumptions to and use the same methods in their classification. Yet they have salient differences that are not always appreciated. Trivially, sherds are fragments of pots. Pots were integral wholes and, until breaking, did not undergo significant change in size and form during use. At least in North America, most bifaces (i.e., points) that we sort into types were rather small parts of much larger composite tools, not integral wholes. This distinction is more than academic. Because most typed bifaces were hafted, the specimens perhaps should be subdivided into at least two elements: blade and stem. Moreover, many bifaces were resharpened and hence reduced by the nature of their use; they experienced significant continuous change in size and proportion during use.

Most pottery types are defined by combinations of technology (e.g., paste, temper) and decoration. Most biface types are defined by form and size, only secondarily by technology and not at all by decoration. Pottery types are defined mostly on categorical variables, biface types mostly on metric variables but also some categorical ones. The nature of the materials and their use make pottery much likelier to break into relatively small pieces of the original whole from which the vessel's size and form are not easily inferred. Size and form of the original whole vessel is secondary in most cases, and incidental in some, to type construction. By comparison, bifaces often are found intact, and only large pieces of the original whole can be used to define types. Size and form of that original whole—itsself part of a larger composite whole—is integral to type construction.

As a result, pottery types usually are defined by categorical decorative traits. By definition, categorical traits cannot vary continuously. Thus, the types formed tend to persist unchanged or little changed by embellishment or simplification, and then to disappear either abruptly or gradually. Pottery types do not ordinarily change into other types; instead, they cease to be, and are replaced by other types. They are archaeological approximations of essential types (Mayr 1988:15, 172). Biface types are defined chiefly but not entirely by continuous traits of size and form, most of which probably were grounded in function, and only secondarily in stylistic expression. Continuous variation

can be substantial and can occur within defined types. Such variation may be due to inexact technical or manufacturing standards, to drift or random error, or to function. Biface types can change measurably over time. They may disappear quickly or gradually, to be replaced by other types. But they may instead grade continuously over time from one type to the next. Biface types are archaeological approximations of empirical, not essential, types. Typological methods for essential types defined on categorical decorative grounds may not be well suited to empirical types defined on continuous functional grounds.

In a time series of defined types, the ideal pattern in either categorical or continuous data is discreteness. Figure 13.1a shows such a pattern, in which dots are objects, and types (y axis) are distinct clusters of objects that pattern in metric variables and sort out in time (x axis). However unlikely such patterns are in empirical data, pottery types seem closer approximations because they are based mostly upon patterns of association of discrete variables. A different pattern appears in Figure 13.1b. Here, the distribution of objects is patterned but the types lack internal cohesion; they are more dispersed and lack external isolation. The pattern is continuous; types exhibit no more differences between one another than within any one type.

Continuous and Episodic Change in Material Culture

To define biface types is to make distinctions that we hope are valid. There is agreement that, for some but not all purposes, stone is worth distinguishing from pottery, or among stone tools that bifaces are worth distinguishing from unifaces. There is agreement that finished bifaces are worth distinguishing from unfinished ones, although there is not always agreement on the grounds for distinguishing them or the particular specimens to distinguish rather than to group. Among finished bifaces, there is agreement that, for instance, late Pleistocene fluted bifaces are worth distinguishing from late prehistoric triangular ones because they are separated by 11,000 years and great differences of technology, size, and form. Probably we can agree that Late Archaic bifaces are worth distinguishing from Early Woodland ones, although the differences of time, technology, and form are much fewer. Indeed, in this case agreement probably is weaker, haggling over specimen assignment greater. Thus, challenges increase as differences of material, condition, technology, form, and time diminish. The nearer the convergence in any or all dimensions, the more problematic the distinctions and the greater the possibility that we split single hairs rather than separate distinct ones.

Typology partitions variation, and much variation registers in time. Naturally, then, typological practice influences our perception and resolution of time. We construct phases and mark them by diagnostic biface types in ways that emphasize the differences between them. We maximize variation between what we consider successive phases and minimize it within them. Erecting such types and building phases upon them, we perceive time as the passage from type to type and resolve time no more finely than the duration of types. Thus, we assume that variation in material culture is episodic, characterized as long periods of stasis punctuated by occasional furies of rapid change. This is a normative view of culture and the process of change. Taking it, we become the archaeological equivalent of biological saltationists (Mayr 1988:172).

Nowhere are normative views more problematic than in lithic studies. Bifaces vary at least as much in continuous, as in discrete, terms; we should be able to resolve time

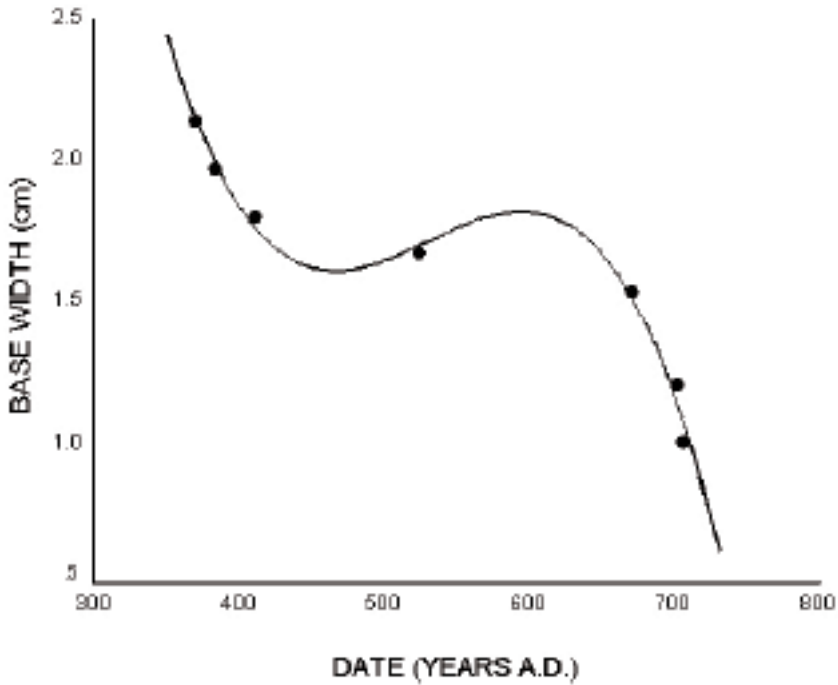


Figure 13.2 Continuous, time-dependent variation in base width, American bottom assemblages. Cubic regression line shown. (Source: Shott 1996 and unpublished data)

continuously in their patterns of variation. We can do this only by seeking time-dependent continuous variation in bifaces. Although we recognize metric and formal variation in bifaces, we ignore it more than explain it. Instead, sequences of point types through time are assumed to reflect vagaries of style or the episodic replacement of one culture by another. Even today, we tend to regard points largely as markers of cultural norms.

This view of variation is needlessly constraining. Type definitions, for instance, can be notoriously problematic in conception and certainly in practice. Archaeologists disagree on how to define types, what constitutes a particular type, and on the assignment of specimens to types. Types defined as similar solutions to typological challenges in different areas receive different names, requiring lengthy lists of concordances (e.g., Justice 1987). Archaeologists invest a good deal of the scarce time and effort in needless agonizing over such matters. We regard the imprecision of type definitions and the difficulties of assignment as disagreeable consequences of the need to impose chronological order on the archaeological record. We may even view them as products of lax standards of prehistoric artisanship. Less often do we regard them as a property requiring or deserving explanation, still more rarely as a source of exceptionally fine chronological resolution of change in the past.

For instance, a sequence of biface types is thought to characterize the period from roughly 1500-1000 B.P. in the American Bottom near St. Louis. The series of types was resolved, at least partly, as a time-dependent trend in biface mean metric dimensions;

much of the variation mapped onto types really is continuous variation in individual dimensions (Figure 13.2) (Shott 1996). These types were constantly becoming, but never arrived. Some may think that this case offers too little evidence, yet there are many other examples. It is especially evident in late prehistoric triangular bifaces across eastern North America (e.g., Geier 1983; George and Scaglione 1992; Kuhn 1996; Litfin et al. 1993; McManus 1985; Seaman and Munson 1980; Tuck 1971). Geier's (1983:Fig. 2) Appalachian Virginia data seems to show continuous metric variation through time. But variation was not the same everywhere. George and Scaglione (1992:79, Table 4) found that length, width, and thickness of western Pennsylvania Monongahela points all declined steadily through late prehistory. In the Mohawk Valley, length and width did not apparently pattern separately with time but length-width ratio, a measure of elongation, somehow did (Kuhn 1996:Table 2) such that points grew narrower through time. In central New York, a time trend toward longer and narrower (Tuck 1971:202) points developed. Interestingly, the trend in the northeast toward smaller points apparently reversed by protohistoric times. In western Europe, Mesolithic microlith assemblages also have been reimagined by discarding type concepts and examining instead continuous metric variation (e.g., Finlayson and Mithen 1997: Fig. 4). In whatever time and place, what is most important is that variation was not by discrete types of whole objects, but continuous change in individual or paired variables.

Traditional Approaches to Biface Classification

The archaeological literature on classification and typology is so voluminous as to defy synthesis. Broadly, object clustering and variable analysis are the most common approaches to classification. Object clustering acts on properties of objects as wholes, variable analysis on reduced or abstracted properties like dimensions of length, width, and so on. Object clusters *qua* types are best when internally homogeneous and externally distinct (Cowgill 1982:32, Fig. 3.1), but empirical data do not always pattern as felicitously as we might like. Often the patterns in object data are not perfectly typable (Cowgill 1982:35) because variation is as in Figure 13.1b (not 13.1a, above). Variable analysis decomposes objects into dimensions or other abstract properties. It does violence to the integral nature of objects, but when those integral natures are by-products of complex patterns of variation among variables, the violence is worth committing. It reveals significant patterns of variation not just between, but within defined types. Object clustering and variable analysis are complementary, not antagonistic (Cowgill 1982). Here, I aspire to the former but approximate it imperfectly via the latter.

Archaeologists have long sensed the problematics of biface classification, the difficulty of devising comprehensive systems of variables or attributes that definitively assign specimens to distinct types. This has not dissuaded them from classifying (Binford 1963; Black and Weer 1936; Justice 1987; Thomas 1981; Wilson 1899). Generally, we indulge one of two opposing urges: to classify subjectively by gross form and size or to devise elaborate schemes that include dozens of variables. The former involves object clustering, and might be called a *gestalt* approach; Hoffman (1985:570) normative-empiricist types often were formed in this way. The latter has no obvious name, but has obvious exemplars as a variable approach (Binford 1963; Thomas 1981). Normative assumptions underlie *gestalt* approaches. Types are material representations of ancient ideas (Justice 1987:6). Among attribute schemes, the simpler and less detailed the better, a judgment borne out

Table 13.1 Study Assemblages by Time-Ordered Phase

Phase	Assemblage(s)	Span
Meyer-Dickson	Meyer-Dickson	ca. A.D. 600
Maples Mills	Liverpool Lake, Mile Marker, Barrelhead, Grand Island 5, Cameron	A.D. 750-1000
Eveland	Eveland	A.D. 1100-1200
Orendorf	Orendorf	A.D. 1200-1275
Larson	Larson	A.D. 1275-1300

(Conrad 1991, 1999)

in the wide use of Thomas’s Great Basin scheme and the virtual neglect of Binford’s general but cumbersome one. Yet even the most widely used classifications, whether based on categorical variables or categorical and continuous ones, are imperfect because many specimens resist classification. Classification is confounded by what seems like “the infinite variation in...projectile-point form” (Black and Weer 1936:291), by reduction effects (Hoffman 1986), and by observer variation or error, among other factors.

