

TECHNOLOGICAL AND FUNCTIONAL VARIABILITY OF
CONVERGENT TOOLS FROM NAHR IBRAHIM, LEBANON:
BEHAVIORAL IMPLICATIONS FOR
LEVANTINE MOUSTERIAN TECHNOLOGICAL ORGANIZATION

A Dissertation

by

JOHN EDWARD DOCKALL

Submitted to the Office of Graduate Studies of
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Major Subject: Anthropology

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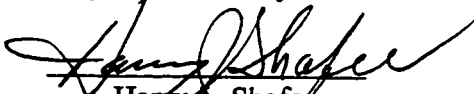
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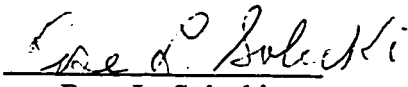
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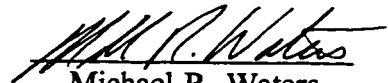
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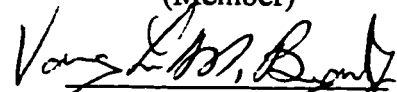

Harry J. Shafer
(Co-Chair of Committee)


Ralph S. Solecki
(Co-Chair of Committee)


Rose L. Solecki
(Member)


Michael R. Waters
(Member)


Vatche P. Tchakerian
(Member)


Vaughn M. Bryant
(Head of Department)

May 1997

Major Subject: Anthropology

ABSTRACT

**Technological and Functional Variability of
Convergent Tools from Nahr Ibrahim, Lebanon:
Behavioral Implications for**

**Levantine Mousterian Technological Organization. (May 1997)
John Edward Dockall, B.A. University of Texas, Permian Basin;
M.A., Texas A&M University**

**Co-Chairs of Advisory Committee: Dr. Ralph S. Solecki
Dr. Harry J. Shafer**

Convergent tools are hallmarks of the Levantine Mousterian and have long been considered an important portion of the technology. Previous typological and technological analyses alluded to a variety of purposes for these implements, including weapon tips. The role of convergent tools in Levantine Mousterian technological organization is explored through a detailed technological and functional analysis of these implements from Nahr Ibrahim, Lebanon. Comparative data are derived from Levantine Mousterian cave sites of Skhul, Kebara, Qafzeh, Tabun, Hayonim, and Tor Faraj. A small sample of convergent tools from Shanidar, Iraq represents the Zagros Mousterian.

The relationship between tool manufacture and use is reflected in a set of implement design criteria employed by Levantine Mousterian hominids. Technological analysis included metric and attribute studies to determine techniques of manufacture. The method of core preparation prior to flake removal was critical to achieve the desired convergent flake shape.

Functional analysis relied upon fracture mechanics of brittle solids and low-power use-wear techniques to determine tool motion, worked material, and activity sets. Activity sets were divided into extractive tasks (associated with procurement or

processing of food) and maintenance tasks (attributed to tool or artifact maintenance, repair, and procurement of non-food resources). Functional analysis revealed that convergent tool uses were similar throughout the Levant, regardless of whether the implements were attributed to anatomically modern humans, archaic hominids or *Homo sapiens neanderthalensis*.

Primary design criteria that were desired included broader proximal dimensions and distal convergence. Width and length were emphasized and thickness was controlled through use of the Levallois technique. Non-Levallois convergent tools, while somewhat thicker, were employed in a similar range of extractive and maintenance tasks as their Levallois counterparts. Levantine Mousterian convergent implements functioned as multi-purpose components of personal toolkits and were a significant component of the subsistence technology. Technological and functional variability was to some degree related to differences in activity location, the ranges of inferred tasks that were performed or anticipated by hominids, and varying intensities of individual, activity, and locality provisioning. Evidence indicates that there was not a great degree of behavioral difference associated with convergent tool manufacture and use during the Levantine Mousterian.

ACKNOWLEDGEMENTS

The production of this dissertation is not solely the efforts of one individual. I wish to take this opportunity to thank my wife Helen Danzeiser Dockall for making this possible. Her love, kindness, understanding, and unflagging support provided me with the determination to proceed during the entire course of my tenure as a doctoral student. Helen read virtually the entire document in a variety of semi-coherent drafts and assisted me in many ways beyond the limits of what was reasonable. I am eternally grateful to know her as my best friend and my partner in life. Other family that contributed to my mental well-being during the dissertation are Sassie and Thomas, our wonderful cats. They have managed to provide emotional stability through their unconditional affection and attention.

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I would also like to thank the entire staff and students of the Center for Environmental Archaeology. The Center provided me with employment, field experience, and comradeship during the last two years of my dissertation research

and served to provide numerous different perspectives on archaeology. My time working at the Center for Environmental Archaeology has been rewarding, always challenging, and never dull. In particular I would like to thank Drs. Alston Thoms, David Kuehn, and Phil Dering for including me as a contributing member in their projects and for their trust in me to meet goals and deadlines.

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CHAPTER I
INTRODUCTION:
ASPECTS OF TECHNOLOGICAL AND FUNCTIONAL VARIABILITY
IN LEVANTINE MOUSTERIAN INDUSTRIES

This study represents the results of a detailed technological and functional study of convergent tools from the site of Nahr Ibrahim located in northern Lebanon. Additional comparative data on convergent tool function is drawn from a detailed study conducted by Shea (1991) and a functional analysis of similar implements from Shanidar Cave in northern Iraq (Dockall 1993). An analysis of manufacturing technology and use-wear of implements from Nahr Ibrahim will be utilized to develop hypotheses concerning Levantine Mousterian convergent tool design. Aspects of tool design, manufacture, and use are then employed as datasets to develop hypotheses regarding the role of convergent tools in Levantine Mousterian technological organization.

The goals of this dissertation can be addressed at several basic levels. These goals are more specifically described in the research design and methodology (see Chapter 5) but are summarized below.

- (1) provide a separate and independent test and evaluation of a newly devised methodology of recording and quantifying use-wear traces of Middle Paleolithic convergent tools (see Shea 1991).
- (2) identify and explain functional similarities and differences within the convergent tool category between Tabun C and D assemblages at Nahr Ibrahim and those from other Levantine Mousterian sites.
- (3) provide data and interpretation of the technological/metric properties of tool blanks and the relationship between tool manufacture and use.

This dissertation follows the style and format of *American Antiquity*.

(4) examine the influence of raw material type, size, and variability, resharpening, breakage patterns, and tool curation/recycling among convergent tool samples from Tabun C and D assemblages at Nahr Ibrahim.

(5) ascertain the potential behavioral meanings of patterning observed from the North (Tabun D) and Central (Tabun C) Galleries at Nahr Ibrahim as compared to other Levantine Mousterian sites.

The level of investigation approached in this dissertation requires a detailed understanding of the causes and consequences of lithic assemblage variability. There has perhaps been no greater topic of research and debate among Lower and Middle Paleolithic researchers with the exception of the issue of cognitive development and symbolic/ritual expression. Consequently, this chapter provides a detailed summary of the major research areas concerning variation within Lower and Middle Paleolithic industries, focusing on the Near East.

Phases of Levantine Research

The results of roughly a century of concerted archaeological research in the Levant has resulted in the discovery and excavation of a plethora of Middle Paleolithic sites (Figure 1.1) concentrated along the Mediterranean coastline. The research that led to the discovery of these and other archaeological sites is described in detail below. Figure 1.1 provides the location and identification of the principle Levantine Mousterian sites mentioned in the dissertation and those that provided sources of convergent tool comparative data.

The initial phase of archaeological research in the Levant included the work of Turville-Petre (1927). Turville-Petre's major contribution to the regional research is perhaps his demonstration of the direct association of Middle Paleolithic assemblages and fossil hominid remains at the sites of Emireh and Zuttiyeh in the Wadi Amud, Israel (Jelinek 1982a:57). However, his research was characterized by unsystematic methods of excavation and sampling.

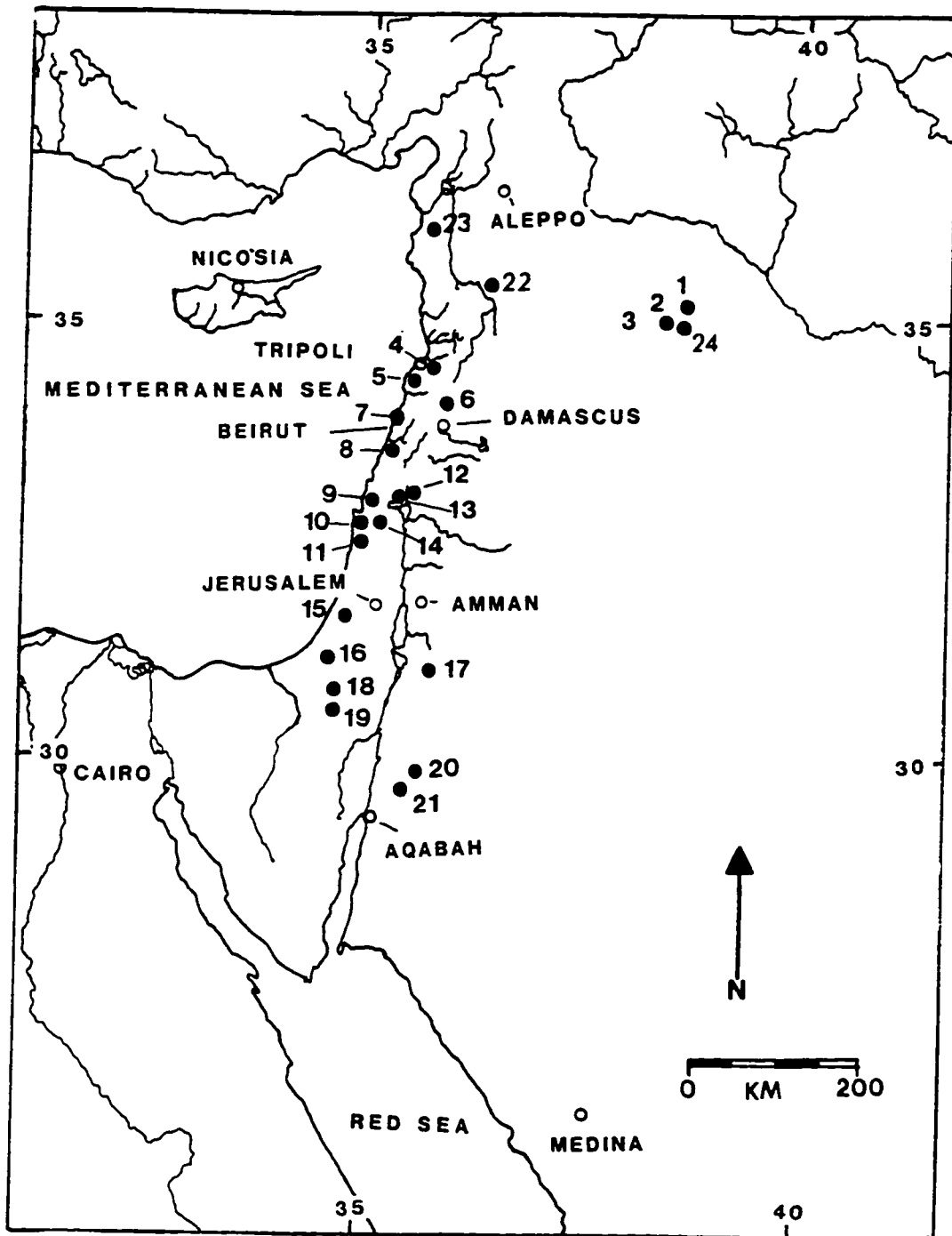


Figure 1.1. Distribution of Major Levantine Mousterian sites used in this study and mentioned in the text. Numbers correspond to general site location. (1) El Kowm, (2) Douara, (3) Jerf Ajla, (4) Keoue, (5) Nahr Ibrahim, (6), Yabrud, (7) Ksar Akil, (8) Adlun, (9) Hayonim, (10) El Wad, Tabun, Skhul, (11) Kebara, (12) Quneitra, (13) Amud, Emireh, Zuttiyeh, (14) Qafzeh, (15) Shukbah, (16) Fara II, (17) Ain Difla, (18) Rosh Ein Mor, (19) Ein Aqev, (20) Tor Faraj, (21) Tor Sabiha, (22) Tulul Defaai, (23) Mchairfet el Samouk, (24) Bir el Hummal. Base map adapted from Bar-Yosef et al.(1992:Figure 1).

A second phase of exploration characterized by greatly improved field methods and larger areal excavation was conducted at Shukbah, Tabun, El Wad, and Skhul (Garrod and Bate 1937). Neuville also conducted research at Umm Qatafa, Abu Sif, Erq El Ahmar and Et Tabban (Neuville 1951). In addition Moshe Stekelis worked at Kebara (Schick and Stekelis 1977).

A third period of intensive research, identified by Jelinek (1982a:57), began in the early 1960s and continued to the present (at time of Jelinek's writing). This period included the application of more intensive archaeological and geological and other related investigations with more exacting methodologies and research designs.

Hours (1975:249-250) has provided a summary of Lower Paleolithic research in Lebanon and Syria. Pere Zumoffen conducted the first explorations for archaeological sites in Lebanon between 1890 and 1910 (Zumoffen 1900). Pere Bergy surveyed the region of Beirut and the Bekaa Valley between 1925 and 1940. Alfred Rust conducted excavations in the Yabrud-Nebek region of Syria prior to World War II (Rust 1950). Also, after WWII, Pere Fleisch investigated the coastal reaches of Lebanon and Van Liere surveyed portions of the Damascus Basin, Ghab, Nahr el-Kebir, and Jesireh (Roe 1983). Van Liere also discovered the site of Latamne. Hours concentrated his research in the area of Mount Lebanon and the southern Bekaa Valley. More recently, Copeland and Schroeder conducted Lower Paleolithic research in the region. Copeland (1978) has studied material excavated by Garrod at Adlun from 1958-1963.