Study Area and Data

Biface variation can be discussed in the abstract, typological or otherwise, but must be studied empirically. I studied bifaces from six central Illinois Valley assemblages or combined assemblages of similar affinity. Broadly, these are Late Woodland to Mississippian assemblages and phases occupying the interval from roughly A.D. 600 to A.D. 1400.

The Myer-Dickson component at Myer-Dickson consists of several dozen rubbish-filled storage pits scattered over perhaps 15 ha on the west bluff of the Illinois River near the mouth of the Spoon River. The sample was selected from features producing a pure Myer-Dickson ceramic sample, supplemented by specimens from the plow zone, which closely conform to the type sample. Maples Mills assemblages are from a series of settlements on the natural levees of the Illinois River and a single settlement in the upland interior between the Illinois and Mississippi Rivers. Eveland lies at the base of the west bluff of the Illinois River below Myer-Dickson and Dickson Mounds. It consists of about ten buildings, including two large council houses, two sweat lodges, a cruciform possible fire temple, and dwellings. Presumably Eveland was an administrative/ceremonial node. The sample was gathered from several buildings and features. Orendorf consists of five sequential settlements, at least some of which are fortified, on a naturally defensible bluff finger on the west bluff of the Illinois Valley. The sample was gathered from Settlement D, a burned, 5 ha, fortified town. Larson is an approximately 8 ha stockaded settlement located on the edge of the bluff overlooking the confluence of the Spoon and Illinois Rivers, approximately 1.5 km west of Myer-Dickson and Eveland. The sample derives from the stockaded settlement.

Table 13.2 Specimen Counts by Assemblage and Stem Form

Assemblage	notched/stemmed	unnotched	indeterminate ¹	total	% unnotched
Myer-Dickson	13	4	1	18	22.2
Bauer Branch	3	2	0	5	40.0
Liverpool Lake	11	5	0	16	31.2
Maples Mills assems.	7	15	0	22	68.2
Eveland	10	1	0	11	00.0
Orendorf	10	14	5	29	48.3
TOTAL	54	41	6	101	40.6

¹Most probably are notched triangles resharpened past original shoulders and notches.

Assemblages or phases are ordered in time based on radiocarbon dates, ceramic seriation, and context (Conrad 1991, 1999)(Table 13.1). In Conrad's opinion, all were briefly occupied or single-component sites or contexts with relatively homogeneous biface assemblages. Within the limits of chronological resolution, assemblages are taken to represent the range of variation in biface size and form at a series of intervals essentially discrete relative to the span of the entire series. They are the nearest archaeological approximations possible to the biface characteristics of a time-ordered series of isolated moments. Bracketing dates of phases in Table 13.1 are constructed from radiocarbon dating, typological cross-dating with seriated pottery assemblages, and stratigraphy and other contextual data. (Larson's radiocarbon dates fall on average approximately a century earlier than its Table 13.1 placement. Rim-height seriation also suggests earlier placement for Larson [Fishel 1995:76-77]). They do not necessarily measure the accumulation span of individual assemblages. Constructed phases are reasonably grounded units, although chronology construction from such sources can be problematic (e.g., Fox 1998). All bifaces are broadly triangular in general form. Fifty-nine are notched and 83 unnotched (Table 13.2). Several have broken blades and so could not be measured for blade variables. As a result, sample size differed between analyses depending on which variables were included.

This is a time-ordered series in which to seek either the comings and goings of discrete types (Conrad's [1999:1] phase-specific types) or more complex and perhaps continuous variation in form. I assume that assemblages contain specimens typical of those in ordinary use during each phase, and acknowledge but otherwise ignore the possibility that Eveland may be atypical because it comes not from a subjectively identified occupation site but a ceremonial and administrative node (Conrad 1999:3). In presenting results, I sometimes group Myer-Dickson and Maples Mills assemblages as early phases, and Eveland and Orendorf as late ones. As we explain below, I distinguish Larson from the others.

Some assemblages are dominated by notched triangles, others by unnotched ones. Some have roughly equal numbers of both (Table 13.2). There is no neat time-order to the count or proportion of notched triangles, although they are more common in earlier

assemblages overall. Obviously, unnotched triangles can be preforms rather than finished tools but those in our sample probably were finished. Certainly some were, because they underwent resharpening. Moreover, most late prehistoric bifaces across the Midwest were unnotched. Unless we wish to argue that the late prehistoric record preserves only preforms and that finished and notched triangles all were destroyed in use or somehow disappeared mysteriously, we must conclude that many or most unnotched triangles were finished tools.

Analysis

Biface Function

Biface is a general category that includes functional variants like spear, dart and arrow points. The sequence of assemblages spans the approximate interval of the dart-arrow transition in the Midwest (Shott 1993, 1996). First, I considered the possibility that the sample freely mixed dart and arrow specimens, which may be subject to different metric and functional constraints. If substantial numbers of both variants exist in the sample, it may be advisable to distinguish them in analysis.

Unable to measure thickness of bifaces, I could not apply most of the classification solutions used to distinguish dart and arrow points by their dimensions. But Shott's (1997:95) one-variable solution used only shoulder width. Applied to these data, it classified 69 of 73 measured specimens as arrow points. Only three Myer-Dickson specimens were classified as dart points. Therefore, I assume that all or almost all specimens were arrow points.

Paradigmatic Classification

Discrete attributes are used commonly in biface classification. Following Wilhelmsen (1997), I used discrete variables and continuous ones reduced to ordinal modes to produce a paradigmatic classification. Variables (Wilhelmsen's [1997: Fig. 6 "dimensions"], all from the stem, were base outline form, angle of inflection and orientation of inflection (Wilhelmsen (1997:5, Fig. 6). I omitted Wilhelmsen's lateral stem edge form for uncertainty in its description. Like Wilhelmsen, I confined classification to stemmed/notched bifaces. Because these are common only in early assemblages, classification was confined to Myer-Dickson and Maples Mills assemblages.

Angle of inflection was constant at Wilhelmsen's mode 4, orientation of inflection nearly constant at his mode 2. Essentially, these constancies of form made base outline the sole meaningful variable, reducing the paradigmatic classification to this variable only. Bases grow more concave from Myer-Dickson to Maples Mills assemblages (Table 13.3). In paradigmatic terms, these assemblages are virtually identical. If normative-empiricist views see several types in these assemblages, paradigmatic classification sees one. It may order assemblages that span longer chronological intervals but elides a great deal of metric variation in these data, so I also attempted to classify bifaces by metric dimensions.

Variable Analysis

There may be the presence of interesting continuous variation in what seem like sequences of distinct types. This suspicion was guided by Bradbury and Carr's (in press) demonstration that the biface types of the canonical Early Archaic Piedmont Sequence

Table 13.3 Modes in Paradigmatic Classification of Stemmed/Notched Bifaces

Base outline mode	Orientation of inflection			
	2	3	2	3
Myer-Dickson		Maples Mills		
1	10	0	6	1
3	2	0	3	0
5	0	0	5	0

(Coe 1964) are arbitrary partitions of a multivariate continuum of size and form variation. Clusters formed in analysis essentially cross-cut empirically defined types. Variation is not by the abrupt or even gradual replacement of one discrete type by another. Instead, it is continuous in metric dimensions.

Bradbury and Carr showed that how I look influences what I see. If I seek types as discrete modes in continuous variables or distinct clusters in categorical variables, I will find them no matter the nature of variation in the data and the ontological status of the type construct. If, however, I do not seek them but design analysis to reveal them if they exist, whether I find them is an empirical matter.

Methods

If most biface variation is functional, then the methods used for pottery typology may be irrelevant to bifaces. No doubt lithic equivalents of pottery type are useful in some cases. Generally, though, continuous functional change is best measured using variable, not object-clustering, approaches. Typically, we accomplish this by measuring orthogonal dimensions of stone tools. There is nothing wrong intrinsically with this practice. Obviously, however, it is a limited depiction of tools in the same way that stick-figures are limited depictions of the human form. Any measurement scheme short of complete three-dimensional mapping of each point on a biface's surface must be limited. But we should consider other measurement schemes because, however limited, they may reveal variation in object size and form not easily measured by orthogonal dimensions. I aspire to, but have not nearly reached, McPherron and Dibble's (1999) and Nowell et al.'s (2000) technical virtuosity in digital imagery, which is probably superior to both orthogonal and polar dimensions and electronic measurement of object silhouettes. Eventually I hope to use digital imagery to measure specimens. Until then, I content ourselves with the use of polar, not orthogonal, coordinates. This approach remains a variable one, but seems a somewhat closer approximation to whole-object form than do conventional orthogonal schemes.

The choice has precedents. Hoffman's (1985) now-classic study was perhaps the first well-known use of polar coordinates in the study of North American bifaces. Figure 13.3 shows Hoffman's (1985:Fig. 18.12) measurement scheme. Like all systems, polar coordinates presume a standard orientation of specimens and the accurate location of

the second parallel to the first at the point of greatest stem width (Bradbury and Carr in press: Fig. 2). From the midpoint of the latter line, Bradbury and Carr projected a perpendicular line whose intersection with the first line marked a point used to orient specimens (Figure 13.4). Unlike Bradbury and Carr (in press: 3-4), however, I used the midpoint of this line as our controlling landmark. From there, I measured the distance along polar-coordinate axes, blade length, and stem length, all in mm.

At a minimum, biface plan views include two major segments: blade and stem. Their juncture can be difficult to locate in bifaces like lanceolates and triangles, or in any heavily reduced specimens. Some Illinois Valley triangular bifaces have visible inflections or indentations on their margins, which surely are resharpening effects. In such cases, the inflection point could be treated as the haft-blade juncture. Because many triangular bifaces lack such points, however, most could not be measured. This left no choice but to omit them, and to confine analysis to notched specimens or unnotched ones with pronounced shoulders.

I used polar-coordinate data to estimate width at various intervals along specimens' blades and stems, following Bradbury and Carr. However, I omitted width between points z1 and z2 because the frequent and considerable asymmetry in blades is especially pronounced there, which is near the tip. Values resulting from calculating the distance between points z1 and z2 often would be oblique, not perpendicular, to the specimen's long axis. I also omitted width between h1 and h2 because it often defined merely an arbitrary segment of base width. Distance between g1 and g2 also sometimes exhibited some arbitrary value smaller than complete stem or base width, but I retained it because usually it encompassed base width. Then I calculated scale-free shape variables from these values (Bradbury and Carr in press: 6). For various analyses, therefore, I used combinations of 18 polar-coordinate values, seven width values approximately perpendicular to specimen long axis, seven shape values at the same locations, and two orthogonal measures, maximum blade length (not necessarily normal to the long axis), and stem length. This treatment, like Bradbury and Carr's, reduced specimens to two dimensions. It also recreated orthogonal measures of width from polar-coordinate data. Methods did not treat objects as wholes, but at least reduced them to more dimensions than do conventional orthogonal measurement schemes.

Hoffman examined variation in a type or class of large, stemmed Late Archaic bifaces. He suspected that most variation was from blade reduction, not normative typological differences. Indeed, defined types largely apportioned a continuum of blade reduction in a single stemmed class (Hoffman 1985:Fig. 18.16). Substantially, continuous variation was by reduction, not time, ethnicity or function. Bradbury and Carr (in press) examined variation in a set of mostly notched Early Archaic biface types. Although some variation owed to resharpening, they suspected that defined types apportioned a chronological continuum of variation in stem size and form. Bradbury and Carr ignored blades (at least for some analyses), held reduction constant, and examined variation that they interpreted as

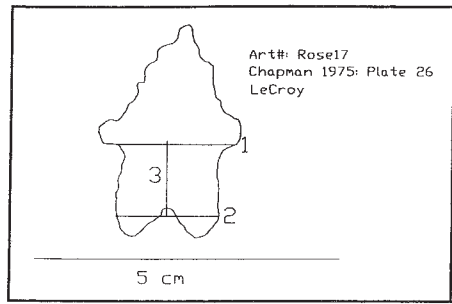


Figure 13.4 Bradbury and Carr's Reference Lines. (Source: Bradbury and Carr in press: Fig. 2).

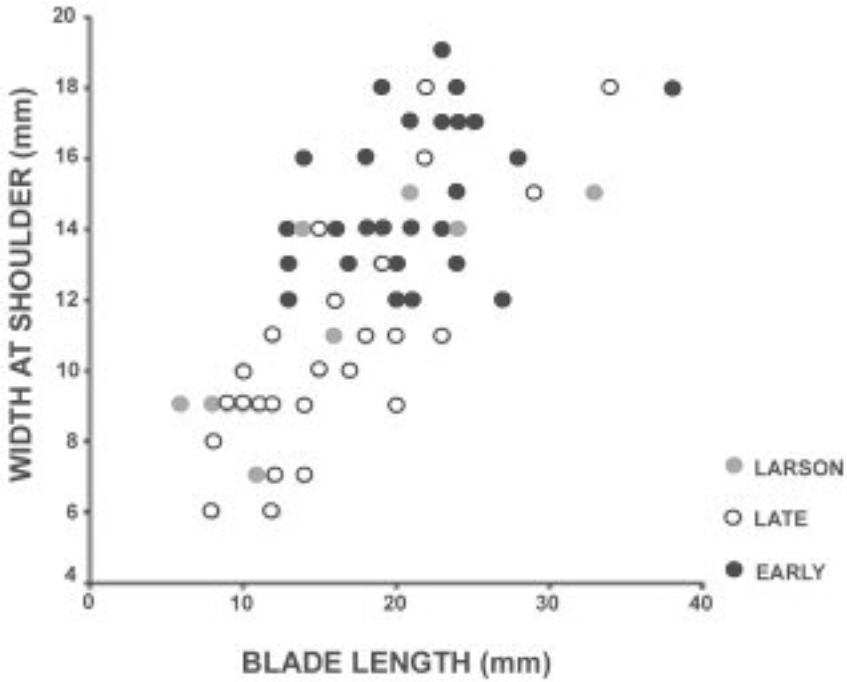


Figure 13.5 Shoulder width against blade length in Central Illinois Valley notched/stemmed bifaces.

time-dependent, simultaneous change in size and form. Variation was produced chiefly by means of change through time in stems.

In my data, the range of play for reduction is much less because late prehistoric arrow points are smaller than Archaic bifaces, and because arrow points are not as often or as extensively resharpened as are larger, multifunctional bifaces. Some variation must owe to reduction, but most to function or changing stylistic norms. Because much formal variation resides in stems, ordinarily covered in use by lashing and hence of little value in expressing style, function seems the likeliest source of variation. The question is whether functional variation is continuous and, if so, simple or complex, or whether it is categorical.

Results

Parsimony abjures multivariate statistics where simple ones suffice. The first task was to seek simple patterns of variation. Bivariate plots reveal relationships, although their orthogonal design makes orthogonal dimensions most suitable to examination. Shoulder width (d1-d2) against maximum blade length shows a typical pattern of positive correlation (Figure 13.5). (Maximum blade length is not necessarily normal to the long axis, but I ignore that slight complication.) Early- and late-phase assemblages overlap and do not form distinct, cohesive clusters. There is continuous variation here, not discrete

types, albeit in a plot of two variables only. But later-phase specimens range more narrowly on both variables; within their narrower overall range on blade length, early-phase assemblages vary widely in shoulder width. In later-phase assemblages, blade length and shoulder width seem more closely correlated. In some respects, however, variation is discontinuous or at least weakly continuous. In several dimensions, including shoulder width (Figure 13.6), phase assemblages seem to resolve into reasonably distinct sets of larger (earlier, including Myer-Dickson and Maples Mills assemblages) and smaller (later, including Eveland and Orendorf) modes. Larson seems to fall between them. (Again, Fishel [1998] made similar observations from ceramic data.) Admittedly, there is great overlap in ranges of values, so the sets are not especially distinct.

Testing for Reduction Effects

Many specimens from Eveland and Orendorf and one from Larson are double-notched (i.e., they bear two pairs of opposing notches); one specimen is triple-notched. All Myer-Dickson and Maples Mills specimens are stemmed or single-notched. Double-notching may be a design attribute for especially secure hafting. Alternatively, it may be an expedient practice connected with reduction and intended to refashion a resharpened specimen with a shorter base (i.e., it may be a way to increase blade length, even after resharpening, by reducing stem length).

I tested for differences in dimensions between single- and double-notched bifaces, finding none. In particular, single- and double-notched specimens did not differ significantly in maximum blade length, stem length or maximum width, or blade asymmetry. Granted, double-notched bifaces have slightly shorter and narrower blades, and are slightly more asymmetrical than are single-notched ones. But differences seem not to owe to

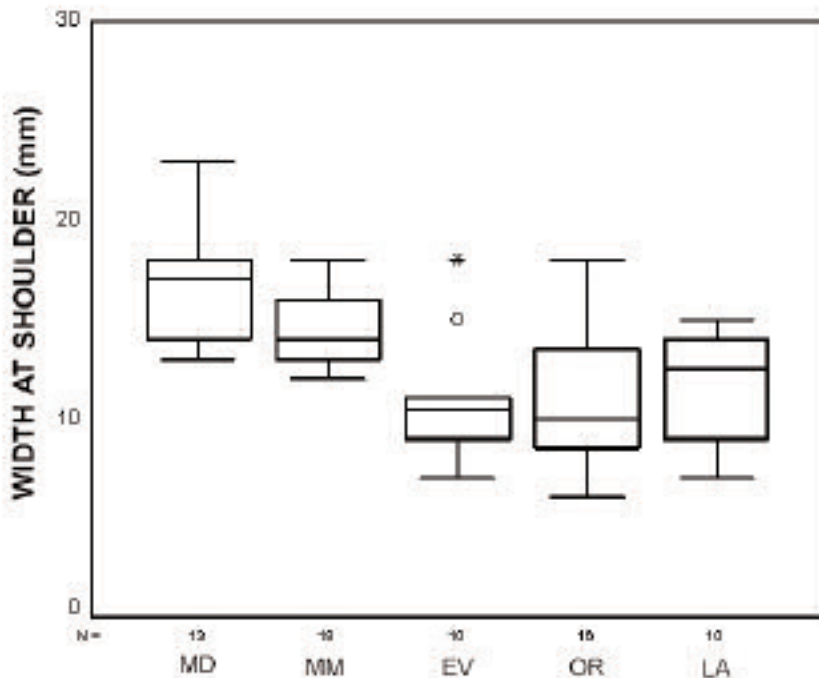


Figure 13.6 Box-plots of shoulder width by time-ordered assemblage. MD=Myer-Dickson, MM=Maples Mills, EV=Eveland, OR=Orendorf, LA=Larson.

size in ways that can be attributed to resharpener. This judgment was reinforced in analysis, because omission of double-notched specimens did not substantially alter results of multivariate analyses that used blade variables.

Multivariate Analysis

Multivariate statistics should be used advisedly and only if simpler statistics do not suffice. Among their limitations are that multivariate methods do not detect unusual or complex patterns of covariation (McPherron 1994:62-5). I screened for such patterns and found none.

Cluster Analysis

Bradbury and Carr used cluster analysis to group specimens into the number of empirical types thought to be represented in them. If the types were valid or at least reproduced by cluster analysis, then nearly all specimens assigned to a particular one should fall in the same cluster; instead, empirical types and multivariate clusters did not co-occur. Indeed, specimens classified as LeCroy bifaces were scattered nearly evenly among clusters (Bradbury and Carr in press: Table 2). Generally, however, specimens of any empirical type were assigned to that type's cluster or the cluster representing chronologically adjacent types. Types partitioned a complex but continuous pattern of variation.

Like Bradbury and Carr, I grouped specimens into *de facto* types by K-means cluster analysis, setting the number of clusters equal to the five phases. Results differed little in separating or combining blade and stem variables, in clustering by size, shape, or both sets of variables, and in using original polar-coordinate or orthogonal measures. In all cases, the clusters formed cross-cut assemblages or phases but tended to group specimens from successive phases. These types cross-cut the fine divisions of time defined by assemblages. Table 13.4 shows results for stem-shape variables. (Two clusters containing few cases were omitted from the table.) Cluster 1 dominates early phases, Cluster 3 later ones; Cluster 2 patterns ambiguously with time. In this solution and all others, chronological patterning would be clearer if Larson were placed before Eveland and Orendorf (Table 13.4), as its radiocarbon dates and rim-height data would suggest.

Also like Bradbury and Carr (in press: 8), I realized that correlation between original variables can affect cluster analysis. Like them, therefore, I performed principal components analysis on all size and shape variables for both blade and stem. The four resulting components explained 88% of variation, not an unusually high figure considering the number of components involved. The virtue of this measure is that components of necessity are independent, eliminating the problem of variable correlations. Again, clusters formed cross-cut phase assemblages (Table 13.5), although Larson is not conspicuously out of order by frequency seriation.