Changing Interpretations of Levantine Mousterian Variability

Based upon her research at Tabun and other sites in the Wadi el-Mughara, Israel, Garrod immediately recognized the futility of applying French models of prehistory to explain the Levantine Mousterian. Most significant was the fact that the Levalloisian and the Mousterian were not separate industries in the Levant as they were in Europe (Marks 1992a:127). The sites of Tabun and Shukbah yielded lithic assemblages abundant in typical Middle Paleolithic tool types as well as Levallois

blanks. Consequently, Garrod developed the term Levalloiso-Mousterian (Garrod and Bate 1937).

Garrod (Garrod and Bate 1937) constructed a Middle Paleolithic sequence divided into an Upper and Lower Levalloiso-Mousterian based upon technological and faunal assemblage differences. The Lower Levalloiso-Mousterian was present in Layers D and C at Tabun and contained triangular and lamellar flake blanks and several Upper Paleolithic tool types (burins, endscrapers, backed knives). Typical Mousterian tool types included Mousterian points and sidescrapers (Garrod and Bate 1937:115-116; Marks 1992a:127). The Upper Levalloiso-Mousterian was present in Layer B and in the Chimney at Tabun. The lithic assemblages exhibited more Mousterian characteristics, abundant sidescrapers and few points (Garrod and Bate 1937:71-74; Marks 1992a:127).

Even though these differences between Upper and Lower Levalloiso-Mousterian were present, Garrod noted that they were largely a matter of proportional differences between points and scrapers (Garrod and Bate 1937:115). She considered the distinctions between Upper and Lower Levalloiso-Mousterian less apparent or significant than the observed differences between these industries and Middle Paleolithic assemblages in Europe (Garrod and Bate 1937:120). Garrod further noted that Upper and Lower Levalloiso-Mousterian belonged together but could be distinguished on the basis of technology in addition to typology (Marks 1992a:127).

Initial research by Garrod (Garrod and Bate 1937) on Levalloiso-Mousterian variability resulted in the interpretation that the Tabun sequence reflected an in-situ development from the Late Acheulian. Skinner (1965), Perrot (1968), and Bordes (1955) emphasized typological attributes over technological attributes in an effort to subdivide the Levantine Mousterian (Bar-Yosef 1980:114; Marks 1992a:129).

Copeland (1975) and Hours (Hours et al. 1973) amplified Garrod's earlier division of the Middle Paleolithic sequence at Tabun. Garrod's Lower Levalloiso-Mousterian was divided into a Phase 1 (Tabun D) and Phase 2 (Tabun C). The Upper Levalloiso-Mousterian (Tabun B) was renamed as Phase 3. Briefly, these

changes reflected technological differences: elongated flakes and points in Phase 1, the disappearance of elongated pieces and points in Phase 2, and the presence of short and wide flake blanks and points in Phase 3 (Marks 1992a:129). Chapter II provides a more detailed discussion of the chronological significance of the Levantine Mousterian sequence.

Skinner (1970) divided the Levantine Mousterian into three major groups: (1) Yabrudian (Quina Mousterian), (2) Acheulian or Yabrudian facies, (3) four distinct sub-groups defined by type locality (Abu Sif, Tabun, Yabrud, Erq el-Ahmar). Perrot's (1968) scheme was divided into Mousterian of Acheulian Tradition, Mousterian, Abu-Sif or Mousterian with elongated points, Typical Mousterian, and a Denticulate Mousterian (Bar-Yosef 1980:114).

A further explanation of Levantine Mousterian variability was proposed by Binford and Binford (1966) and Binford (1973:148). The Binfords interpreted the variability in terms of seasonal differences in tool kits/task sets associated with groups of nomadic hunter-gatherers.

Jelinek (1982a) has established a line of inquiry into Levantine Mousterian variability by using width/thickness ratios of complete unmodified flakes and blades from each level of Tabun. At Tabun the width/thickness ratio, median, and variance appear to increase with time. This temporal progression seems to demonstrate that flakes were becoming thinner relative to width (Jelinek 1982a:81-82) which suggests a technological continuity to the assemblage. Jelinek (1982a:99) extends the significance of the trend to also infer both cultural and biological continuity in the region. He argues for the in-situ development of modern humans in the Levant between 50,000 and 40,000 B.P. because the technological trend indicated that the Tabun I hominid (exhibiting pronounced Neanderthal features) was significantly earlier than anatomically modern hominids from Skhul/Qafzeh. Recent re-dating of the specimens from Skhul, Qafzeh, and Tabun indicate that anatomically modern humans and Neanderthals may have been roughly contemporary and that Neanderthal specimens from Amud and Kebara are significantly younger than Skhul, Qafzeh, and Tabun.

Munday (1979) applied length/width indices to examine technological variability of the Levantine Mousterian from the Negev and noted that temporal shifts in both flake shape and core preparation techniques were related to changes in occupational intensity. Increasing blank elongation was interpreted as increased production efficiency and shifting core reduction strategies (Munday 1976, 1979:95-96). This technological shift in the Negev is correlated with both demographic and subsistence changes that followed climatic and environmental deterioration during the Early Wurm (Munday 1979:87). Munday (1976) had determined that Levantine Mousterian technological shifts in the Central Negev (Avdat/Aqev area) were part of an overall adaptive response to site location and raw material resource distribution. Within the Avdat/Aqev area raw materials were exploited methodically to reduce trips to source localities. Economizing behaviors such as more intensive core preparation techniques took place at sites located at some distance from chert sources (Munday 1976:139).

Jones (1985) has cautioned researchers in the use of variance statistics in studies examining technological variability such as conducted by Jelinek and Munday. When width/thickness indices are calculated for combined artifact samples, the results can be influenced by typological variables. It is advisable to calculate these values for specific artifact classes such as flake debris and Levallois points (Clark and Lindly 1989:646; Jones 1985).

A typological analysis of Levantine Mousterian assemblages (Marks 1992a) revealed that technological and typological variability does seem to be parallel. With few exceptions, Early and Late Levantine Mousterian assemblages are both technologically and typologically different. Early Levantine Mousterian assemblages emphasized the manufacture of elongated tool blanks and fewer retouched tool types. The Late Levantine Mousterian is characterized by increasing emphasis on flake and blade manufacture and retouched tool types with fewer Upper Paleolithic types. This interpretation of Mousterian variability is at issue with Garrod's and later researchers interpretations regarding temporal and cultural interrelationships between the Early and Late Levantine Mousterian (Marks 1992a:138-140), a sentiment which is echoed

by Clark and Lindly (1989:645-646) in their discussion of Levantine Middle Paleolithic chronology (see Chapter 2).

Other Studies of Middle Paleolithic Variability

Retouch Intensity and Tool Blank Production

Recently, Rolland and Dibble (1990) proposed that Middle Paleolithic variation can best be explained by constraints of raw material and differential reduction/reuse intensity. Although their research was mainly directed toward European Middle Paleolithic assemblages their research can be applied to the Near East. Rolland and Dibble (1990) further suggested that aspects of varying site occupation duration and patterns of tool manufacture/repair were also significant contributors to variability.

Dibble (1984, 1987, 1988) has developed and refined a model of scraper variation whereby observed techno-morphological differences of various scraper types are a function of continuous resharpening of the edges. This model has been proposed as a partial explanation of the observed variability among European and Near Eastern Middle Paleolithic assemblages. Two basic patterns of scraper reduction have been isolated based on both experimental and archaeological data (Dibble 1987, 1988). The first pattern traces the transformation of a single-edge sidescraper in which the second lateral edge is also retouched creating a double-scraper. The continued retouch of both edges results in the development of a convergent scraper. The second pattern involves the change from a sidescraper to a transverse scraper as the lateral edge is retouched and the edge axis crosses the flake axis.

A significant degree of similarity was noted among the material from La Quina (France) and Tabun (Israel) concerning overall dimensions of implements at each reduction stage (Dibble 1988:51). There is also a close correspondence between La Quina and Tabun regarding the median retouch intensity present on single, double, convergent, and transverse scrapers. Data from Bisitun and Warwasi in the

Zagros Mountains of Iran are used to support the presence of the first scraper reduction pattern--single, double, convergent (Dibble 1984, 1988:51-52; Dibble and Holdaway 1993; Holdaway 1989).

Dibble (1985, 1988; Dibble and Whitaker 1981) has also argued that aspects of raw material, flake size, shape, and platform type and size to some degree dictate the techniques of scraper manufacture and continued reduction. Differences regarding the blank morphology of scrapers between the Zagros Mousterian and the Yabrudian are argued to be reflected in the differing strategies of scraper retouch (Dibble 1991; Dibble and Holdaway 1993). Both industries are characterized by high proportions of side scrapers but differ in initial blank production technology. The Yabrudian is characterized by thicker, broad flakes compared to the longer and thinner flake blanks of the Zagros Mousterian.

Based on debitage and tool blank similarities Dibble (1991:251) also observed technological similarities between the Quina Mousterian and the Yabrudian and Ferrassie Mousterian and Zagros Mousterian, respectively. Dibble did not infer or suggest a cultural link between these Near Eastern and European Middle Paleolithic industries. Rather, the observed similarities were interpreted as reflecting similar methods of exploiting like-shaped tool blanks produced by different technological systems. Dibble (1991:253) ultimately interpreted this variability as a result of independent choices to apply a particular technology for manufacturing tool blanks of a suitable size and shape that could accommodate repeated resharpening. These inferences are highly suggestive of a significant degree of planning and foresight in the lithic technology (contra Binford 1989).

Chaine Operatoire

The concept and definition of the *chaine operatoire* has been recently summarized by F. Sellet (1993:106) as the logical sequence of both mental and technical aspects of stone tool manufacture. The stated goal of the *chaine operatoire* as an analytical framework is to define and interpret all "cultural" changes that raw

material proceeds through (Sellet 1993:106). This is inclusive of both actions and mental reasoning necessary for the production and maintenance of the tool.

The chaîne opératoire is further subdivided into a number of logical steps: raw material acquisition, reduction/manufacture, use, maintenance, and discard. The chaîne provides a more dynamic interpretation of tool life histories than conventional typological schemes. Technical knowledge is a key aspect of the chaîne (Sellet 1993).

Application of this concept to Middle Paleolithic industries has been common recently among a number of French researchers (Boëda 1986, 1988; Boëda et al. 1990; Geneste 1985). More recently, it has been applied to Near Eastern Middle Paleolithic assemblages (Bar-Yosef and Meignen 1992). Bar-Yosef and Meignen (1992) applied the various stages of the chaîne in an analysis of material from Kebara Cave. Variation in reduction method and technique between Kebara, Qafzeh, and Tabun was interpreted as behavioral in origin, thus supporting the existence of three distinct facies of the Levantine Mousterian.

Both Jelinek (1991) and Sellet (1993) have critiqued American scholars for not applying the chaîne opératoire concept. According to Jelinek (1991:8-9), similar approaches by American archaeologists were a development from the experimental programs of Bordes, Tixier, and Crabtree and the development of processual archaeology. The abandonment of this methodological approach is attributed to the largely ill-defined reduction trajectories utilized in interpretations of North American lithic industries and the general poorness of patterning in New World assemblages. Sellet (1993:107) noted the similarity of the chaîne and American methods but stated that the difference was in the emphasis on theory-building in American archaeology, while the French desire has been to produce an analytical tool. The chaîne opératoire differs from American models of lithic reduction in its immutability; American models are flexible and dynamic and incorporate change within the reduction or manufacture trajectory.

Philip Chase (1993:1) has stated that an additional goal of the chaîne is to reconstruct "prehistoric mental activity." The link in attempting to recreate the

prehistoric mind is that of the goal of the flintknapper: What was the ultimate purpose of the reduction scheme? The chaîne opératoire infers that each behavior is the result of a logical progression toward the end-product. Therefore, according to Chase (1993:2), the chaîne is treated as a complete entity with little analytical consideration given to changes in reduction strategy or the production of similar products by different techniques. End-product efficiency (whether tool or blank) is emphasized at the neglect of such issues as production costs, time stress, or technological organization (see Nelson 1991).

Chase's (1993) criticisms (with which I concur) of the chaîne opératoire include the following: (1) there is not enough consideration of the factor of changing core reduction strategies; (2) too much emphasis is placed on the goal of the flintknapping sequence; (3) little attention is relegated to studies of cost/benefits of tool production and core reduction and how the sequence is related to such factors as subsistence, settlement, or raw material. The principle difference between the chaîne opératoire and analytical frameworks developed by Collins, Ahler, and others is that it is considered an intractable trajectory of reduction towards the end-product.

Variability as a Function of Settlement Patterns

A variety of settlement models based on survey and excavation data have been developed to interpret Middle Paleolithic assemblage variability. The major variables included in these models include site function, site size, elevation, environmental zonation and resource distribution, and climatic changes.

Crew (1975:149-150) concluded that technological variability between coastal and inland Levantine Mousterian assemblages could be a function of abundance of good quality stone material, distance of that material from a base camp, amount of raw material needed, length of occupation, and the tactical needs of the populations. Variation at the technological and typological level of analysis reflected the application of different adaptive strategies to successfully exploit environmentally distinct regions. Inland and drier regions were characterized by proportionally less dorsal preparation of flints and platform faceting and generally thicker flake blanks.