Examining Variation Via Principal Components Analysis

Clusters do not pattern neatly between assemblages. They resist forming types that pattern clearly with time. Whatever the general validity of the normative-empiricist type concept, it may not reveal underlying patterns of variation in these data. Clustering of original variables, polar or orthogonal, serves the above heuristic purpose but is problematic owing to correlation between some of the variables. Therefore, I carried out further

Table 13.4 Specimens by Cluster Assignment, Stem Shape Variables

Cluster				Cluster			
Phase/Assemblage	1	2	3	Phase/Assemblage	1	2	3
Myer-Dickson	13	0	0	Myer-Dickson	13	0	0
Maples Mills	15	2	1	Maples Mills	15	2	1
Eveland	1	0	9	Larson	5	2	3
Orendorf	1	4	10	Eveland	1	0	9
Larson	5	2	3	Orendorf	1	4	10

Left: Original order of assemblages; *right:* Reordering by rough frequency seriation.

principal component analysis (PCA) on several combinations of variables. PCA reduces complex variation to its major dimensions, which by design are independent of one another. These properties lend its results greater validity and interpretive clarity.

Principal component analysis results were generally similar. All combinations of original variables yielded at least three components with eigenvalues exceeding 1.0 that accounted for most variation in the data. I summarize results graphically. Figure 13.7 is a cross-plot of PC1 and PC2 among size variables only for both blade and stem. PC1 is a general size component, PC2 a base size one. For ease of interpretation, I group Myer-Dickson and Maples Mills assemblages as early phases, Eveland and Orendorf as later ones, and show Larson separately owing to its unusual patterning in time. Certainly, phase assemblages do not form discrete clusters. Instead, patterning is complex but early-phase specimens tend to be large, with relatively small bases. Because most early-phase bifaces fall in a fairly dense swarm near the plot's center (save a few Maples Mills specimens), they seem to be relatively uniform in size and in base size. Most later-phase spec-

Table 13.5 Specimens by Cluster Assignment, Principle-Component

Cluster					
Phase/Assemblage	1	2	3	4	5
Myer-Dickson	7	1	1	1	0
Maples Mills	9	5	3	1	0
Eveland	0	0	4	4	2
Orendorf	1	2	5	3	5
Larson	0	1	5	1	3

Scores as Input Values.

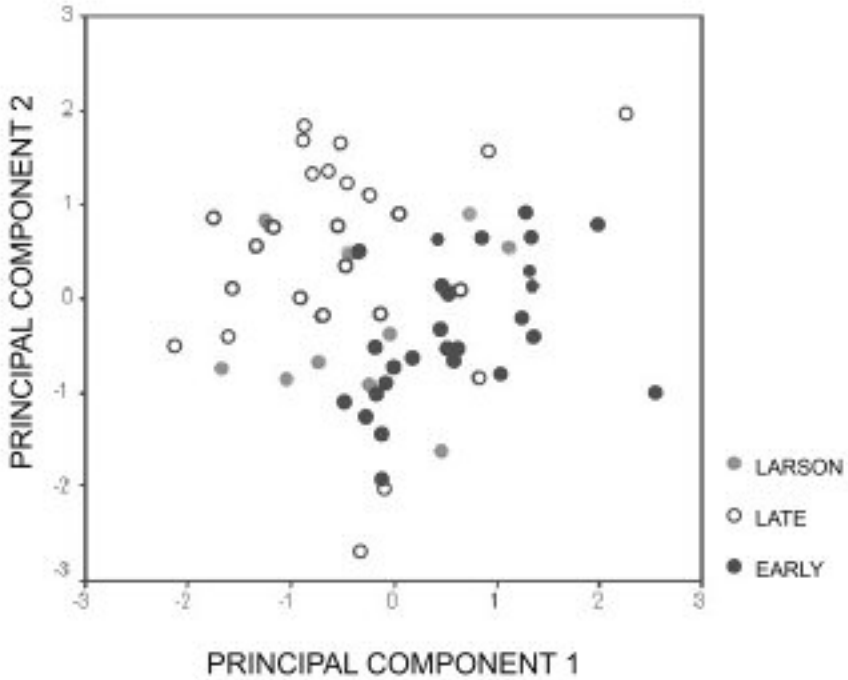


Figure 13.7 Cross-plot of PC1 and PC2 in blade and stem size variables.

imens are smaller (i.e., have negative values on PC1), but their distribution is much more scattered; they are more variable. Most of them have large bases (high PC2 values) but a few have the lowest PC2 values of all specimens. Broadly, earlier-phase bifaces lie near the plot's center, later-phase ones toward the edges, especially to the left (toward smaller size) and top (toward larger base size).

Figure 13.9 is a cross-plot of PC1 and PC2 among shape variables only, for both blade and stem. The distribution is more diffuse than in Figure 13.7, but similar in form. Here, PC1 is a blade-narrowness and haft-smallness component. PC2 is a stem form, especially breadth, one. Again, early-phase assemblages are toward the center (average to somewhat broad blades, relatively wide stems) and somewhat more tightly clustered, therefore more uniform, than later-phase ones. The latter again are peripheral and diffuse, therefore more variable and especially skewed toward narrow blades and wide stems.

Figure 13.9 is a cross-plot of PC1 and PC2 among size and shape variables, for both blade and stem. PC1 is a blade length and width, therefore size, and stem smallness component; PC2 measures mostly stem width. Again, early-phase specimens cluster near the center, and are relatively uniform, especially on PC1. Again, late-phase specimens are more diffuse and peripheral. Now, however, all but a few are on the left side of the plot, clustering near mid-range values for stem width but low ones for blade length and width and stem smallness (hence they have large stems). With considerable variation, the general trend from early to late-phase specimens is toward modestly large blades on stems of

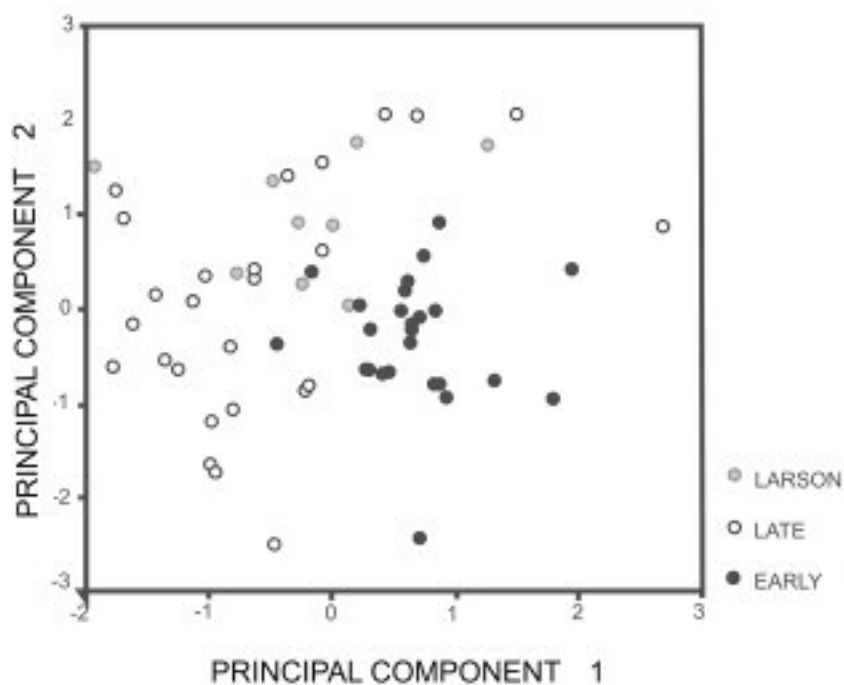


Figure 13.8 Cross-plot of PC1 and PC2 in blade and stem shape variables.

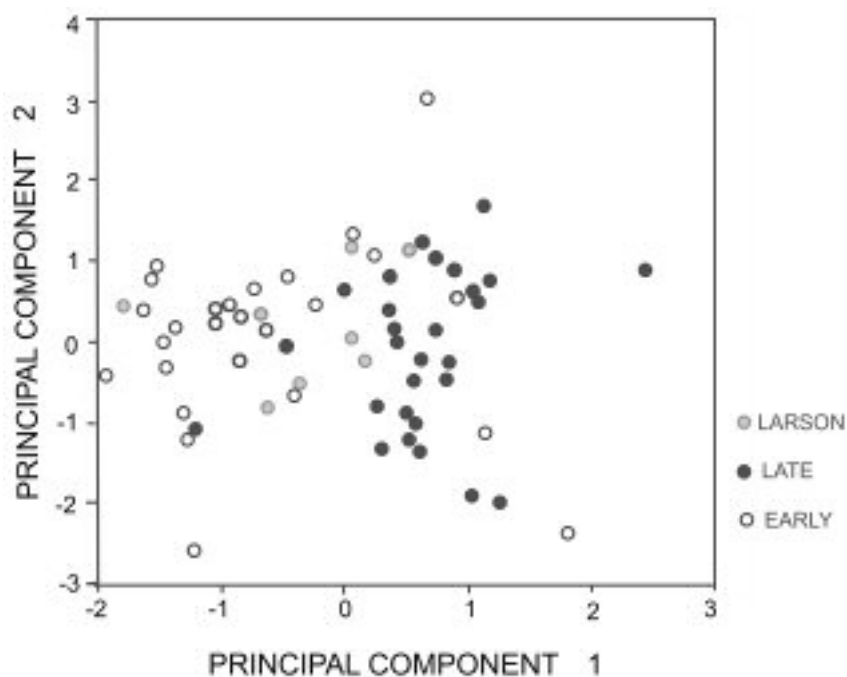


Figure 13.9 Cross-plot of PC1 and PC2 in blade and stem size and shape variables.

varying width to short, narrow blades on stems of uniform width. Early stem size and form is more variable. Later blade length and width are more variable, stem size more constrained.

Summarizing Pattern in Multivariate Data

The existence of types in biface assemblages is an empirical question, not an a priori assumption. So far as this analysis suggests, central Illinois Valley bifaces vary in interesting and comprehensible ways, but typology does little to illuminate the variation. Instead, it is complex and largely continuous. Whatever the collective properties of biface assemblages, the only types I legitimately may speak of were constantly arriving, never arrived. Biface size and form changed over time, but not as a succession of discrete types. Not seeking the complex continuous variation revealed here, I would not find it. Not finding it, I would not attempt to explain it, which must be a future goal.

Conclusion

To define valid types we must decide what variables are salient, and understand the causes of the variation residing in them. That is, we must define types theoretically, not empirically. This is an ironic conclusion, because I made no such effort in this study, instead using both variables and methods that were inductive. If we expect that biface variation has functional causes, we must define functional variables and classify specimens by them. Then we can gauge direction and rate of functional change through time. If biface variation is stylistic, we must determine which variables best register style.