Coastal assemblages were characterized by broader and thinner tool blanks, increased dorsal surface preparation, and platform faceting. Crew (1975:149) inferred that the lesser degree of dorsal preparation and thicker blanks at inland sites were the result of economic decisions made based on shorter site occupation. The technology of most inland Levantine Mousterian sites was judged to have been less influenced by raw material availability and more by time-stress: the need to produce a suitable implement in the least amount of time. Similarly, Torrence (1983:13) argued that tool diversity is negatively correlated with the length of time at hand to complete a task. Tool complexity is also interpreted to have an inverse relation to time available.

Crew (1975:155-157) stressed that the lack of economizing behavior at inland sites is in general agreement with a short winter occupation by very mobile groups. This suggests a model of seasonal transhumance between the coastal and interior regions. Crew also proposed that the same patterning could be interpreted as different local populations occupying these areas year-round on a more sedentary basis. Coastal inhabitants exploiting resident populations of fallow deer and roe deer would be more sedentary than inland groups exploiting the more mobile steppic and desertic faunal species. Crew offered these models as possibilities to be tested with further data.

Marks and Friedel (1977:137-142) provided a model of settlement/site type variation of the Middle Paleolithic sites of the Negev of Israel. They identified three types of Early Mousterian sites: intensive occupation sites, quarries and workshops, and small scale hunting/processing or multipurpose extractive camps. The variation that was identified technologically was representative of the different phases of a reduction sequence from procurement and manufacture to use, maintenance, and discard. The geographic distribution and abundance of water and distance from each other were also found to be crucial variables. Sources of permanent surface water seem to have been significant factors in the establishment of key habitation sites with smaller special purpose extractive camps (quarries, workshops, and hunting camps) established away from the base camps. According to Marks and Freidel (1977:142)

this radiating settlement pattern enabled the Avdat/Aqev area inhabitants to increase their potential exploitable territory without losing stable basecamps near water sources. Residential stability was made possible by more mesic environmental conditions that expanded Mediterranean plant communities (Clark and Lindly 1989:656).

A different model of settlement/subsistence organization based upon modern and historic observations of Bedouin settlement patterns in southern Jordan was developed by Henry (1992). The seasonal transhumance model is also founded upon archaeological work in the Wadi Hisma area of southern Jordan (along the southern edge of the Jordanian Plateau) at the sites of Tor Faraj and Tor Sabiha, separated by 17 km. Tor Faraj is at an elevation of 1000 masl while Tor Sabiha lies at 1300 masl. The environmental differences between these sites appear to have resulted in seasonal occupation and task differences. Tor Sabiha is located at the transition between Mediterranean woodland and steppe while Tor Faraj is at a lower area of steppe as it meets the desert. Both temperature and precipitation differences are also significant. Deeper occupation deposits, hearths, and ash lenses at Tor Faraj suggest a winter occupation of longer duration than at Tor Sabiha. Deposits and site setting at Tor Sabiha suggest a short-term occupation by small groups. All datasets indicate that both sites were occupied at roughly the same time and may have been located within, and part of, the same settlement system area. Technological and raw material variability provide strong evidence for the role of each site in the regional settlement system. The occupants at Tor Faraj employed a "logistical" procurement and manufacture scheme in which raw material was procured at some distance from the site but reduced at Tor Faraj. The occupants of Tor Sabiha employed a more opportunistic strategy of raw material procurement and manufacture of tools from local chert (Henry 1992:159).

A third model of settlement and subsistence patterns for the Levant was developed from site survey data of the southern portion of the Wadi Hasa in Jordan (Coinman et al. 1986). This model incorporates aspects of both Marks and Friedel's (1977) and Henry's (1992) models. The Wadi Hasa data also indicate a radiating

settlement pattern for the Lower-Middle Paleolithic. The Middle and Upper Paleolithic of the Wadi Hasa region are characterized by similarities in site size suggesting that the pattern continued into the Upper Paleolithic. This is in contrast to the Middle-Upper Paleolithic transition of the Negev which represents a shift to a circulating settlement pattern (Coinman et al. 1992:164-165). The "modal" settlement pattern data from Wadi Hasa for the Middle to Upper Paleolithic seem also to mimic Henry's transhumance model.

Recent studies by Shea and Lieberman (Lieberman 1993; Lieberman and Shea 1994) have elaborated considerably upon the general models of radiating settlement and seasonal transhumance during the Levantine Mousterian. These studies include data on technology, use-wear, hominid skeletal remains, and faunal assemblage seasonality data (based on cementum increment analysis of gazelle teeth).

Sites that have yielded both Archaic *Homo sapiens* and early modern *Homo sapiens* in the southern Levant have contained techno-typologically similar lithic assemblages (Lieberman and Shea 1994:300-301). Shea (1991) has demonstrated a distinct similarity in patterns of tool use between these groups of sites. Seasonality data from gazelle teeth, however, indicate a behavioral difference in the exploitation of this resource. Kebara VII-X and Tabun B both indicate that gazelles were hunted on a year-round basis inferring multi-seasonal occupation and a radiating settlement pattern. Both sites are associated with archaic *Homo sapiens*. Qafzeh XVI-XXI patterning supports the contention that gazelles were hunted primarily on a spring/summer seasonal basis that was probably associated with a circulating settlement pattern of early modern *Homo sapiens* (Lieberman and Shea 1994:310, Table 1). Archaic and early modern humans responded quite differently to a similar set of climatic and environmental possibilities. The most obvious difference lies in the contrasts of hunting intensity between the two hominid groups.

The multiseasonal occupation of sites by archaic humans was probably the result of numerous visits of a short duration by one or several groups. The authors felt that this was a more likely scenario than a year-round habitation by a single group (Lieberman and Shea 1994:318). Also, the greater frequency of spear point

usage at these sites that have yielded archaic hominid fossils supports the inference of increased and sustained hunting efforts by archaic hominids. Conversely, the lower proportions of pointed tools and impact damaged points at Qafzeh and Tabun B suggest the early modern hominids may have left these sites prior to depleting game resources in the surrounding area (Lieberman and Shea 1994:318).

Studies of Acheulian and Mousterian Functional Variability

At the time of Semenov's publication of *Prehistoric Technology* in 1954, there had been no systematic functional analysis of Lower or Middle Paleolithic tool assemblages. Semenov (1964:83) briefly discussed the microwear research of Zamyatnin on a single scraping implement from the Mousterian site of Volgograd. His research was more substantial but more esoteric in that he applied his use-wear research to questions of physical and cognitive/intellectual evolution (Levitt 1979:30).

Semenov's work (cited in Levitt 1979) also included such topics as Neanderthal predominance of right-handedness and their different tool grasping abilities. Semenov (1950a, 1950b) argued that Neanderthals held tools and exerted forces in ways that modern humans could not. This inference was based upon osteological evidence (morphological differences of phalanges and metacarpals) and archaeological evidence (the presence of use-wear on very small unhafted Mousterian tools).

Levitt (1979:31-32) and Plisson (1988) summarized the contributions of V.E. Shchelinski to Middle Paleolithic use-wear research. In particular, Shchelenski noted the difficulty of observing wear on Lower and Middle Paleolithic tools due to post-depositional processes. His work has documented a number of different tasks such as stone and skin or hide working, bone and wood working, and sewing (works cited in Levitt 1979). Shchelinski also emphasized the importance of considering raw material, technology, and function in assessing behaviors associated with tool use. His Middle Paleolithic use-wear studies have included obsidian tools from Erevan Cave, Armenia, chert tools from La Gouba (Monaseskaya) in the Prekuban (Final or

Late Mousterian) and also the Eastern Europe Mousterian of Acheulian Tradition (MAT) site of Nosovo I (Plisson 1988).

The studies cited above have all applied methods that were initially developed by Semenov. The following studies discussed here have applied either "high power" (Keeley 1980) or "low power" analytical methods (Odell 1977, 1979).

Use-wear studies for the Lower Paleolithic interval are few. Keeley (1980) conducted an intensive high-power analysis of stone tools from the Golf Course site, Clacton-on-Sea (Essex), Lower Loam at Swanscombe (Kent), and Hoxne (Suffolk). His study is as much a methodological work as it is a seminal study of Lower Paleolithic tool-use behavior. Use-wear data from these sites indicated a range of activities and worked materials. Woodworking, butchery, hide processing, and a limited amount of bone working were identified. In addition, Hoxne contained evidence of cutting and slicing of soft plant material. Analysis of handaxes from these assemblages suggest that they were used in butchering tasks. In spite of recent reactions against high-power methods, the data retrieved can be usefully employed in the reconstruction of tool use on Lower Paleolithic assemblages. The site of Carrieres Thomas, Casablanca, Morocco (Beyries and Roche 1982:267-277) yielded a number of tools (flakes, polyhedrons, and other tools) with wear from cutting and scraping of bone and wood. The dominance of woodworking activities in Keeley's (1980) and Beyries and Roche's (1982) study is further supported by an earlier analysis of flakes from several Lower Paleolithic sites at Caddington, England (Keeley 1978).

Behavioral interpretations concerning the Middle Paleolithic are on more solid footing due to a proliferation of use-wear research in recent years (see Anderson 1979, 1980; Anderson-Gerfaud 1981, 1990; Beyries 1987, 1988; Dockall 1991b, 1993; Hays 1993; Lee 1987; Panagopolou 1985; Shea 1987, 1988a, 1988b, 1989a, 1989b, 1990). There has been a geographic split in methodology among these studies. Those focusing on European Mousterian assemblages have applied the high power techniques developed by Keeley (1980). Researchers using this technique

include Beyries and Anderson-Gerfaud. Maureen Hays (1993) applied a low power approach in her analysis of the lithic material from Burrone Scierra I, Calabria Italy.

Use-wear studies that have been conducted for Levantine Mousterian assemblages have unanimously applied the low power analytical approach. Also, in one way or another, all low-power researchers have been affiliated with Odell or have been greatly influenced by his research. The point of this brief discussion is to note that some aspects of functional variation between European and Levantine Middle Paleolithic assemblages are due in part to the philosophical and theoretical orientation of the respective analysts.

Studies by Anderson-Gerfaud (1990) and Beyries (1987, 1988) indicate that woodworking was a predominant activity among European Mousterian peoples. Tool use in butchering tasks was not very abundant. Both researchers have demonstrated that major retouched and un-retouched tool types and debitage were used as tools. Evidence for hafting of both scraping and cutting implements was also identified. Neither researcher has identified any evidence to indicate the use of hafted projectiles in technologically assisted hunting. The purported absence of evidence of technologically assisted hunting in Europe during the Middle Paleolithic is in direct agreement with Binford's (1989:31) contention that scavenging and not hunting was the principal method of animal food acquisition. This inference is further supported by ancillary studies of stone tool fracture patterns of Zagros Mousterian assemblages (Dibble and Holdaway 1993:78-79; Holdaway 1989, 1990) although recent studies have indicated that this can be called into question (Dockall 1993; Solecki 1992; Solecki and Solecki 1993).

Again, there is some degree of variance between European Middle Paleolithic functional studies and those dealing with Levantine Mousterian assemblages. Shea (1991) has documented significant amounts of woodworking, butchery, hide preparation, plant processing, and damage patterns associated with hafted projectile points. Shea's data is based on the microwear analysis of entire assemblages from a number of Levantine sites. Panagopolou (1985) conducted an analysis of an assemblage of sidescrapers (following Bordes [1961] typology) from the Central

Gallery of Nahr Ibrahim, Lebanon. Her results indicated that a range of tool motions were represented: transverse, longitudinal, graving, boring, projectile use, prehension, and others. Transverse and longitudinal motions were the most abundant suggesting their use primarily as knives (Panagopolou 1985:199-200, Tables 18 and 19). The most commonly worked materials included soft, soft-medium, hard, and hard-medium. Panagopolou (1985:115) equated these hardness categories to materials such as meat, fat, skin, soft plants, soft and hard wood, dry hides, bone, and antler. For this tool category, butchery, wood and hide working were the principle tasks performed. Lee (1987) provided a functional analysis of Levallois points from the southern Jordan sites of Tor Faraj and Tor Sabiha (see Henry 1992). A high degree of functional specificity of this category was interpreted. The majority of tool motions identified by Lee were longitudinal (cutting) and soft material (meat) was the principle worked material. Butchering was the dominant activity interpreted for this tool type (Lee 1987:79-83). Other tool motions included projectile impact, grave, shave, scrape, plane, and drill. Pilot use-wear studies of convergent tools from Nahr Ibrahim, Lebanon (Central Gallery) and Shanidar Cave, Iraq (Layer D) also demonstrated a range of tasks and worked materials (Dockall 1991b, 1993). Convergent tools at Nahr Ibrahim were used in cutting, scraping, boring, drilling, projectile impact and graving tasks (no assessments of worked material were made). A selective sample of convergent tools from Shanidar Cave (mainly Mousterian points) were used to cut, scrape, grave, wedge, drill, and awl, while some were hafted projectiles. Among these tools, scraping, followed by cutting, were the dominant tool motions. Butchery, hide-working, and light duty woodworking were the dominant activities. Hafting was present as a minor wear form at both Nahr Ibrahim and Shanidar Cave.

Cognitive Development as a Source of Technological Variability

Binford (1989) has concluded that the degree and patterning of technological systems are, to a large extent, indicative of the general cognitive skills and planning abilities of early hominids. Technological systems associated with *Homo sapiens*

sapiens, and by extension, early anatomically modern humans, consist of both significant planning depth and tactical depth (Binford 1989:19). Tactical and planning depth form the basis of an extended discussion of technological organization in Chapter IV but are used here to address issues of variability. The definitions of these terms are quoted from Binford (1989:19):

Tactical depth--"The potentially variable length of time between anticipatory actions and the actions they facilitate, amount of investment in anticipatory actions, and proportions of activities so facilitated...."