North American biface classification remains unsystematic. We use variables but do not justify them theoretically. We define types in many ways with varying degrees of rigor. Such practice is consistent with the view that types are constructed, and we should classify in many ways. But construction must be guided by standards, and we have none. We use no common variable and coding scheme for basic description and measurement. Lacking common terms of description, we cannot compare bifaces from different areas nor gauge properly changes in biface form and size over long periods. For stemmed and notched bifaces, Thomas's (1981) scheme seems to work reasonably well in the Great Basin. Without prejudging the question of its broader geographic merits, and contingent upon theoretical grounding of its variables, perhaps we might use it generally with some adaptation to local circumstances. If it proves unworkable, we can devise a better replacement. This is no brief for narrow typological rigor, a cookbook approach to biface classification. It is merely to advocate more systematic, more replicable and therefore more comparative biface measurement and coding.

References

Binford, L. R.

- 1963 A Proposed Attribute List for the Description and Classification of Projectile Points. In *Miscellaneous Studies in Typology and Classification*. A. L. White, L. Binford, and M. Papworth, eds. Pp.193–221. Ann Arbor: University of Michigan Museum of Anthropology.

Black, G. A., and P. Weer

- 1936 A Proposed Terminology for Shape Classification of Artifacts. *American Antiquity* 1:280-294.

Bradbury, A. P., and P. J. Carr

- n.d. A Method for Quantifying Size and Shape Dimensions of Hafted Bifaces. In *Lithic Analysis at the Millennium*. N. Moloney and M. Shott, eds. London: Archetype.

Coe, J. L.

- 1964 Formative Cultures of the Carolina Piedmont. *Transactions of the American Philosophical Society* 54(5).

Conrad, L. A.

- 1991 The Middle Mississippian Cultures of the Central Illinois Valley. In *Cabokia and the Hinterlands: Middle Mississippian Cultures of the Midwest*. T. Emerson, and R. Lewis, eds. Pp. 119-156. Champaign-Urbana: University of Illinois Press.
- 1999 Toward a Chronologically Significant Classification of Arrowheads from the Central Illinois River Valley. Paper presented at the 64th Annual Meeting of the Society for American Archaeology, Chicago.

Finlayson, B., and S. Mithen

- 1997 The Microwear and Morphology of Microliths from Gleann Mor. In *Projectile Technology*. H. Knecht, ed. Pp. 107-129. New York: Plenum.

Fishel, R. L.

- 1995 A Preliminary Analysis of Mississippian Jar Rim Heights from the Central Illinois River Valley. *Illinois Archaeology* 7:69-81.

Fox, G. L.

- 1998 An Examination of Mississippian-Period Phases in Southeastern Missouri. In *Changing Perspectives on the Archaeology of the Central Mississippi Valley*. M. O'Brien and R. Dunnell, eds. Pp. 31-58. Tuscaloosa: University of Alabama Press.

Geier, C. R.

- 1983 Some Thoughts on the Taxonomic and Temporal Implications of Late Woodland and Triangular Projectile Points from Sites in the Ridge and Valley Province of Virginia. *Quarterly Bulletin of the Archaeological Society of Virginia* 38:197-233.

George, R. L., and R. Scaglion

- 1992 Seriation Changes in Monongahela Triangular Lithic Projectiles. *Man in the Northeast* 44:73-81.

Hoffman, C. M.

- 1985 Projectile Point Maintenance and Typology: Assessment with Factor Analysis and Canonical Correlation. In *For Concordance in Archaeological Analysis: Bridging Data Structure, Quantitative Technique, and Theory*. C. Carr, ed. Pp. 566-612. Kansas City, MO: Westport Press.

Justice, N. D.

- 1987 *Stone Age Spear and Arrow Points of the Midcontinental and Eastern United States: A Modern Survey and Reference*. Bloomington: Indiana University Press.

Kuhn, R. D.

- 1996 A Comparison of Mohawk and Onondaga Projectile Point Assemblages. *Journal of Middle Atlantic Archaeology* 12:27-34.

Litfin, J. C., P. C. Jackson, and K. D. Vickery

- 1993 A Chronological Seriation Approach to Fort Ancient Triangular Arrowpoints in the Central Ohio Valley. Paper presented at the 58th Annual Meeting of the Society for American Archaeology. St. Louis.

Mayr, E.

- 1988 *Toward a New Philosophy of Biology: Observations of an Evolutionist*. Cambridge: MA: Harvard University Press.

McManus, J. M.

- 1985 An Analysis of the Lithic Artifact Assemblage from the Forbush Creek Site (31Yd1), Yadkin County, North Carolina. *Southern Indian Studies* 34:3-48.

McPherron, S. P.

- 1994 A Reduction Model for Variability in Acheulian Biface Morphology. Ph.D. dissertation, Department of Anthropology, University of Pennsylvania.

McPherron, S. P., and H. L. Dibble

- 1999 Stone Tool Analysis Using Digitized Images: Examples from the Lower and Middle Paleolithic. *Lithic Technology* 24:38-52.

Nowell, A., K. Park, D. Metaxis, and J. Park

- 2000 Biface Variability and Deformation Modeling. Paper presented at the 65th Annual Meeting of the Society for American Archaeology, Philadelphia.

Seeman, M. F., and C. A. Munson

- 1980 Determining the Cultural Affiliation of Terminal Late Woodland-Mississippian Hunting Stations: A Lower Ohio Valley Example. *North American Archaeologist* 2:53-65.

Shott, M. J.

- 1996 Innovation and Selection in Prehistory: A Case Study from the American Bottom. In *Stone Tools: Theoretical Insights into Human Prehistory*. G. Odell, ed., Pp. 279–309. New York: Plenum.
- 1997 Stone and Shafts Redux: The Metric Discrimination of Chipped-Stone Dart and Arrow Points. *American Antiquity* 86–101.

Thomas, D. H.

- 1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3:7–43.

Tuck, J. A.

- 1971 *Onondaga Iroquois Prehistory: A Study in Settlement Archaeology*. Syracuse: Syracuse University Press.

Wilhelmsen, K. H.

- n.d Events of Manufacture Ordered by Attribute-Scale Occurrence Seriation. In *Lithic Analysis at the Millennium*. N. Molone, and M. Shott, eds. London: Archetype, In press.

Wilson, T.

- 1899 Arrowheads, Spearheads, and Knives of Prehistoric Times. *United States National Museum Annual Report for 1897*, 1:811–988. Washington, DC.



14

AN OVERVIEW, WITH SOME THOUGHTS ON THE STUDY OF BIFACES

Derek A. Roe

This chapter offers an overview of this published record of the conference session, first considering some of the general points that arise and then commenting briefly on each chapter. The author concludes with a few brief thoughts on points that particularly interested him during his reading of the edited texts, based on his own experience of studying bifaces in Britain and Africa.

It is a pleasure and a privilege to be invited to contribute a closing chapter to this volume. Sadly, I was unable to attend the conference session at which these papers were given: it looks to have been a very interesting and worthwhile occasion. For the purposes of writing this paper, I have been sent the typescripts of all the contributions, and most of the accompanying illustrations. It seemed appropriate to attempt some kind of general review of them, and then to add some brief comments arising out of a selection of points the various authors have made.

My own experience of studying bifaces goes back to my doctoral research at Cambridge University on handaxe groups of the British Lower and Middle Paleolithic, in 1961–67. Indeed, it starts just a little earlier than that. I had the great good fortune as an undergraduate at Cambridge to be a contemporary of the late and much-missed Glynn Isaac, and in the later stages of our course Glynn and I used to go each week, together with S.G.H. Daniels, to read our student essays on Palaeolithic Archaeology to Dr (later Professor) C.B.M. McBurney. Charles McBurney was a fine teacher, always interested in new methods and techniques: for example, it may be forgotten by many that he made pioneering experiments with microwear analysis of flint tools in the early 1960s, and it is not surprising that he was also an early exponent of the metrical and statistical analysis of stone artifacts, including handaxes (see for example West and McBurney 1954:145–54). His work in the latter field was quite independent of that of François Bordes, by which he was not initially impressed (145–46). McBurney encouraged Glynn and myself to experiment with measuring stone tools, using British Acheulean material, which we did, and in the event we both continued what we began then, in different ways, when we became research students (see also Roe 1989:82–83). I had actually devised the first version of my tripartite shape diagrams for handaxes, to which some of the authors in this volume refer, before the end of my second undergraduate year, and I subsequently developed the same ideas as part of my doctoral research (Roe 1964, 1968). For Glynn, the early experiments certainly played an important role when he came to develop ana-

lytical methods for African stone artefacts in the course of his superb study of the Olorgesailie Acheulean assemblages (Isaac 1977): the African material posed some interesting new metrical problems, which we had not encountered in Britain. I was to discover that for myself, when I first went to Africa to study the Kalambo Falls Large Cutting Tools for Desmond Clark, and the Olduvai Gorge handaxes and cleavers for Mary Leakey, soon after the completion of my doctorate.

Although it remains perfectly valid, much of the work to which I have referred belongs to those heady early days of metrical and statistical analysis in Palaeolithic archaeology, which few will now remember, not merely before the age of computers, but even before the age of affordable pocket calculators and, indeed, before the first use of the phrase “mental template.” Not everything we tried worked: I remember, for example, a hilarious morning in Cambridge in 1960 or 1961, during which Glynn and I tested experimentally Charles McBurney’s belief that the volume of a handaxe could be easily and accurately calculated by displacement of millet seed from a wooden box, and established that the method was, to put it mildly, highly unreliable. This is really no place to indulge in personal reminiscences, but there is an important point to make. In measuring each implement laboriously by hand, and also processing the results manually, we got to look very closely at each specimen, usually several times, and hence to see exactly what were the differences of morphological detail (often reflecting factors of technology) that were causing our measurements and ratios to vary, and just how the variation in individual specimens contributed to the group means and standard deviations that were the prized outcome of much time-consuming calculation. One simply cannot obtain individually by hand some 38,000 items of metrical data (some of them being absolute measurements and others ratios) from British handaxes, as I did, without coming to know the British handaxes quite well.

It is not easy to convince the present generation of students that this is how things necessarily used to be. The price that may sometimes have to be paid for using the array of technological wizardry now available to lithic analysts, which we all take for granted, is a much lesser degree of acquaintance with the objects actually being studied. Indeed, it is possible to offer new pronouncements on stone tool assemblages, and doubtless on their implications for past human behavior, without ever seeing or handling the artifacts themselves, but simply using and manipulating numerical data recorded, stored and made available by someone else. How very old-fashioned of me to think that there might be something wrong with that, and also to be delighted that the contributions in this volume are mainly based on careful first-hand study and personal collection of data.

Reviewing the Contributions

General Considerations

It is interesting to note the differing extents to which the various authors feel it necessary to offer any definition of the term ‘biface.’ Not unreasonably, most assume that the titles of their articles, and the readers’ own knowledge, will make clear the nature of the tools they are discussing. For a few, notably Bamforth, the chosen topic makes a fuller consideration of the term *necessary*. All but two of the titles include the word “biface,” “bifaces,” or “bifacial.” Of the two exceptions, Nowell and her co-authors refer to “handaxe morphology,” whereas Aubry and his colleagues directly specify Solutrean laurel leaf

points. It is thus perhaps worth considering briefly what is actually meant by the term "prehistoric bifaces" in the title of the volume.

A working definition might be that a prehistoric biface is an object of stone, dating from any part of the prehistoric period, which has been shaped by the deliberate removal of flakes from each of its two main faces. That definition would be broad enough to allow that bifaces could be finished tools of various kinds (complete or fragmentary), or unfinished versions of such tools ('preforms' or 'roughouts'), or cores that show substantial flaking from two opposed main surfaces. If we were defining "prehistoric bifacial tools" rather than "prehistoric bifaces", the cores would be cut out, but the roughouts and preforms could reasonably remain: the definition would then begin "a tool" rather than "an object." Because those authors in this volume who refer to cores are mainly discussing them incidentally, we need not pursue the discussion of a general definition any further.

It follows, however, that the term "bifacial technology" must refer to the general way in which tools of this kind are made. Whatever may have been assumed in the past, there is clearly no reason to suppose that all the different kinds of bifacial tools in prehistory have a closely linked relationship, or that a continuous "biface tradition" existed and contrived to remain distinct from a corresponding "core and flake tradition," in which the tools were made unifacially on flakes or other blanks. This point is made specifically by Otte and by Kozłowski, and in passing by several of the other authors. There are in fact only a limited number of ways of working stone to create tools (quite irrespective of time or place), and most of the methods involve the striking of flakes. But that can be of two kinds. Generally speaking, the flakes struck off in the shaping of a bifacial tool are waste products, while in a "core and flake" industry, the general principle is to strike from core flakes that are either directly usable as tools or, more often, are intended to be the blanks for tool manufacture by retouch of one sort or another, the exhausted core being a waste product. Alas for clear and simple definitions: confusion soon arises.

In the core and flake procedure, the desired useful flakes cannot be struck without the accompanying creation of a large quantity of waste flakes and fragments. This is balanced by the likelihood, in biface manufacture, that at least a few of the "waste" flakes struck off in shaping the tool might subsequently be used casually, or even selected for retouch. All of this is a part of what Ashton and White refer to as "flexible flaking," especially if we recognize that the very same people may on some occasions make bifaces and on others create unifacial tools by retouching flake blanks which had been deliberately struck from cores for that purpose. There is nothing that should surprise us about this: we know very well, for example, that just such flake tools may occur alongside the handaxes in typical Acheulean assemblages. There is also the point that in some Acheulean industries, the bifaces are actually made on specially struck flake blanks. On the other side, it is not unknown to encounter bifacial flaking in classic "core and flake" industries: for example, in his "chopper/chopping tool complex," Movius (e.g., 1955:261) defined choppers as flaked essentially unifacially and chopping tools bifacially. Simple bifacial handaxes are found in the later stages of the Oldowan.

As for what actually constitutes waste material, it would really require microwear analysis to confirm that amongst any particular set of unretouched flakes or blades there were none that had been casually or even systematically used for cutting or scraping tasks, because that certainly did take place (cf. Juel Jensen 1986, for good examples of Mesolithic age, and a general discussion). Even cores, which are usually classifiable as waste-products of knapping, are occasionally claimed to have had a brief second career

as “core-scrapers” or “chopper cores.” One may often feel doubtful about such diagnoses, because what may look like heavy utilization of a core edge or of a ridge between flake scars, is often no more than deliberate “scrubbing” with a hammerstone in the preparation or maintenance of a platform, as on many blade cores, or else post-depositional damage to an angular feature that is naturally vulnerable. Microwear analysis can again give interesting results: L.H. Keeley, studying British Lower Palaeolithic artifacts in the 1970s, found clear evidence that two of the pieces classified as “chopper cores” from the Golf Course Site at Clacton-on-Sea (Clactonian) and two from the Lower Industry at Hoxne (Acheulean) had indeed been used for chopping tasks (Keeley 1980:116, 140, 146). The others showed no such evidence.

Yet, when all the flexibility has been allowed for, we are still confronted with the phenomenon that some prehistoric artifact assemblages seem to display a strong tradition of bifacial tool manufacture, whereas in others, bifaces are virtually absent. The broad ‘Mode 1’ and ‘Mode 2’ classifications of Early Palaeolithic industries proposed by J.G.D. Clark (1977:23–38) offer a case in point, referred to by several of the authors. Explanation is certainly required, even if it may vary from case to case. If it can ever be satisfactorily shown that such differences relate to chronology, or to a genuine process of technological evolution, or to the traditional behaviors of different human groups, that would clearly be of the greatest importance. In the past, assumptions of precisely that kind were frequently made, although not often carefully argued.

If we turn more specifically to bifacial tools, similar explanations have traditionally been offered for clearly observable and often strong preferences for particular shapes or manufacturing styles at individual sites. Many of the authors contributing to this volume are concerned to suggest rather different reasons, far more in line with modern thinking, for such morphological and technological variability—for example, the constraining effects of particular rock types, or of the shapes and sizes of the units in which they occur at particular sources; or the differing immediate functions which the makers of particular sets of bifaces may have had in mind for their tools; or the way in which the morphology of tools at the time of their final abandonment may sometimes reflect lengthy histories of curation, reuse, and resharpening. It is a striking feature of this collection of papers that many of the authors quite independently make similar points of these kinds, and they are doing so in respect of sets of bifaces which are of very different ages, and come from quite different parts of the world: Acheulean bifaces from East Africa, India, Britain, and the Near East; late Mousterian bifaces from France; leaf points of Middle and Upper Palaeolithic age from Central and Western Europe; or projectile points and other bifacial tools from several parts of North America, ranging in age from Late Pleistocene to Late Prehistoric.

It is evidence of precisely these kinds that does indeed enable us to make the transition from the static situation of sets of bifaces, whether found *in situ* at an excavation site or merely encountered as an old collection, stored in boxes in a museum, to the dynamic reconstruction of past human behavior. When I chose to study Lower Palaeolithic handaxes, all those years ago, one reason was a vague belief that the effort and care which had gone into the shaping of such elegant bifacial implements was much greater than that involved in the casual use of an unretouched waste flake, or in the brief and often informal retouch which had created a flake tool, and that somehow there was a correspondingly greater amount of behavioral (I would then have said “cultural”) information waiting to be released, if one could only discover the key. Whether anyone would express it

quite so naïvely today, I am not sure, but it seems to me that similar thinking lies behind the title of this book. Although the individual authors are mostly offering case studies, the reader has the chance to draw them all together, and should not be disappointed with the result.

More Specific Points

The preceding section touches briefly on some of the general themes of this book and against that background, the individual contributions fall into natural groups.

Typical of its author's broad interests, Marcel Otte's "The Pitfalls of Using Bifaces as Cultural Markers" ranges widely across time and space, while professing to concentrate on Europe. He argues that, although the distribution of some specific biface types must reflect the migrations of particular people, the whole record of bifaces in prehistory is largely a matter of convergence—many of the occurrences of broadly similar tools can have no possible connection. The text of the paper is brief, but there is also much information in the figure captions that should not be overlooked.

Nowell *et al* include a particularly interesting discussion of the different kinds of standardization that can be perceived in handaxes and other tools. The undoubted existence of standardized biface types is crucial to most of the other chapters in this volume; whether their authors formally discuss it, it is something that is all too easily assumed to be explainable solely and directly in human behavioral terms. This particular contribution shows that some kinds of "coincidental" standardization have little or nothing to do with human behavior: its emphasis is mainly methodological, exploring techniques of establishing what factors may have created the standardization that can be observed in any particular case. The application of the methods to real archaeological data sets is published elsewhere.

All the other chapters are built around case studies involving chosen sets of bifaces, although they also include plenty of discussion of issues of general significance. We have already seen that many periods and areas are represented. The linking factor is that all the authors are seeking to account for the morphological range and preferences of their particular bifaces, and to decide whether the controlling factors are general principles of human behavior, or something more local and immediate. I can do no more in the space available here than make the briefest mention of each contribution, doing justice to none, and my comments are merely the thoughts of one reader: others, I am sure, will prefer to concentrate on very different aspects of this feast of archaeological information and commentary, as they make their way through the book. There is always the risk, too, when one has to refer so briefly to points which the authors have discussed at length, of summarising their actual views inaccurately: I hope I have not done that too often.

Clark and Schick provide a valuable account of the prolific Acheulean of the Middle Awash Valley in Ethiopia—a succession of stratified assemblages covering some 700,000 years of Early and Middle Pleistocene time, about which very little has previously been published. There are admirable examples here of many things that are of great significance to this volume: these include contemporaneity of Mode 1 and Mode 2 industries, some clear evidence for technological evolution of bifaces over time, clear association of stone artifacts with the carcasses of large animals (especially hippopotamus), and examples of individual Acheulean industries in which there are strong enough morphological and technological preferences for the authors to speculate that clear rules or conventions were being followed by the biface makers. In contrast, there are also assemblages whose

variability seems to be related to immediate environmental situations and other cases in which, when broadly contemporaneous occurrences are compared, the different size-ranges and compositions of the tool kits might suggest that different segments of the local population (in the sense of groups with different compositions of sex, age, and experience) were involved. There are also sets of tools whose ranges of size and morphology seem clearly influenced by resharpener and reuse.

East Africa is also the starting point for Noll and Petraglia, who study some of the excavated Acheulean assemblages from Olorgesailie, which they compare with those from selected sites in the Hunsgi and Baichbal valleys in south-central India—the latter still not nearly as well known as they should be, in spite of the excellent work by K. Paddayya and his colleagues over the last 25 years. The authors study the size ranges and to some extent the shapes of the Acheulean bifaces, and are particularly interested in the way in which their makers used the local sources of lithic raw materials. In both regions, there was a high discard rate for bifaces and little sign of curation, or indeed of long-distance transport of either raw material or finished implements. At the Indian sites, biface morphology can be seen to vary far more with differences in the actual raw materials used than is the case at Olorgesailie.

McPherron takes us firmly out of Africa to the Near East, to the great site of Tabun Cave on Mount Carmel, Israel, where it is still no easy matter to correlate the observations made by different excavators over so many decades of research. He reaches this destination via quite a long excursion into the British Lower Palaeolithic and the continuation of his debate with Ashton and White., which is not unreasonable, since they were all participants at this conference session. He confirms the validity of the “reduction model,” which he has proposed in a number of papers relating to biface variability, mainly in the Lower Palaeolithic of Britain and Northern France: I wonder just how surprised Ashton and White were to hear that this model works equally well at Tabun, where McPherron is building on the work done by G.O. Rollefson some 20 years ago—this paper being an interim report on his progress. The Tabun sequence is a long enough one for some chronological patterning of the bifaces also to be apparent; however, McPherron finds that raw material did not have much of a role to play here in determining biface morphology.