Planning depth--"The variable capacity, based on stored knowledge of mechanical principles, environmental characteristics, and hence opportunities, to find more than one way to skin a cat."

Curation and maintenance are considered as variable aspects of modern human technological systems. Binford (1989:20) stated that curation can potentially be indicated by the varying choices regarding raw material selection and in the effort put into maintaining a technology. The degree of maintenance is reflected in tool complexity, design, and manufacturing effort to ensure a prolonged tool service life. Planning depth and tactical depth and curation are crucial aspects of successful adaptation in various different environments (Binford 1989:21).

This brief discussion of Binford's (1989) view of technological organization was selected due to its previous widespread application to archaic and early modern hominid behaviors and cognitive abilities (see Lieberman 1993; Lieberman and Shea 1994; Henry 1992; Kuhn 1992; Mithen 1994a, 1994b; Roebroeks et al 1988; Stiner and Kuhn 1992). Binford (1989) has provided us with a model by which we can critically evaluate the patterning of technological organization observed during the Lower and Middle Paleolithic.

Binford's (1985, 1989) interpretations of behavioral, cognitive, and organizational skills of modern human ancestors provide an excellent point of departure for a discussion of evidence for or against essentially modern behaviors during the Lower and Middle Paleolithic and how these interpretations have influenced our current understanding of technological variability.

Lower Paleolithic

It has been proposed that Lower Paleolithic technological organization exhibits a lack of significant planning and foresight with no evidence of anticipated occupation and return to specific localities (Binford 1989:25). This interpretation is readily apparent in Binford's assessment of material and patterning from Kalambo Falls, Isimila, and Olduvai Gorge in Africa (Binford 1987) and Choukoutien (Binford and Ho 1985). The conclusions regarding these and other sites are based on Binford's own reading of the spatial (horizontal and vertical) distribution and patterning of artifacts and faunal remains. These patterns do not fit the patterning of artifacts and other material remains that would identify them as base camps.

The spatial patterning at these sites is interpreted by Binford (1989:25-34) as both horizontally and vertically diffuse, being the result of two or three different strategies of tool use/manufacture that are not characteristic of home base or base camp assemblages (Binford 1987:27). These three strategies also characterize the bulk of Acheulian sites interpreted as base camps.

(1). The majority of tools found were manufactured in one locality and transported ultimately to the place of final discard. This is especially notable for large heavy tools such as handaxes, choppers, and cores or polyhedrons.

(2). Small tools made from local raw materials are recovered in varying proportions in association with larger tools of non-local material. This is indicative of the on-site manufacture of expedient tools.

(3). Given that some sites contain large core tools of imported raw materials, then sites characterized by abundant manufacturing debris should exist.

Diffuse horizontal and spatial patterning and the inverse correlation between small flake tool manufacture and the presence of large imported core and tools suggested several things to Binford (1987, 1989). He considered the small tools as being the residue of a group different from those associated with or responsible for the imported cores or tools. This was interpreted as evidence for distinct subsistence ranges for each group. Hence, these sites are not interpreted as base camps following the criteria of Isaac (1977) and Leakey (1971), but as the result of episodic

occupation. These tool accumulations were apparently not the result of a cultural behavioral system but were associated with a biological adaptive system that was technologically aided (Binford 1987:29, 1989:28-29, Binford and Ho 1985:429) in a similar manner in which chimpanzees employ twigs and stones as aids in food procurement.

Although much older than the Acheulian, Richard Potts (1984, 1991) has provided a model of sites with Oldowan material which represent a transitional phase prior to the development of home bases. This model represents a middle ground between both Isaac's (1977) home base and Binford's (1987, 1989) acultural episodic accumulations scenarios. Potts (1984:345) argued against the home base concept from four lines of data: (1) competition among early hominids and carnivores for faunal resources (marrow and meat); (2) presence of hominid transported food packages that attracted carnivores; (3) evidence for the incomplete processing of faunal remains; (4) apparent long temporal span over which bones and tools were deposited. All of this suggests a distinct dichotomy with what we know regarding the formation processes of modern hunter-gatherer base camps (Potts 1984:345).

Potts developed the model of the stone catchment area to explain tool accumulations at various sites. This model also accounts for the presence of large imported tools and small expedient tools manufactured on-site. According to his model (Potts 1984:345, 1991), tools of non-local raw materials were transported and left at localities within the forage range of early hominid groups. The result of this behavior was the development of stone tool and raw material caches or accumulations during the course of the foraging round. Another critical aspect of this model, in addition to raw material transport, was the frequent transport of food (carcasses, portions, bones) to stone tool caches (Potts 1991:170).

These models are crucial to most discussions of Lower and Middle Paleolithic variability because Binford (1989) applied his views to both time periods. The different models presented by Binford, Isaac, and Potts can also be interpreted as indicating different levels of cognitive development, tactical depth, and planning depth during the Lower Paleolithic. This is a significant factor when interpreting the

Middle Paleolithic. These models reflect a continuum of cognitive development and characteristic human behaviors. Isaac (1977:218-219) suggested that early hominids were organized, efficient hunters with food-sharing, mutual protection, and group cooperation as behavioral characteristics. He felt that early Pliocene and Pleistocene hominids did not possess efficient language skills and modern human cognitive abilities. Of greatest importance is that even though early hominid culture was "slight" by modern standards, technology was an important part of the adaptive repertoire of cultural development. A significant degree of planning and tactical depth to the technology is also indicated contra Binford's (1989) contentions for the Lower Paleolithic.

Although Potts (1984, 1991) did not consider Isaac's evidence and data from other Oldowan sites as indicative of a home base, his interpretation is still suggestive of a degree of planning and tactical depth beyond that proposed by Binford. It also suggests some understanding of the concept of risk-minimization in the caching of stone resources and tools near the site of use. The reuse of these locations also is indicative of forethought and planning. The use of stone material caches as food processing areas is implied to mean that the social activity that occurred was in many ways similar to modern hunter-gatherer base camps (Potts 1984:346). If this type of behavior was associated with the oldest stone technologies as suggested by Potts (1984), then we may expect that it was even further developed in the Middle Paleolithic.

Middle Paleolithic

Abundant research exists to demonstrate that the Middle Paleolithic is replete with examples of archaeological patterns associated with faunal and stone tool assemblages that can be interpreted in various ways (Binford 1989:31). Binford's (1989) interpretation serves as an example of the apparent consensus view: Middle Paleolithic patterning and variability is indicative of a change in the adaptive role of technology in hominid evolution (Binford 1989:32). A quote that best summarizes Binford's thoughts is presented below:

"Middle Paleolithic sites are palimpsests of many episodes of use and not planned occupations of any substantial duration. In further contrast to sites produced under modern human conditions, they do not display the variation in sequentially accumulated remains that results from tactical exploitation of their environments in terms of planned strategies...."

"I view this as evidence that there is no organized integration between the social domain and its "needs" and the tactical flexibility in the technology" (Binford 1989:33-34).

Other lines of data cited by Binford (1989:34-35) as evidence of a dramatic difference between Middle Paleolithic hominids and modern hunter-gatherers include proportional comparisons of fauna and tools, planning and organization, and curation-recycling. Hominid groups during the Middle Paleolithic are described as small and highly mobile with only a modicum of technological organization. Technology is perceived as having a rapid replacement rate and an absence of planning (see Binford 1989:34-35). Significant in this interpretation are Binford's (1984, 1985, 1989) opinions and hypotheses regarding hunting during the Lower and Middle Paleolithic.

The faunal records for the Upper Pleistocene of Europe were evaluated in light of his examination of fauna from Klasies River Mouth (Binford 1984) and ethnoarchaeological research (Binford 1978a, 1978b). The ultimate conclusion regarding the Middle Paleolithic hunting of moderate-large sized game animals was that it was not systematic or regularly planned (Binford 1985:321). Binford (1984:97-98, 196) regarded the faunal evidence at Klasies River Mouth as suggestive of a lack of planning depth and organization and also inferred that the hunting technology necessary for taking large game was absent (1984:200). This conclusion is also present in his interpretations of European and Near Eastern data inferring that lithic tools were used primarily as toolsets for the dismemberment of scavenged animals rather than as hunting weaponry.

Binford's conclusions that the Lower and Middle Paleolithic indicate little or no planning depth to either subsistence, settlement, or technology is at odds with more recent archaeological, settlement, faunal, functional, technological, and cognitive studies of Lower and Middle Paleolithic patterns and data. Also, according to Binford, explanations of patterning in the Lower and Middle Paleolithic cannot logically be founded on models based on ethnographic analogy, dynamics and patterns of modern human cognitive development, or comparisons with archaeological remains associated with anatomically modern humans.

Just as Binford's critical and thought provoking reading of variability in the Lower and Middle Paleolithic has forced researchers to consider other explanations for their data, so too has recent research in the cognitive and symbolic abilities of Lower and Middle Paleolithic hominids. Whether or not one is in agreement with these studies, the researcher is now forced to contend with the less tangible or visible aspects of the prehistoric past in an effort to reconstruct past behaviors. The single most useful line of evidence that has been used to reconstruct past hominid cognitive development and associated behaviors has been lithic technology. The evolution and development of hominid cognitive and intellectual abilities has been approached through studies of technical skill associated with the manufacture and use of stone tools.

Steven Mithen (1994b) remarked that Lower and Middle Paleolithic hominids possessed behavior and thought patterns very similar to modern humans. His examination of these areas of cognitive skill (social, technical, and natural history) demonstrated this similarity. Mithen (1994b:33) noted that to have survived in the more glaciated areas of northern Europe during the Lower and Middle Paleolithic, large groups maintained by complex social and ritual relationships would have been necessary. Also, similarities in artifact form and manufacture imply the repeated replication of mental templates. This aspect of learning is linked to social organization and social intelligence (Gibson 1993; Ingold 1993a; Mithen 1994a, 1994b; Reynolds 1993; Ridington 1982; Wynn 1991, 1993).

At the level of technological or technical intelligence, there is considerable complexity reflected within the Lower and Middle Paleolithic. The very act of flintknapping is goal-oriented, implying at least some level of planning, forethought, and the mental ability to conceive and memorize methods of tool production to achieve a desired end-product. Systematic reduction strategies as complex as any Upper Paleolithic chipped stone tool manufacturing sequence were in operation during the Lower and Middle Paleolithic (see Bar-Yosef and Meignen 1992; Boëda 1982, 1988, 1993; Boutie 1981; Dibble 1981; Isaac 1977; Marks and Volkman 1983; Meignen and Bar-Yosef 1988a, 1988b; Van Peer 1992, 1995; Wynn 1977). The bifacial handaxe manufacturing sequence (Wynn 1977, 1989, 1991) and Levallois reduction strategies (Van Peer 1992) involved the application of complex spatial and volumetric concepts. The achievement of artifact symmetry at the end of the flintknapping operation is also evidence of the ability to conduct three-dimensional symmetry operations. The maintenance of symmetry as raw material is transformed infers a high degree of organizational ability (see Wynn 1979, 1991).

Some Paleolithic researchers have advocated the application of Piaget's principles to approach an understanding of prehistoric intelligence (Henry 1992; Wynn 1977, 1983, 1985, 1989, 1991, 1993). Piaget's theory outlined the intellectual development of children from birth to adolescence. The Piaget theory also incorporates information regarding the individual's position, movement in, and exploitation of the environment (Wynn 1991:54). Intelligence is defined as the ability to organize--whether it be tasks, settlement patterns, or resource procurement. This theory of intelligence is based on cumulative experience and the mental organization of external phenomena. Systems of internal organization are employed until they are no longer adequate, at which time they are modified. There is a dynamic relationship between internal organization and external variables (Wynn 1991:54).

Wynn (1985, 1991) also noted that Piaget's theory was operational in that any stage of learning is at once both a result of a previous stage and a precursor to the next stage of learning and intellectual development. The characteristics of

operational thought that are most crucial for a discussion of Lower and Middle Paleolithic intelligence are reversibility and conservation (Wynn 1991:56).

Reversibility indicates that each operation has an opposite while conservation implies a transfer of material across a boundary (boundary in this instance could represent the transition from one stage of a process to another). Reversibility and conservation also involve the application of certain organizational principles (Piaget 1970; Wynn 1991). One of these principles is that of compensation for errors or problems before they arise (Wynn 1991:56). This requires the cognitive abilities of planning and foresight. One also has the ability to enact a procedure mentally before acting, foresee problem areas and allow for contingency plans in the event problems arise. These are the qualities of operational thought.

Operational thought is characterized by logical and internal consistency. Piaget conceived of operational thought in two stages: concrete and formal (Gardner 1972:90-104; Piaget 1970; Wynn 1991:56-64). Concrete operations exhibit the properties of reversibility, conservation, and anticipation and correction of problems. Concrete operations also are an organizational facility which, according to Wynn (1991:57), are used to organize such things as "tasks, tools, kinship, politics, and religion..." Evidence for the presence of concrete operations in prehistory include the bifacially flaked Acheulian handaxes (Gowlett 1984; Mithen 1994a; Wynn 1977, 1991, 1993). The manufacture of bifacial handaxes requires not only a concept of bilateral and cross-sectional symmetry, but the symmetry must also be visualized by the knapper in relation to size, weight, material, and other physical properties. This indicates that reversibility and foresight are necessary to achieve the final product. The same conceptual requirements are also necessary for the application of the various Levallois techniques (Mithen 1994b; Van Peer 1992; Wynn 1991:59). Lower and Middle Paleolithic flaked stone industries reflect a sophisticated degree of technical intelligence, spatial patterning, and motor skills (Mithen 1994b:34).