Many will be grateful to Doronichev and Golovanova for the mass of factual information they provide on the Lower and Middle Palaeolithic sites of the Caucasus region, backed by copious references. The exciting discoveries over the past few years at the immensely important early hominid site at Dmanisi in Georgia have drawn the archaeological world's attention firmly to this region, but there is very little general awareness, let alone understanding, of the later stages of the Lower Palaeolithic there, in which bifaces play an important but variable role, as indeed they do in its Middle Palaeolithic aftermath. The authors make a plea for new research using modern methods, and it is clear that we cannot meanwhile draw many clear conclusions about human behavior from the Caucasian industries which feature bifaces. However, there are clearly many sites here with great potential to yield such information, ranging from strategically located cave occupations with relatively sparse material to prolific manufacturing sites such as Satani-dar, Atis or Djaber, where the presence of high-quality rock sources was doubtlessly the decisive factor in site location and use. I wonder whether others beside myself will be struck by the resemblance of some of the Middle Palaeolithic bifaces figured by Doronichev and Golovanova to types associated with the Lupemban of Central Southern Africa. Is this just convergence of the type noted by Otte or could the routes

out of Africa that had earlier brought humans to the Caucasus area have still been occasionally operating?

Ashton and White resume the exchange of views on how best to explain morphological preferences in British handaxe assemblages, which has involved themselves, McPherron, J. McNabb, and several others over the past seven years or so—they cite the relevant references. It is pleasing, if rather surprising, to find that the idea of an “Ovate Tradition” and a “Pointed Tradition” in the British Acheulean, which I suggested more than 30 years ago, can still stimulate such productive and worthwhile discussion, even though our knowledge of the Lower Palaeolithic generally, and of the British Pleistocene succession, have advanced by some orders of magnitude since then. Ashton and White restate, with some embellishments, the raw material model which they continue to favor as a key explanation of the variability in British biface morphology; a study of handaxe roughouts reveals to them further “problems” in accepting McPherron’s reduction model at least so far as Britain is concerned. They are happy to allow for at least some human idiosyncrasy, and particular knapping styles, in handaxe manufacture, citing some nice examples from British sites, but for them, overall, the making of a biface was the practical realization of a “mental construct,” with the ovate form as the desired outcome, whenever the raw material allowed it.

Soressi and Hays offer the last of the studies of handaxe manufacture and use, this time involving not Acheulean bifaces but some from the late Mousterian of Southwest France. The site is Grotte XVI of the Le Conte Cliffs (Dordogne), which yielded 19 bifaces. Faced with the task of deciding whether these represent an expedient or a curated technology (as defined by Binford), the authors argue convincingly and with great elegance that the latter was the case, using a combination of analytical techniques. A study of the raw materials from which the bifaces were made, and the flake material which accompanied them, shows clearly that they had not been made in the immediate area of the site, although some reworking of their edges may have taken place there; some of them had clearly been reshaped after use. There was excellent microwear evidence to show that five had been used for working wood, and four in butchery; two others showed multiple uses (on bone and wood in one case and on hide or meat and wood in the other). Morphologically, they consistently showed a working edge opposite a blunt area designed for holding in the hand, and there was no evidence for hafting. This may be a small study relating to a single site, rather than a sweeping review of a whole region, but it certainly provides some excellent evidence directly linking bifaces to human behavior.

Perhaps to the relief of many, we can here turn from handaxes to other bifacial tool types, starting with leaf points, which have always held a great fascination for Palaeolithic archaeologists because they occur in many different cultural and chronological contexts, in many parts of the world. Kozłowski reviews the Central and Eastern European industries in which leaf points are found, drawing the rather scattered literature very helpfully together. He is able to show that the region’s leaf points have a great range in time, starting as early as OIS 10 as a Central European innovation which has nothing to do with Acheulean bifacial technology. Some are a part of the important “eastern Micoquian” tradition, from which they continue on into several of the industries which are transitional to the Upper Palaeolithic in Central and Eastern Europe, while others occur as a rather unexpected feature of the Southeast European Mousterian, in which Levallois technology plays a strong role—some have even called it “Levalloiso-Mousterian.” The dating of the various groups, and important differences in blank procurement and manufacturing

technology, help to show that the various leaf point occurrences are discontinuous and convergent, rather than closely related, which certainly has implications for human behavior.

The leaf points studied by Aubry and his co-authors are laurel leaves from the Solutrean, which is a relatively short Upper Palaeolithic episode with a fairly compact distribution in Southwest Europe (France and Iberia), dating from around the time of the Last Glacial maximum. They selected two quite separate groups of sites on the margins of the Solutrean distribution, respectively in the Creuse Valley and the Portuguese Estremadura, and have been able to reconstruct some remarkable details of the ways in which the larger and smaller versions of the laurel leaf points were made, used, and broken. Work at the French site of Les Maitreaux has been especially important in this. It is clear that rather special rock sources were needed for laurel-leaf manufacture: raw material, performs, or finished implements were transported over long distances, up to 60 km in some cases, suggesting an extensive network of contacts. Translucent flint was especially valued. There are many differences between the two study areas in the technological processes involved; one example being that heat treatment of the flint was used regularly in Portugal, but not in France. This chapter has much good information on human behavior, both general and detailed, derived directly from the study of bifaces.

The last three chapters in the whole set relate to North American biface assemblages. Shott's contribution involves the youngest study material, falling in the time-range c.600–1400 A.D., and he reminds us of the extraordinary abundance of bifaces in North America, which he refers to as "Biface Central." Whether he is really right in guessing that there are more bifaces in the North American archaeological record than in the whole of the African Palaeolithic, I am not so sure; in any case, no one is likely to go out and count, and the fact of abundance is not in question. Effective methods of study are therefore very important. He discusses carefully the archaeologist's need to classify many categories of evidence and the reality or otherwise of "types" within what may often be a spectrum of continuous variation. Bifaces offer a supreme example. There is general significance, accordingly, for the way in which Shott approaches the task of devising metrical and analytical methods for the study of this particular time-ordered series of hafted projectile points from the central Illinois Valley. He concludes that in this case biface size and form changed over time, but not as a succession of discrete types; indeed, "typology does little to illuminate the variation."

Bamforth's chapter is concerned with the use of bifaces by the Folsom and later Paleoindian people who were present on the Great Plains in the post-Clovis period around the end of the Pleistocene and during the opening millennia of the Holocene. He mounts a specific and evidently overdue challenge to that part of the traditional view of these peoples as "high-tech foragers," which asserts that they made and transported their bifaces with the intention that these would initially act as cores for flake production and only later become preforms for the manufacture of bifacial tools, being eventually fashioned into knives and projectile points. He argues effectively against this scenario, using evidence from a large number of sites in passing, but concentrating on the Allen Site in Nebraska as a particular case study. Although there is no doubt that implements and raw material were indeed transported over long distances, the mechanisms are quite different from what had been assumed. Many true cores existed, and were often taken to a succession of sites before abandonment. Few genuine flake tools were ever made from biface reduction flakes. Archaeologists must clearly give greater attention to the whole range of Paleoindian site types, rather than concentrating on just the kill sites, if the real role of

the bifaces and indeed the wider social and economic strategies of their makers, are to be understood.

Hofman is also writing about the Folsom people of the Great Plains, but he is concerned with what can be learned by studying the distribution of typical Folsom artifacts, including bifaces, made from certain high-quality lithic materials, in relation to the known sources of those particular rock types. He refers first to the Southern Plains region of New Mexico, Texas, and Oklahoma, where the established distribution of artifacts of Edwards chert westwards as far as 400 km from the source in central Texas is not balanced by any return movement of artifacts made of other rocks, which the Folsom people certainly used. This situation is interpreted as reflecting recurrent movements westward by the Folsom bison hunters, always taking with them sufficient equipment to achieve their intended quota of game, with no need to seek alternative lithic sources during the expedition; returning, they would have had things to transport that were at least temporarily more important than stone artifacts. Seeking to establish whether this might be a general or only a local pattern, Hofman here turns to the Central Plains in Northeast Colorado and western Nebraska, with the Nolan Site offering some key evidence, and he finds a very similar pattern, this time linked to the distribution of Flattop chalcedony. Again, unidirectional movement of lithics need not imply unidirectional movement of people, so much as a long-term pattern of recurrent movements by bison hunters in their subsistence quest.

Concluding Comments

There are several common themes relating to the manufacture and use of bifaces, which one can trace through many (or in some cases all) of the contributions to this volume. Thus, for example, many of the authors put forward their own favoured explanations to account for striking similarities and differences in biface morphology, whether within individual assemblages or when comparisons between assemblages are made. I find no reason to suppose that any of these explanations is invalid: that is to say, one can surely find examples somewhere in the prehistoric period to show each of the suggested factors operating in precisely the way proposed. It would be quite another matter to claim—and no one does—that there is any unique explanation which constitutes a universally correct and sufficient answer to the question, “Why do these particular sets of bifaces closely resemble (or strikingly differ from) each other?” Local situations must always be carefully considered, and usually several factors rather than a single one will be found to apply: this can be glimpsed even in the summaries of the various chapters which I gave in the preceding section, and is of course far better documented in the authors’ own texts. If I were now to offer my own comments on all the points in this volume that interested me, it would double the length of this book. With space limited, I must choose just a few of them, and hope I will be forgiven for sticking mainly to handaxes.

Any special factors relating to lithic raw materials will always be important influences on the morphology and technology of stone tools, including bifaces. They certainly require human tactical responses, which means they may significantly affect human behaviour at a more general level. Amongst such factors is the matter of access to sources of good stone. A case in point is Hofman’s demonstration that the Folsom bison-hunters of the Great Plains needed to equip themselves with sufficient finished implements, or reserves of workable stone, to achieve their targets, before setting out on a long hunting expedition, because the good hunting grounds might lack easily accessible rock sources.

This was a liberating strategy, doubtless based on accumulated group experience. Reading this, I thought at once of a parallel in the British Lower Palaeolithic: the Acheulean handaxe-makers who followed the River Thames upstream to reach the Upper Thames Valley in what is now Oxfordshire, passed in doing so out of the area where flint occurs and they accordingly brought with them finished tools made of flint from the Chiltern Hills (cf. Lee 2001; Buckingham *et al.* 1996). When these implements were all broken or lost, they made a few handaxes as best they could, and some other tools too, from the locally available quartzite cobbles and any other workable clasts they could find: all are exotic rocks brought into the area by glacial or glaci-fluvial action, and they are far less satisfactory for knapping than flint. Returning in due course downstream, they were content to leave their stone tools behind, having, no doubt, other things to carry, and knowing that they were returning to where flint was abundant. Thus in the Upper Thames Valley we find handaxes made of both Chiltern flint and locally gathered rocks, but no Chiltern flint knapping debris beyond the occasional resharpening flake; on the other hand, no artefacts made from the rocks available in Oxfordshire appear to have found their way back to the Chilterns.