Other evidence for the presence of concrete operations during the Lower and Middle Paleolithic is found in the transport of both tools and raw material over large areas (see Geneste 1988; Hayden 1993; Henry 1992; Marks et al. 1991; Roebroeks

et al. 1988). The transport of raw materials and finished tools over considerable distances (60-80km) indicates that a significant amount of planning and tactical depth was associated with the technological organization. This type of behavior requires a broad mental database of geographic information; specifically, the location, abundance, and quality of raw materials for stone tools. The skills required for this type of behavior are grouped under the rubric of cognitive mapping (Goldin and Thorndyke 1981:1) and include map learning, navigation, and orienteering. Cognitive mapping skills are also crucial aspects of natural history intelligence (see below).

Mithen (1994b:34-35) included those cognitive skills necessary for productive use of environmental variation, plants, and animals within natural history intelligence. As ecological and environmental information is processed, this information is combined with technical and social intelligence to adapt to changing environmental conditions. There is some indication that Lower and Middle Paleolithic archaic hominids differed in their application of natural history intelligence than either Middle Paleolithic or Upper Paleolithic anatomically modern humans but the nature of this difference is still incompletely understood.

Faunal studies have determined a significant degree of sophistication regarding Middle Paleolithic hunting strategies (Chase 1988, 1989; Kuhn 1992; Lieberman 1993; Lieberman and Shea 1994; Stiner and Kuhn 1992). Settlement pattern and subsistence data do, however, indicate a certain level of conservation associated with the Lower and Middle Paleolithic that is not observed in the Upper Paleolithic (Chase 1986; Lieberman 1993; Lieberman and Shea 1994; Mellars 1989a, 1989b). Lieberman and Shea (Lieberman 1993; Lieberman and Shea 1994) demonstrated that archaic hominids in the Near East responded to changing environmental conditions by increasing the level of hunting whereas anatomically modern hominids adapted the settlement and subsistence patterns to changing conditions. The natural history intelligence (Mithen 1994b:34) of both archaic and anatomically modern humans was sufficient to enable them to exist (or co-exist) in a variety of environments. It did not, however, allow archaic humans to achieve the

rate of adaptability of anatomically modern humans, which limited their ability to respond to external change. Although both groups hunted and had a functional level of natural history intelligence, such that survivability was possible, archaic humans apparently had less planning and tactical depth (in reference to natural history intelligence). This is in stark contrast to previous views of no planning and tactical depth.

Such conservatism is even more apparent with reference to technological change in the Lower, Middle, and Upper Paleolithic. The similarity of flaked stone industries throughout much of the Old World during the Lower and Middle Paleolithic contrasts sharply with the rate of technological change, diversity, and succession of the Upper Paleolithic industries. This is apparent in spite of the problems with typology. Mithen (1994b:34) noted that prior to the Upper Paleolithic the role of technology as an adaptive tool was different and suggested that there was a distinct difference between technical and natural history intelligence. To a degree, we are obliged to accept Binford's (1989) observation that technology during the Lower and Middle Paleolithic was an "aid" and not a "means" of adapting. But rather than emphasize a distinction in technical intelligence, it is perhaps more accurate to acknowledge a narrow link between technical and natural history intelligence. The overall picture that emerges during the Lower, Middle, and Upper Paleolithic is one of high levels of social, technical, and natural history intelligence (Mithen 1994a, 1994b; Wynn 1989, 1991).

Major differences between these periods of prehistory lie in the degree of integration between social, technical, and natural history intelligence. Mithen (1994b) applied the term *mental modularity* to describe the Lower and Middle Paleolithic. Technical intelligence was limited to the manipulation of stone and natural history intelligence did not reach a level sufficient to achieve similar degrees of adaptive response to environmental change (Mithen 1994b:35).

The final stage of human intelligence in Piaget's model is that of formal operations (Gardner 1972; Wynn 1991). Formal operations are used as tools to generalize beyond sets of data and single objects and are inclusive of the cognitive

skills necessary for hypothetical and deductive logic and reasoning (Wynn 1991:58). The formal operations stage is associated with an individual's ability to react to both real and imagined objects in addition to grammatical and symbolic expressions (Gardner 1972:98). Wynn (1991:58) and Gardner (1972:88, 99) identified "inversion" and "reciprocity" as properties of formal operational thought. In accord with Piaget's model, Wynn (1991:59-60) has demonstrated that Lower and Middle Paleolithic stone tool manufacturing techniques also exhibit the reversibility patterns of inverse and reciprocal relationships (as do Upper Paleolithic techniques) and that nothing is significant regarding their connection to formal operations and modern cognitive abilities.

The concept of curation of tools and raw material was also evaluated as evidence of formal operational thought (Wynn 1991:59-60). There are several lines of data that have been central to arguments for and against curational behavior during the Lower and Middle Paleolithic. These include hafting (Mellars 1989a:351; Shea 1991), raw material transport (Henry 1992; Roebroeks et al. 1988), repaired or resharpened tools (Dibble 1984, 1987, 1988; Gordon 1993), and tool type versus site type (Marks 1988). Wynn's (1991:60) definition for curated tools is quite limiting in that it only considers curated tools as being generalized and multi-purpose with several use periods. Curated tools are also carried among various localities. According to Wynn, then, curated tools cannot include those manufactured for specific purposes. This not only results in a very biased view of curation but also obscures a growing body of data relating to curation of raw materials, tools, and cores. Wynn is correct in his assertion that the crucial aspects of curation that could potentially inform us of formal operational intelligence lie in the organization of such behaviors within the technological and social system at large (Wynn 1991:60). This would include settlement/subsistence systems, resource distribution, and the ways in which technology is organized in relation to these variables.

However, from a Piagetian perspective the cognitive prerequisites for curational behaviors as responses to these variables are those already established as aspects of concrete operations (see Wynn 1991:60-61). Wynn (1991:60) also stated

that the long-term strategies of curational behavior cannot be directly observed and in effect are unknowable.

Formal operations are considered by some researchers (Gardner 1972:103; Wynn 1989:94, 1991:63) to be a product of western educational systems or formal educational systems. Gardner (1972:103) further added that formal operations may not be a vital aspect of most individuals in their daily existence. Formal operations then may not be a universal even today, having their own history and evolution in western education (Wynn 1991:64). If so, then it is futile to expect to find evidence for them in the archaeological record.

The only realm of investigation that could have potential for evidence of formal operations in prehistory may be in the area of ritual and symbol (see Wynn 1989:95-96, 1991:61). Symbolism has been claimed as one of the greatest differences between anatomically modern and archaic humans. Old World prehistorians typically associate this with the Middle to Upper Paleolithic transition. The evidence for and against the presence of symbolic acts and symbolic artifacts in pre-Upper Paleolithic contexts is wide open to differences in individual interpretation. Perhaps this is a reflection of the difficulty of identifying aspects of formal operations in prehistory. Regardless of the claims that Neanderthals and other archaic hominids had equivalent capacities for symbolism, ritual, and art (see Hayden 1993), the fact remains that it was not expressed to the degree of the later Upper Paleolithic. The Upper Paleolithic is characterized by a wide diversity of art forms, personal adornments, elaborate bone and antler work, and ritual burial practices (Mellars 1989b:362). Although some evidence for symbolic expression and formalized burials has been documented for the Middle Paleolithic, it does not approach the visibility and complexity of the Upper Paleolithic.

The emergence of this sophistication in the Upper Paleolithic has been attributed to the increased complexity of individual and cultural expression associated with the appearance of anatomically modern humans (Mellars 1989b:363). Hayden (1993:125) perceived the appearance of parietal art, bone and antler work, and evidence of ritual to be a reflection of more complex status-oriented hunter-gatherer

groups. These complex hunter-gatherers are contrasted sharply with generalized groups of the Lower and Middle Paleolithic. Hayden (1993:125-126) characterized generalized hunter-gatherers as having a restricted ability to procure and preserve resources, low population density, opportunistic food procurement, essentially egalitarian social organization without status display, and a social organization that forbade private ownership and personal wealth acquisition.

These interpretations appear to correlate well with Wynn's (1991:65) inference that formal operations are essentially a function of socio-cultural climate and are not biological in origin. Increased socio-cultural complexity provided the framework to enable individuals to begin to solve more complex problems. This required the development of a different type of organizational thinking in addition to concrete operations.

Summary

Understanding of Middle Paleolithic technological variability has encompassed a broad variety of topics. These include technological, typological, functional aspects of lithic technology and stone tool manufacture. Potential evolutionarily significant areas of technological variability include cognitive and behavioral differences between anatomically modern and archaic/Neanderthal hominids. Subsistence and settlement differences have been suggested as key sources of behavioral variability between these hominid groups.

Changing interpretations of the cognitive differences between Lower, Middle, and Upper Paleolithic hominids suggest an increasing awareness among paleolithic archaeologists of the importance of technology as an adaptive strategy. As part of the complete set of adaptive strategies available to hominids, technology should be considered within a theoretical framework that includes settlement and subsistence patterns, tool manufacture/use/discard sequences, and the integration of technology within other facets of the adaptive program of human groups.

Differences in cognitive and behavioral patterns have garnered much of the research focus of late. Researchers have begun to incorporate evolutionary and

intelligence issues into their research concerning technological and functional aspects of assemblage variability within and between the Lower, Middle, and Upper Paleolithic of the Near East and Europe. Aspects of the environment and chronological data will, however, continue to provide the framework upon which models of variability are examined. Chapter II provides an examination of the chronology, environment, and hominid fossil record for the Levant to provide context to discussions of technological and functional variability of convergent tools from the Levantine Mousterian.

CHAPTER II

CHRONOLOGY, ENVIRONMENT, AND HOMINID PALEONTOLOGY OF THE LEVANT

This study is directed toward the analysis of a narrow range of tool types within the Levantine Mousterian. Consequently, a solid understanding of the Levantine Mousterian as a label is necessary. This includes an understanding not only of the history of research concerning the Levantine Mousterian, but a knowledge of the environmental and climatic setting in which the Levantine Mousterian developed. If the behavioral aspects of functional and morphological variability of lithic assemblages are to be studied, two key concepts must be kept in mind; (1) that lithic technology is part of the cultural and social system, and (2) that lithic assemblages do not operate and change in a vacuum, but are part of the overall adaptive strategy of the group in question. The late Pleistocene environment of the Levant provided the backdrop for the development of the Levantine Mousterian industry. Lithic technology also represents a dynamic and integral part of the overall adaptive strategy of humans to their social and physical environment. Significantly, the Levant appears to have been a region of considerable ecological and environmental diversity and was sensitive to changes throughout the Pleistocene.

Geographic Significance of the Levant

The significance of the geographic location of the Levant is in part a result of the regional position of the Middle East. Held (1989:3) stated that the Middle East represents the "tricontinental hub" of Africa, Asia and Europe. The geopolitical significance of the region is apparent. Also, as the juncture between three continents, the Middle East and the Levant have been and are subject to considerable environmental diversity as succinctly stated by Henry (1989:57). The Levant represents a coastal corridor of the eastern Mediterranean and has been dominated at

different times by biotic communities of each of these three different continents. Topographic and climatic differences have created floral and faunal refuges in some areas and have led to a diverse array of environmental settings including forest, desert, and steppe. Floral and faunal distributions are easily altered by variation in precipitation and temperature.

Geomorphic Provinces of the Levant Region

The Levant can be most easily described as a region in which the major physiographic zones are parallel (roughly north to south) to the Mediterranean coastline (Horowitz 1979:11-18). Along a west to east axis, there are four principal geomorphic zones (Figure 2.1) defined: (1) the Coastal Plain, (2) Western or Mediterranean Hills, (3) Levantine Rift System, and (4) the Eastern or Jordanian Plateau (also see Henry 1989:57-61; Horowitz 1979:11-18; Shea 1991:16-19).

Coastal Plain

The Levantine Coastal Plain is narrow in the north along the Mediterranean coasts of Syria, Lebanon, and northern Israel but widens significantly as it reaches the Mount Carmel area (Henry 1989:58; Horowitz 1979:12). The southern portion of the Mediterranean coastline of Israel is characterized by the presence of three sandstone ridges (kurkur ridges) separated from each other by fertile plains of a few kilometers in width. These ridges parallel the coastline and represent consolidated dune ridges marking the previous extent of the shoreline during the Pleistocene.

The general character of the Levantine coastline is the result of local deposition of alluvial sands and sediments from the Ethiopian Highlands and the Nile via the eastern flow of the Mediterranean Longshore Current (Henry 1989:58). The Mediterranean coastline of Israel is straight for virtually its entire length, but becomes characterized by abundant bays as the coastline approaches Lebanon

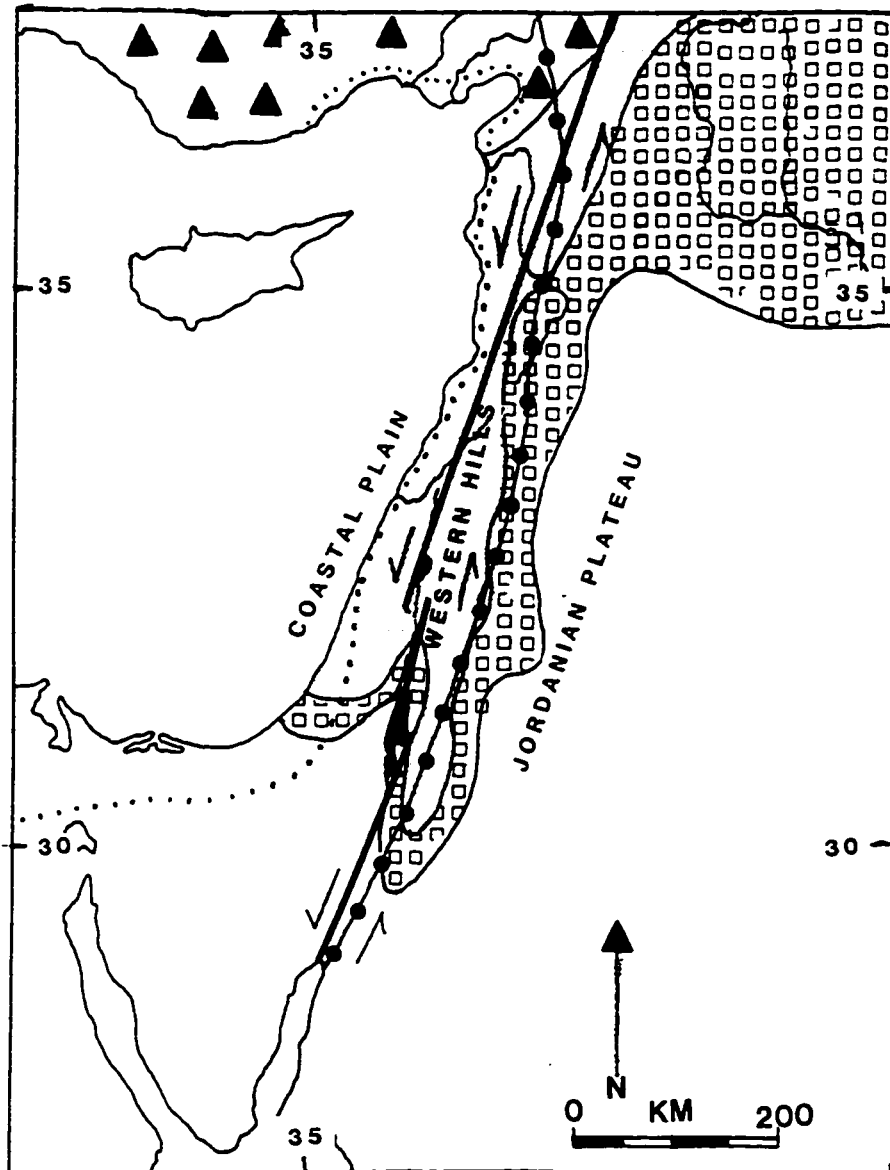


Figure 2.1 Map of Near East showing the principle physiographic units and phytogeographic zones of the Levant. Stippled area represents the Mediterranean zone; area filled with squares is the Irano-Turanian; large filled triangles represent the Euro-Siberian; unfilled area represents the Saharo-Sindian. The dotted line along the coast represents the boundary between the coastal plain and the Western Hills. The line with black dots is the division between the Western Hills and the Jordanian Plateau. The solid black line represents the Levantine Rift system.

(Horowitz 1979:12). The coastal plain of Israel is also a continuation of the coastal plain of the Sinai.

The difference in character from the coastlines of Lebanon and Israel can be explained in part by eustatic sea-level changes. Butzer (1958:32-33) characterized the coast of Lebanon as a coastline of submergence but it is now known to be the result of complex plate tectonics associated with the Arabian Plate (Horowitz 1979:47-62). The Lebanon Massif abruptly descends below the sea and this has allowed former high sea stands to be preserved along the shores as raised beaches and terraces.

The Western or Mediterranean Hills

This region is the culmination of the last major orogenic event, the Alpine Orogeny. During this event the mountains and hills of the Levant formed as the result of folding along an S-shaped track from Sinai to western Syria. Regional differences in this pattern are the direct result of later faulting, uplift, and erosion (Henry 1989:58; Horowitz 1979:54).

In Israel, this region forms a formidable mountainous zone stretching the entire length of the country. This zone forms a watershed between the Mediterranean Sea to the west and the Dead Sea and Bay of Elat on the east. Pleistocene upwarping has influenced all previous tectonic structures, anticlines, synclines, and rift valleys, and represents a significant factor that has created the current character of the Mediterranean Hills zone (Henry 1989:58; Horowitz 1979:54).

Mesozoic and Cenozoic activity along the Levantine Fold Belt followed by subsequent faulting and upwarping has created a continuous mountainous region the length of the Levant from Hatay in southeastern Turkey to the Central Negev, Israel (Henry 1989:59). Highland areas that were formed as a result of the faulted and upwarped structures east of the Fold Belt include (from south to north) the Judean

and Samarian Hills, Upper Galilee Highlands, Mount Lebanon, and the Jabal al-Nusayriyah. The Anti-Lebanon Mountains lie to the east of the Bekaa Valley and the Palmyra Folds lie beyond these mountains (Held 1989:34).

The mountains and hills of this region are dominated by various carbonate rocks such as limestones, dolostones, and chalk. The exception is the southernmost portion around Elat that is characterized by volcanic/igneous and metamorphic lithologies (Horowitz 1979:14) and the massive alluvial fans of the Southern Negev. The largely Cretaceous limestones and other carbonate rocks are typically rich in flint and chert thereby providing hominids with abundant sources of raw material for chipped stone tools (Henry 1989:59-60).

The Levantine Rift System

The Levantine Rift System is also known variously as the Dead Sea Fault, Jordan-Dead Sea Rift, and the West Arabian Fault Zone. It is a left-lateral fault that created a total horizontal displacement of 107 km during two main episodes of formation. The system is also characterized by four deep basins: the Gulf of Aqabah, the Dead Sea, the Sea of Galilee, and the Huleh Basin. These basins are actually pull-apart zones at which depressions formed as grabens (Held 1989:34).

The Levantine Rift System is a major feature of the western Fertile Crescent. This complex rift system extends from the northwestern end of the Red Sea and follows the Gulf of Aqaba, and along a path from the Wadi al-Arabah, Dead Sea, Jordan Valley, the Bekaa Valley of Lebanon, to the Ghab Depression in the northwestern portion of Syria (Held 1989:34). Two main phases of formation include the rotation of the Arabian Plate away from the African Plate during the Miocene and a subsequent period of rifting during the Pliocene and Pleistocene (Held 1989:24).

The Levantine Rift System is characterized by three major segments. The first segment includes the trench and associated features that extend from the Gulf of

Aqaba north to the Huleh Basin. The second portion originates with the southern border of Lebanon at which the Levantine Rift System turns to the northeast. This segment is characterized by a less deep but still prominent linear depression through Lebanon, known as the Bekaa Valley. This segment is also known as the Yamunah Fault which is still quite active. The third segment begins at the northern border of Lebanon where the fault system turns north to the Ghab Depression and its ultimate termination at the base of Mount Amanous near Hatay, southern Turkey (Held 1989:34; Henry 1989:60-61).

Eastern or Jordanian Plateau

The Jordanian Plateau is characterized by Cretaceous limestones, dolostones, and sandstones, with older Pre-Cambrian and Cambrian rocks exposed at the surface along the eastern edge of the Jordan Rift Valley. The exposure of older rocks is due to tilting of the Transjordanian Block. The areas of northern Jordan and the Golan Heights are characterized by extensive exposures of Pleistocene basalts. Uplift of the Transjordanian Block began during the Oligocene and Miocene, with the most extensive movement occurring along the edge of the Jordan Rift Valley (inclusive of the Wadi al-Arabah, Dead Sea, Lower Jordan Valley, and the Upper Jordan Valley) (Henry 1989:60-61).

Current Environment and Climate

The climate of the Levant is Mediterranean with regional variation because of the effects of latitude, altitude, mountains, and proximity to the Mediterranean Sea. These and other factors can result in marked seasonal and regional differences in precipitation and temperature. Henry (1989:62) noted that the Levant lies within a transition between subtropical and cyclonic circulation belts. Winters in the Levant are dominated by the cyclonic belt with summers dominated by a subtropical system as the cyclonic belt is displaced to higher latitudes. This shift in systems also results

in a marked seasonality in precipitation with 70-80 percent occurring from November to February. The Mediterranean climate of the Levant is identified as CSa type following the world climatic classification of Köppen (Taha et al. 1981). CSa climates are characterized as warm, temperate, and rainy with hot and dry summers. This climatic type is also found in the Black Sea region, the Aegean, the Mediterranean coasts of Turkey and Cyprus, Syria, Lebanon, and Israel.

Regional Environmental Variation

The environment of the Levant has been characterized in three major phytogeographic zones: Mediterranean woodland, Irano-Turanian steppe, and Saharo-Arabian (or Saharo-Sindian) desert (Zohary 1962). Each of these regions is distinguished by a unique plant community and decreasing precipitation.

The Mediterranean woodland region is characterized by about 800 species of flora, which is the greatest variety to be found in any of the discussed regions (Zohary 1982:31-32). The limits of the zone are well-defined: it is present throughout the northern Levant and in areas of the southern Levant that typically experience in excess of 40 cm of annual precipitation (Shea 1991:17). The region can also be subdivided into an upland and lowland zone with distinctive vegetation patterns. Elevations in excess of 300 m are dominated by the Palestinian oak (Quercus calliprinos), pistachio (Pistachia palaestina), and juniper (Juniperus phoenicea) (Henry 1989:63; Shea 1991:17). In lower elevations (below 300 m) the Palestinian oak is replaced by a deciduous oak (Quercus ithaburensis) in wetter portions of the coast adjacent to the hills and interior valleys.

The Mediterranean zone ranges from a montane forest at the Taurus Foothills to an open woodland in the northern and central Levant where terra rosa (alfisols) soils predominate. A maquis environment is present where rendzina soils predominate (Henry 1989:63; Shea 1991:17). Alfisols are the most common soil unit of the Mediterranean woodland in the Levant and form from weathering Upper

Cretaceous limestones. Rendzina soils are derived from the weathering of chalky and marly bedrock and can occur in association with terra rossa (Zohary 1982:18-19).

The Irano-Turanian zone has over 300 species of flora as well as a wide variety of species from adjacent phytogeographic zones (Zohary 1982:32). The region is a semi-desert steppe along the margins of the Mediterranean woodland zone (Shea 1991:18). The vegetation character of the Irano-Turanian is less uniform than that of the Mediterranean region. Part of the reason for the lesser degree of uniformity lies in the fact that this zone interdigitates between the Mediterranean and Saharo-Arabian regions. The region receives between 15 and 35 cm of precipitation annually and has a somewhat continental climate with extreme temperature ranges. Consequently, this area is well-suited to support a patchy surface vegetation dominated by a number of different plant communities of the *Artimedieta herbae-albae* class (Zohary 1982:32). Plants of this class are supported on calcareous soils while *Achillea santolina* and *Hammada scoparia* grow on loess soils (Shea 1991:18; Zohary 1982:32). Other dominant plant species include *Noaea mucronata*, *Reamuria hirtella*, and *Salvia lanigera*.

The Saharo-Arabian region is comprised of deserts lying to the south and east of the Levant proper (Shea 1991:18). There are roughly 300 species of flora in Israel associated with this zone. The region has long dry summers and short winters. Annual precipitation ranges from only 2.5 to 15 cm (Zohary 1982:32-33). The soils of this region are andosols. Characteristic geomorphic features include hammadads, regs, and sands, as well as rocks with flora concentrated along and in the wadis where moisture is concentrated. Plant communities are dominated by four major classes: *Anabastea articulatae*, *Retametea rætami*, *Retamo-Tamaricetea fluviatilis*, and *Suaedetea fruticosae deserti* (Henry 1989:64; Zohary 1982:33). Trees of the region include date palm (*Phoenix dactylifera*) and *Acacia* sp. Stretches of drift sand can also support forests of Ghada trees, *Haloxylum persicum* (Henry 1989:64).

Tchernov and Yom-Tov (1988:1) have noted that the biotic character of the Levant is one of the most complicated in the world. It comprises Ethiopian, Oriental, Euro-Siberian, European, Central Asiatic, and Mediterranean species with a mix of Saharan and Arabian types. It also may be rightly considered as one of the richest and most diverse regions relative to its size in the world. Shea (1991:18) indicated that the larger herbivorous and carnivorous animals in the Levant during the early Upper Pleistocene would have represented hominid prey targets and/or direct competition with hominids for other floral and faunal resources.

Chronological Framework of the Levantine Middle Paleolithic

Published accounts and discussion of Quaternary paleoenvironment and climate change in the Levant are intimately tied to discussions of archaeology and hominid evolution. The paleolithic chronology of the Levant is based upon past and recent research concerning Oxygen Isotope stages. In the Levant, oxygen isotope stage data (Bar-Yosef and Goldberg 1988) are correlated with paleoenvironmental events and archaeological remains by a number of chronometric dates from a variety of contexts. These dates are also produced by an array of dating techniques. This effort in correlation of paleoenvironmental events, geological and archaeological data, and hominid paleontology has provided a chronological referent applicable to the entire Near East. It is necessary to provide a brief sketch of the lithic industries associated with the later Lower and Middle Paleolithic of the Levant.

Mugharan Tradition

The late Lower Paleolithic is associated with the Mugharan Tradition (Jelinek 1981:272-272) also referred to as the "Acheulo-Yabrudian" (Bar-Yosef and Goldberg 1988:14). Jelinek has divided the Mugharan Tradition into three facies but is only present in the northern and central Levant (Bar-Yosef 1989a:590): Acheulian, Yabrudian, and Amudian/Pre-Aurignacian.