Many more examples of such situations could be given. In the East Turkana Research area in Kenya, it is striking how the sediments carried by the streams which drain from the basin rim to the lake become finer and finer as the lake itself is approached across wide, marshy flats (Isaac and Harris 1997). There is nothing surprising about that, but the effect for early hominids wishing to hunt or scavenge on the lake shore was that no cobbles or clasts of tool-making size were available within several kilometres, so they learned to bring with them either ready-made tools, or supplies of stone and knapping equipment. Rock units large enough for handaxe manufacture are only encountered high up the stream courses, before they have made the descent from the volcanic highlands, many kilometres back from the lake, and this is where the only industries loosely attributable to the Early Acheulean are found (FxJj 33, 37 and 63).

As for the influence of rock types on technology and morphology, I will select as an example some of the broad differences between the Acheulean industries of Sub-Saharan Africa and those we encounter in Britain, having worked on both. In Africa, workable stone often occurs in large (sometimes huge) units and, if flat, symmetrical handaxes and cleavers are to be made, it is essential that large flake blanks should be struck for their manufacture: the well-known Victoria West and Kombewa techniques are just two of the ways in which this was done. In Britain, nodules and cobbles of flint are the preferred raw material: these are typically smaller, and flint, being almost pure silica, is easier to flake than the hard African quartzites and volcanic rocks. It will break with equal ease in any direction, given only the presence of an edge with a workable angle (less than 90°). While British handaxes are certainly sometimes made on flakes, there is no overriding necessity for this, and the range of biface shapes is rather different from those of Africa, although there is some common ground. Again, all but a very few British cleavers are worked bifacially from nodules or large cobbles of flint. In Africa, it is the fact that the cleavers are normally made from large flakes that controls their nature and morphology, encouraging, for instance, certain 'angled' shapes which we do not find in Britain. The working of African cleavers is rarely fully bifacial, and the technology of their manufacture is simple, direct, and practical. For example, if the cleaver blank was struck from a large, smooth-surfaced boulder, the maker would often deliberately contrive that the

broad cleaver edge itself should be formed by the intersection between unflaked smooth cortex on the dorsal side and an unaltered area of the ventral surface of the flake, regardless of whether a straight or a convex cleaver edge resulted. Only the sides and perhaps the butt of the cleaver would require a little rough shaping, to complete the implement. The working edge of such a cleaver was strong, flat and highly effective, being uninterrupted on either face by flake scar ridges.

I will resist any temptation to join this volume's debate on British handaxes between Ashton and White on the one hand and McPherron on the other, since it seems to be going along quite nicely without me; however, one point can perhaps be made usefully about the ovate and pointed handaxes, for which the existence of genuine preferences in at least some British Acheulean assemblages seems to be widely accepted. One relevant piece of basic research is still waiting to be done, which is to determine by microwear analysis whether or not acutely pointed and ovate handaxes were used in closely similar ways to work essentially the same materials. If they were not, then functional considerations might be an important part of the morphological preference at a given site. We have the excellent study of ovates from Boxgrove by John C. Mitchell (1998), which showed them to have been used for surprisingly brief periods on tasks associated with the butchery of large animal carcasses and then abandoned without curation or resharpening—quite unlike the French Mousterian bifaces discussed in this volume by Soressi and Hays. There is no corresponding study of a British pointed handaxe industry of, say, Swanscombe Middle Gravels type. It is hard to think of a suitable series of British pointed handaxes in the pristine condition of the Boxgrove artifacts., but it might not be a waste of time to study, as a stop-gap, whatever fresh pointed handaxes one could find, even if they came from several different sites, just to identify some use-patterns and to see whether they were consistent. That would hardly constitute definitive evidence but, whatever the result, it would be worth incorporating into the various explanations that have been offered for the ovate or pointed handaxe preferences.

One final brief reminiscence will allow me to end on a light note which still has a worthwhile point to make: the worthwhile point is simply that one must always keep an eye on terminology, which is ever ready to run out of control, although in this volume the language seems to me to have been kept well in hand. The story is of Mary Leakey, with whom I worked on several occasions at Olduvai. Sometimes during my visits she would show me drafts of texts of hers that were in preparation for publication, and ask for comments. Mary was inclined to use the word "biface" simply as a synonym for "handaxe;" she told me firmly on more than one occasion that she had never really liked handaxes, and much preferred the Oldowan—well, there is no accounting for tastes. In one of her draft papers (ca. 1974), I think in 1974, I came across the phrase "unifacial biface," and bravely ventured the opinion that she simply could not say that, "unifacial handaxe," yes; "unifacial biface," no. Mary's reputation for fierceness was not entirely undeserved, though we always got on well: she might invite comments on her texts, but sometimes, when they were offered, her eyes would turn into icy blue lasers. My defense against that was always to adopt an expression of sublime and unassailably helpful innocence. I am happy to say that on this occasion I won, and Mary did not use the term "unifacial biface." I had the feeling that I had performed a small but worthwhile service to the Palaeolithic Archaeology community.

References

Buckingham, C. M., D.A. Roe, and K. Scott

- 1996 A Preliminary Report on the Stanton Harcourt Channel Deposits (Oxfordshire, England): Geological Context, Vertebrate Remains and Palaeolithic Stone Artefacts. *Journal of Quaternary Science* 11(5):397-415.

Clark, J. G. D.

- 1977 *World Prehistory in New Perspective*, 3 ed. Cambridge: Cambridge University Press.

Isaac, G. L.

- 1977 *Olorgesailie: Archeological Studies of a Middle Pleistocene Lake Basin in Kenya*. Chicago: University of Chicago Press.

Isaac, G. L., and J. W. K. Harris (with contributions by E. M. Kroll)

- 1997 The Stone Artefact Assemblages: A Comparative Study. In *Koobi Fora Research Project*, vol. 5: *Plio-Pleistocene Archaeology*. G. Isaac, ed., assisted by B. Isaac, Pp 262-362. Oxford: Clarendon Press.

Juel Jensen, H.

- 1986 Unretouched Blades in the Late Mesolithic of South Scandinavia: A Functional Study. *Oxford Journal of Archaeology* 5(1):19-33.

Keeley, L. H.

- 1980 *Experimental Determination of Stone Tool Uses: A Microwear Analysis*. Chicago: University of Chicago Press.

Lee, H. W.

- 2001 *A Study of Lower Palaeolithic Artefacts from Selected Sites in the Upper and Middle Thames Valley, with Particular Reference to the R.J. MacRae Collection*. Oxford: British Archaeological Reports.

Mitchell, J. C.

- 1998 A Use-wear Analysis of Selected British Lower Palaeolithic Handaxes, with Special Reference to the Site of Boxgrove (West Sussex): A Study Incorporating Optical Microscopy, Computer Aided Image Analysis and Experimental Archaeology. D.Phil. Thesis. Oxford University.

Movius, H. L., Jr.

- 1955 Palaeolithic Archaeology in Southern and Eastern Asia, Exclusive of India. *Journal of World History* 2(2-3):259-82, 520-53.

Roe, D.A.

- 1964 The British Lower and Middle Palaeolithic: Some Problems, Methods of Study and Preliminary Results. *Proceedings of the Prehistoric Society* 30:245-67.
- 1968 British Lower and Middle Palaeolithic Handaxe Groups. *Proceedings of the Prehistoric Society* 34:1-82.
- 1989 Advancing the Study of Early Man in East Africa. The Interpretation of Prehistory: Essays from the Pages of the Quarterly Review of Archaeology. *Review of Archaeology* 10(1)82-88.

West, R. G., and C. B. M. McBurney

- 1954 The Quaternary Deposits at Hoxne, Suffolk and Their Archaeology. *Proceedings of the Prehistoric Society* 20:2:131-54.



CONTRIBUTORS

Miguel Almeida
Dryas Arqueologia
Rua do Olival de São Domingos
Cimo 3000-445
Coimbra
Portugal

Nick Ashton
Department of Prehistory and Early Europe
British Museum
38 Orsman Road
London NI 5QJ
United Kingdom

Thierry Aubry
Parque Arqueológico do Vale do Côa
Avenida Gago Coutinho 19
5150 Vila Nova Foz Côa
Portugal

Douglas B. Bamforth
Department of Anthropology
University of Colorado
Boulder, CO 80309
USA

J. Desmond Clark
Department of Anthropology
University of California
Berkeley, CA 94720
USA

Vladimir Doronichev
Laboratory of Prehistory
V.O. 14 Linia 3-11
St.Petersburg 199034
Russia

Lubov Golovanova
Laboratory of Prehistory
V.O. 14 Linia 3-11
St.Petersburg 199034
Russia

Maureen A. Hays
Department of Anthropology
College of Charleston
66 George St
Charleston, SC 29424
USA

Jack Hofman
Department of Anthropology
622 Fraser Hall
University of Kansas
Lawrence, Kansas 6604
USA

Janusz K. Kozłowski
Instytut Archeologii
Uniwersytet Jagielloński
ul. Golebia 11
31007 Krakow
Poland

Shannon P. McPherron
Department of Anthropology
The University of North Carolina
at Greensboro
426 Graham Building
Greensboro, NC 27402-6170
USA

Dimitris Metaxas
Division of Computers
and Information Sciences
Rutgers University
110 Frelinghuysen Road
Piscataway, NJ 08854-8019
USA

Maria Joao Neves
Dryas Arqueologia
Rua do Olival de São Domingos
Cimo, 3000-445
Coimbra
Portugal

Michael Noll
 Department of Anthropology
 National Museum of Natural History
 Smithsonian Institution
 Washington, DC 20560-0112
 USA

April Nowell
 Department of Anthropology
 University of Victoria
 P.O. Box 1700
 Victoria, BC V8W 2Y2
 Canada

Marcel Otte
 Université de Liège
 Service de Préhistoire
 7, Place du XX Août
 B-4000 Liège
 Belgium

Jinah Park
 KAIST Computer Science Division
 373-1 Kusong-dong Yusong-ku
 Daejeon 305-701
 South Korea

Kyoungju Park
 Department of Computer
 and Information Science
 University of Pennsylvania
 200 South 33rd Street
 Philadelphia, PA 19104
 USA

Michael D. Petraglia
 Department of Biological Anthropology
 University of Cambridge
 Downing Street
 Cambridge CB2 3DZ
 England

Derek A. Roe
 Pitt Rivers Museum
 Oxford University
 60, Banbury Road
 Oxford OX2 6PN
 United Kingdom

Kathy Schick
 Department of Anthropology
 Indiana University
 419 N. Indiana
 Bloomington, IN 47408
 USA

Michael Shott
 Department of Sociology, Anthropology,
 and Criminology
 272 Baker Hall
 University of Northern Iowa
 Cedar Falls, Iowa 50614-0513
 USA

Marie Soressi
 Institut de Préhistoire et de Géologie
 du Quaternaire
 Université Bordeaux I
 Avenue des Facultés
 33405 Talence Cedex
 France

Bertrand Walter
 Musée de la Poterne
 Les Chirons
 37290 Preuilly-sur-Claise
 France

Mark White
 Department of Archaeology
 University of Durham
 South Road
 Durham DH1 3LE
 United Kingdom



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