The Acheulian facies (Jelinek 1981:269) is characterized by fairly high biface frequencies of about 15%, but lower frequencies of other retouched tools (15-20%). Retouched tools also have a high frequency of Quina or demi-Quina modification (Bar-Yosef and Goldberg 1988:14). Transverse and déjéte scrapers occur in lower proportions but are considered a trait of this facies.

Typologically and technologically, the Yabrudian is very similar to the Acheulian but with significant proportional differences. Retouched tools, with high Quina frequencies, are often present in very high frequencies (about 40- > 50%). Bifaces are rare or non-existent and there are low frequencies of complete flakes (Jelinek 1981:269).

The Amudian/Pre-Aurignacian facies can be considered an enigma of the Mugharan Tradition and has been the source of recent research as to its origin (Jelinek 1990; Ronen 1992). A hallmark of the Amudian is the abundance and variety of characteristically "Upper Paleolithic" tool types (Bar-Yosef and Goldberg 1988:14; Jelinek 1981:272, 1990): abundant blades, backed blades, some end-scrapers and burins, and few bifaces. Jelinek (1981:272) noted that when one looks beyond these unique characters, the Amudian deposits at Tabun are associated with a dramatic increase in the abundance of complete flakes, few retouched tools and bifaces, and decreasing core frequencies. In fact, Jelinek stated that the "high relative frequency of complete flakes alone is sufficient to separate the Amudian levels from the Yabrudian and Acheulian facies" (1981:272).

Mousterian Sequence

Based on stratigraphic and techno-typological analyses of Tabun, Jelinek (1982a:71-71) suggested that there was some evidence for a gradual change from the Acheulian facies into the Early Mousterian. This evidence comes from the upper part of Unit XI to the lower part of Unit IX at Tabun. Unit X at Tabun may represent a "transition" from the Mugharan Tradition to the Levantine Mousterian

(Bar-Yosef and Goldberg 1988:14; Jelinek 1982:72-72). Unlike the Mugharan Tradition, the Levantine Mousterian is characterized by the dominant usage and variability of the Levallois technique, scarcity of bifaces, and the technique of truncating/faceting of flakes (Marks 1992a:232).

Variation in the application of the Levallois technique had led to the division of the Levantine Mousterian into three groups based upon the Tabun sequence: Tabun D, Tabun C, and Tabun B. Early interpretations of this sequence considered it to be a linear development. Copeland (1975) divided the types into Phases 1 through 3, representing Tabun D through B. More recently, this sequence has been reinterpreted and is now discussed by some researchers as being of two phases: early Levantine Mousterian or Tabun D and Late Levantine Mousterian or Tabun C-B (see Jelinek 1982a:74; Marks 1992a:129, 1992b:232). A two phase division is used by some researchers due, in part, to a lack of detailed technological and typological descriptions of Tabun B industries (Clark and Lindly 1989:645).

The Levantine Mousterian three phase sequence of Copeland (Copeland 1975; Bar-Yosef 1989a, 1989b; Shea 1991:29-31) is presented here for discussion and descriptive purposes. Phase 1 (Tabun D) assemblages are dominated by unidirectional and bidirectional Levallois core preparation, high proportions of Levallois blades and elongated points, and Upper Paleolithic tool types such as burins and end-scrapers. Phase 2 (Tabun C) assemblages are characterized by radial core preparation, few Levallois points, more flakes than blades, and a large number of sidescrapers and denticulates. Phase 3 (Tabun B) lithic assemblages are dominated by large proportions of blades and small, broad Levallois points removed from unidirectional-convergent cores.

Clark and Lindly (1989:645-646) noted that the dates for Phase 1 (Tabun D) at Tabun fall between 90-80,000 B.P.; Phase 2 (Tabun C) dates range from 50-60,000 B.P., Phase 3 (Tabun B), sometimes combined with Phase 2 would be about 50,000 B.P. Although the Tabun sequence seems to demonstrate a temporal

sequence for these industries of the Levantine Mousterian, it should be stressed that there is currently no other site that has yielded a superimposed stratigraphic sequence from Phase 1 through Phase 3. The validity of this sequence to the Levant as a whole has also been questioned.

There is now a growing body of data that indicates that the Tabun sequence should not be uniformly applied to the Levant. This research is beginning to demonstrate that there are regional temporal differences regarding the phases of the Mousterian from the north to the south in the Levant.

The initial appearance of the Mousterian in the northern Levant corresponds typologically to Phase 2 (Tabun C). These assemblages are associated with open-air sites and have been dated to the same period as Phase 2 based upon studies of cycles of marine transgression and regression (Clark and Lindly 1989:464; Copeland 1981). Research in the southern Levant in the Negev of Israel and Jordan (Clark and Lindly 1989:646; Henry 1982, 1992; Marks 1983, 1985, 1992a, 1992b) has demonstrated that Phase 1 (Tabun D) assemblages last until Late Mousterian. To summarize, Phase 1 (Tabun D) assemblages are both early and late in the southern Levant while Phase 2 (Tabun C) assemblages seem to be present both early and late in the northern and central Levant. Marks (1992a:130) stressed that these findings not only nullify the basic current Levantine Mousterian nomenclature but also Copeland's (1975) interpretations. The assemblage from the North Gallery of Nahr Ibrahim is Tabun D and represents the northernmost presence of this industry in the Levant further complicating our understanding of the spatial distribution of these assemblages.

Levantine Hominid Paleontology

The assemblage of hominid fossils in the Levant has become significant regarding a number of research issues associated with human evolution. Much of the current effort has been directed toward the classification and dating of human fossils, modeling the origin of Quaternary hominids, and the nature of the Middle-Upper

Paleolithic transition (see Bar-Yosef 1994). The fossil assemblage can be divided into three groups: Archaic *Homo sapiens*, *Homo sapiens neanderthalensis*, and *Homo sapiens sapiens*.

Archaic Hominids

Perhaps the most problematic fossil is that of Zuttiyeh (Jelinek 1994:73; Vandermeersch 1989:160-163). According to Gisis and Bar-Yosef (1974), the Zuttiyeh partial cranium was recovered from a mixed archaeological context by Turville-Petre (1927). Cave breccia on the cranial fragment indicated that it probably was originally in an Acheulian context. The estimated age of the fossil could be in excess of 100,000 years old (Vandermeersch 1989:156). The fragment has no apparent Neanderthal features and may represent an ancestral population in the Levant (Vandermeersch 1989:160-163, 1992:36-37). Trinkaus (1984, 1986) and Smith (1985) also considered it as an antecedent of all Late Pleistocene west Asian hominids. A recent detailed frontal bone morphometric study of Southwest Asian hominids pronounced that the Zuttiyeh specimen shared no derived traits with the Skhul/Qafzeh sample and that it was primitive compared to other Levantine hominid fossils and the Skhul/Qafzeh group (Simmons et al. 1991). Howell (1994:293) agreed that there are certain similarities with the ZKD-1 (Zhoukoudian) group but stressed that they are very general, being plesiomorphic in nature and noted certain similarities to the Jebel Irhoud, Morocco sample. Whether the Zuttiyeh specimen reflects greater similarity to Asian or African fossil hominids remains to be concluded and caution should be applied when interpreting fragments such as this.

Archaic fossils identified as *Homo sapiens neanderthalensis* have been recovered from the cave sites of Amud, Kebara, and Tabun in Israel (Bar-Yosef 1994) and Masloukh and Ras el-Kelb in Lebanon (Solecki 1970, 1975). The virtually complete hominid (cranium missing) from Kebara (KMH-2) was recovered from Unit XII and is currently the only specimen with established chronometric

dates: TL 61-59,000 B.P. (Valladas et al. 1987) and ESR 64-60,000 B.P. (Schwarz et al. 1988). The upper left premolar from Ras el-Kelb was recovered from a breccia in the "Tunnel" section at a depth of 2.45 m (Garrod and Henri-Martin 1961). A radiocarbon date in excess of 52,000 B.P. attributed to the tooth was derived from burned bone from Layer K, "Rail" section. Layer K is equivalent to the layer in which the tooth was found. A preliminary assessment of the single molar recovered from Middle Paleolithic deposits at Masloukh (Solecki 1970:126) attributed it to *Homo sapiens neanderthalensis* on the basis of size and context. A small proportion of the Levantine Neanderthal hominid assemblage (Tabun C1, Kebara 2, and Amud 1) was recovered relatively intact and in an articulated position suggestive of formal burial.

Robust Anatomically Modern Hominids

Fossil remains of robust anatomically modern hominids have been recovered from only two Middle Paleolithic (early Upper Pleistocene) sites: Qafzeh Cave Unit L and Terrace Units XV-XXIV and Skhul Cave Level B (Vandermeersch 1981). Sites associated with the African MSA (Middle Stone Age) that have also yielded remains of anatomically modern humans include Border Cave, Ngaloba, Omo Kibish I, Klasies River Mouth, and Jebel Irhoud. The hominid remains of Skhul V and Qafzeh 11 were articulated and also probably represent deliberate interments. The Mousterian levels producing Qafzeh 11 have been TL dated at $92,000 \pm 5,000$ B.P. (Valladas et al. 1988). Average ESR dates on Mousterian deposits at Skhul range from $81,000 \pm 15,000$ B.P. to $101,000 \pm 12,000$ B.P. (Grun and Stringer 1991).

Summary

The Levant is a region of considerable geographic, environmental, climatic, and physiographic variability. The Near East presents a great degree of diversity within a very narrow portion of the Mediterranean coast and includes the Levantine

Coastal Plain, Mediterranean Hills, and the Jordanian Plateau. The Levantine Rift System is also a significant geographic feature that dominates the landscape. The plant diversity of the Levant can be subdivided into three major phytogeographic zones: Mediterranean woodland, Irano-Turanian steppe, and Saharo-Arabian desert. Each zone has a characteristic environment, geography, plant and animal community. The chronological framework for Lower and Middle Paleolithic prehistory of the Levant is virtually as complex and dynamic as the environment. The basic Middle Paleolithic chronology of the Near East includes the Late Acheulian, Acheulo-Yabrudian, and Mousterian. The Mousterian sequence has been the subject of much debate and the traditional linear sequence developed from Tabun has been called into question. Phase 1 assemblages are both early and late in the southern Levant and Phase 2 assemblages are early and late in the northern and central Levant. Nahr Ibrahim should be placed within this framework of cultural change in order to provide a background to discussions of technological and functional patterns associated with convergent tools (Chapter III).

CHAPTER III

ARCHAEOLOGICAL INVESTIGATIONS AT NAHR IBRAHIM, LEBANON

The site of Nahr Ibrahim, or Asfourieh Cave (Solecki 1975:283) is located along the eastern Mediterranean coast north of Beirut, Lebanon (Figure 1.1). The cave is located within the Halat village district near the larger town of Byblos approximately 25km north of Beirut along the road from Beirut to Tripoli. Coordinates for the site are: Longitude 35 38' 35" North and Latitude 34 04' 46" East. Nahr Ibrahim is situated at an elevation of 14m above sea level (at the cave sill) and is 73m back from the sea. The Nahr Ibrahim River (also Adonis River) is located only 900 m north of the site (Solecki 1970:98, 1975:283).

The cave is formed within a region of karsted terrain that is composed of Cenomanian limestones with bands of chert with a strike of 15 degrees and a westward dip of 23 degree. This region is known as the Adonis Ravine or Nahr Ibrahim Valley. The cave forms part of a promontory or arch of limestone that creates a constricted area in which all traffic is forced to travel between the base of the promontory (the mouth of the cave) and the sea (Solecki 1970:98, 1975:283).

History of Investigations

Nahr Ibrahim or Asfourieh Cave has been the location of three separate seasons of investigations by Columbia University: 1969, 1970, and 1973. The cave had been known for quite some time, being briefly visited during the 19th century by such individuals as P.E. Botta, an Italian prehistorian, and Louis Lartet, father of French prehistory (Solecki 1970:98). In 1890, the Jesuit Father G. Zumoffen made an inspection of the cave including some sondages, produced profile drawings, and illustrated some artifacts from the site (Zumoffen 1900). Zumoffen was the first to refer to the site as Nahr Ibrahim station.

Other individuals who have briefly visited the site include Father Henri Fleisch and Lorraine Copeland. Brief excavations at a small cave adjacent to Nahr Ibrahim were originally planned as part of an expedition conducted by researchers from the University of Tokyo but an alternate site was selected (Solecki 1975: 283; Suzuki and Kobori 1970).

Initial goals of the Columbia University investigations had included both sites of Nahr Ibrahim and Naame, but plans were changed and the nearby site of Masloukh was excavated instead of Naame. Nahr Ibrahim was selected by the Columbia University team because of its impending destruction due to highway construction along the coast of Lebanon. It was also selected at the request of the Directorate General of Antiquities and Museums that an archaeological investigation be conducted at the site (Solecki 1970, 1975). James Skinner (1970) was selected to excavate the nearby site of Masloukh as part of the Columbian investigations at Nahr Ibrahim.

Site Description

Nahr Ibrahim is characterized by three main galleries or chambers (Figure 3.1). The general plan of the cave is in the shape of an N (Stearns 1970:129) and the galleries from North to South are identified as North, Central, Main, and South. The North, Central and Main Galleries are interconnected by passageways. The South Gallery had at one time been connected to the Main Gallery via a passage that was plugged with breccia at the time of excavation giving the appearance that the South Gallery was an isolated nearby cave. The South Gallery was not excavated (Solecki 1975:283). The galleries of the cave follow a joint system within the limestone and trend in a west-northwest direction. The south wall of the North and South Galleries also follows a small fault (Stearns 1970:129).

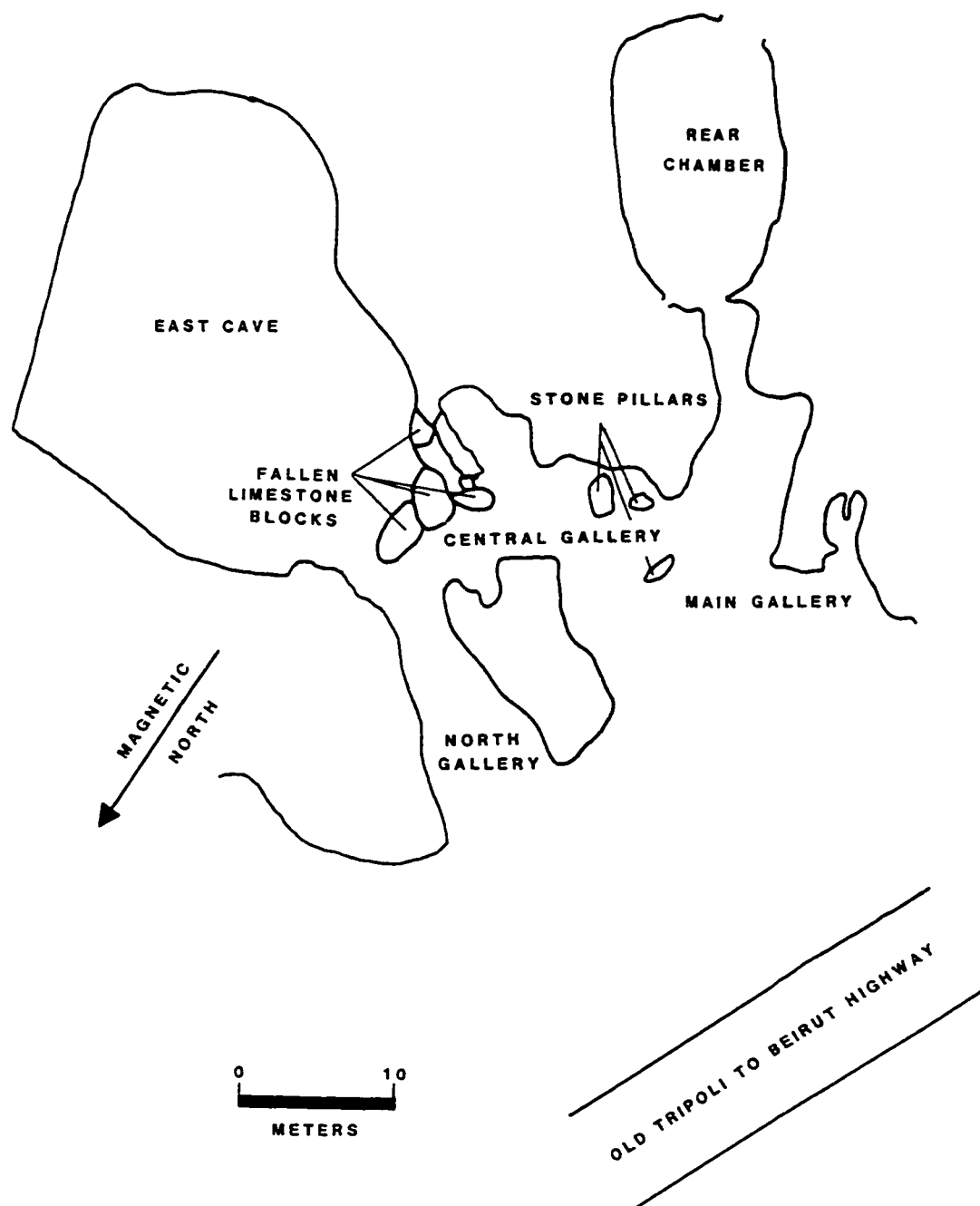


Figure 3.1. Schematic view of Nahr Ibrahim showing location of all galleries (adapted from Solecki [1975:Figure 3]).

The distance between the openings of the South and North Gallery is approximately 30 m. If the South Gallery is not included, then the main portion of the cave mouth is 25 m. Solecki (1970:99) also estimated that the area of habitable living space was about 200 sq m. behind the dripline. This measurement includes the areas encompassed within the Main, Central, and North Galleries. A total estimated population of 20 to 25 individuals could have inhabited this area of the cave (Solecki 1970:99, 1975:283). The deepest habitable portion of the cave was located in the Main Gallery at about 16m (Solecki 1975:283).

An unknown extent of the cave also lies beneath a massive area of rockfall to the northeast of the cave. At the time of excavation this area of rockfall was utilized as a small garden by local peoples. According to estimations, it is probable that another approximately 40 sqm of area could be added to the overall area of the cave (Solecki 1975:283).

According to Stearns (1970:129), the original solution cavities were filled with sediments that were partly removed at some time in the past. Remnants of brecciated sediment were noted on the cave walls in the 1969 season that indicated that the deposits within the cave had originally been thicker. The ground surface in each of the excavated galleries at the time of excavation were not the original deposition surfaces. Stearns also noted that the cave openings (sills) in the limestone cliff face were heavily encrusted with breccia.

Main Gallery

The dimensions of the Main Gallery are 5.5 m across the opening with the main living area extending back 16 m from the entrance (Solecki 1970:102-103, 1975:283-284). An interior grotto proceeds back into the gallery a distance of 30 m. The narrow and restricted entryway led investigators to conclude that this grotto was not inhabited. The elevation of the Main Gallery is 14.2 masl (meters above sea level) and the ceiling at the front is 3.63 m in height above the sill.

Central Gallery

The Central Gallery is 10 m in width at the mouth and extends in depth to about 16.8m from the portal. The present floor, a step up from the floor of the Main Gallery, is 16 masl and the height to the ceiling is 2.3 m. The interior of the Central Gallery is characterized by a noticeable slope of the cave floor from front to back (east to west). At some time in the past, this floor had also been levelled artificially, perhaps at the same time as the floor of the Main Gallery. Large wedged boulders or blocks of stone create a boundary between the Central and North Gallery. Zumoffen also reports conducting some testing in this gallery (Solecki 1970 102, 1975:284-285).

There were remnants of brecciated sediment containing bone fragments and flint along the walls of the Central Gallery at the 18 masl elevation. These sediments were noted to be at the level of the ceiling in several places, indicating that the gallery had been choked with sediment at some time in the past. These sediments were washed into the cave from higher elevations of the overlying garden patch area.

Deposits exposed in a profile along the north wall under a large limestone block demonstrate that only about .5m of sediment or habitation material had been removed. The remainder of material in the gallery was derived from the garden patch outside the cave entrance where archaeological materials were found at an elevation of 21 masl (Solecki 1975:285). The opening of the Central Gallery has no debris slope normally associated with caves or rockshelters. As with the Main Gallery, this slope appears to have been removed at some time in the past.

North Gallery

According to Solecki (1975:285) this gallery has an opening at both its eastern and western ends. The western opening is about 7m across at an elevation of 16 masl. The eastern opening is connected to the western opening by a 12m passage and lies at an elevation of 19 masl. Access can be obtained into the Central Gallery

from the North Gallery via a small corridor that is 6 m in length and 3 m in width: the North Central Corridor. The debris slope outside the entrance to the North Gallery had also been cut away, possibly for use of cave earth for agricultural purposes.

Stratigraphy

Main Gallery

The presence of brecciated sediment containing flint and faunal remains at the ceiling of this gallery initially forced the investigators to assume that the sediments that remained had been washed in from elsewhere at a higher elevation (Solecki 1970:103). The most obvious location for these sediments was judged to have been the North gallery. Localized zones of marine molluscs identified as *Vermets* sp. were identified at the 15.5-16.0 masl elevation by Sanlaville and are important indicators of high sea-level stands.

Much of the interior of the Main Gallery was disturbed by a large pit that had been excavated at some time in the past (Solecki 1970:104). An 8X4 m trench was excavated from the gallery entrance to the back wall and then following the north wall. At the front of the gallery a remnant of plaster flooring was encountered. The pit proved to contain a cluster of five large limestone blocks that had apparently been quarried from the cave interior. Within the pit were encountered Mousterian artifacts, Roman and later period ceramics, human bones, and iron nails, all attesting to the disturbed nature of the deposits. It has been speculated that this pit may be the remnants of testing by Zumoffen.

Intact archaeological deposits were encountered at an elevation of 13.5 masl at the base of the intrusive pit. This stratum was described as a "tough, hardened, dark deposit" and had a "greasy appearance, and was incredibly rich in flints" (Solecki 1970:106). This occupational zone extended beyond the limits of the test

trench in the Main Gallery. The lithic material was field identified as Mousterian.

The test trench was extended to the front of the gallery for 5.7 m but was blocked by large stones. Another test trench was excavated parallel to the previous trench and extended from the entrance out toward the highway in front of the Main Gallery entrance for a distance of 11.5 m. A similar array of large limestone blocks was encountered the length of the trench. The deepest portion of this trench was 1.3 m close to the entrance or sill. Levallois-Mousterian artifacts were identified in both of these trenches but appeared to have originated from elsewhere within the cave because the sediments were not typical of the occupation zones in other areas of the site. Intensive artificial modification of the brecciated deposits and limestone flooring of the Main Gallery (Solecki 1970:109-111) indicated that the area possibly had been used as the location of religious ceremonies associated with the Adonis Cult.

The archaeological deposits of the Main Gallery were divided into six layers: A through F (Solecki 1970:111-115). These sediments are described briefly below.

Layer A was identified as the first stratigraphic horizon and was about 18 cm thick. It was composed of a dark loose sediment that also included small fragments of limestone, plaster, rootlets and burned material. There were also ceramic fragments, tobacco pipe fragments, and other historic material. A 4-5 cm thick plaster flooring was encountered in the sill area.

A large intrusive pit was identified as Layer B. This pit contained a dark loose sediment with abundant rock material in addition to a mixture of recent and paleolithic artifacts. The base of this pit had been excavated to an elevation of ca. 13.50 masl, corresponding to the elevation of the lowest stratum, Layer F.

Layer C was a greyish brown sediment identified in field notes as a "hard grey soil." The deposits of this layer had been artificially truncated in the past. The undisturbed sections of Layer C were about 65 cm thick. A very dense zone had formed beneath the dripline due to sediment cementation by calcium carbonate. The

only feature encountered was a single fire-hearth found in the cross-section of Test Trench 1. Lithic material recovered from this layer indicated that the Levallois technique had been used. Artifact types included sidescrapers, Levallois points, and flakes. Characteristic raw materials included light brown, dark brown, and black flint.

Layer D was identified in the field notes as a "hard red soil" and seemed to be a member of the same stratigraphic unit as Layer C. This stratum extended across the entire excavated area at about 14.0 masl and measured 30 cm in thickness. In some areas Layer D had been disturbed by a large pit and extensive animal burrow. Only one hearth was encountered in this layer. Artifactual material including flint and faunal remains was scattered throughout the deposit. Field identifications of some of the teeth encountered included *Bos*, *Equus*, cervids, and rhinoceros. The base of Layer D was characterized by an extensive region of tabular limestone dripstone and weathered cave spalls. Numerous burned bones, burned flints, and burned sediment were encountered in a thin zone just above and within this dripstone layer. Tools were relatively scarce in Layer D but included sidescrapers. The flint material was a glossy black and brown color.

Layer E was another extensive and broad zone of limestone blocks and cave rubble effectively sealing Layer F below it. Thickness varied from about 8-20 cm. This layer seems to represent a single episode of rockfall.

The contact of Layer F was at an elevation of 13.5 masl and was composed of a very dark grey to black sediment (due to abundant hearths) about 50 cm thick. Hearth features, burned bones and flint were more abundant than in previous levels. Faunal remains included large mammals, primarily rhinoceros. The Levallois technique of tool manufacture was abundant and tools were common. The most abundant artifact types included sidescrapers and racloirs. Some Mousterian points were also identified. A curious feature of a number of the tools recovered from

Layer F was the presence of a technique of truncating, faceting or secondary thinning of the proximal and distal ends or lateral edges.

Central Gallery

Initial examination of this gallery indicated that the sediments had been higher than at the time of excavation because remnant patches of flint and sediment were noted at the ceiling level at 18 masl. At the time of investigation the floor sloped downward from the North Gallery passage and the far rear of the Central Gallery. Some of the sediment in the Central Gallery also seems to have originated from an aperture at the back of the gallery leading to the surface; apparently being washed in at some time in the past. Excavations identified at least five principal sediment units with approximately 16 layers or lenses (Solecki 1970:118-120). These units were designated as Layers A through E. This gallery also yielded a number of carbonate soil horizons identified as "dripstone layers". Below a somewhat mixed upper horizon, the sediments of the Central Gallery exhibited a notable northward downward slope.

Layer A was a reddish sediment of probable recent origin that was washed in and was oriented diagonally from the front to the back of the gallery and measured about 40 cm at the thickest point. There were no stratified cultural remains but the level did contain artifacts of Levallois technique and faunal remains. Snail shells were also encountered.

Layer B was identified as a "soil relict" (Solecki 1970:119) from an older sediment wash similar in origin to Layer A. This layer was about 22 cm. in thickness and was of a distinctive red color. Layer B, as Layer C, had been truncated by Layer A. Abundant snail shells resulted in Leroi-Gourhan's Mesolithic age assessment for Layer B.

Layer C was as extensive as Layers A and B, measuring about 1 m in thickness, and of a reddish brown color. This stratum contained flint artifacts and

faunal remains but definitive traces of occupation such as hearths were not encountered.

The elevation of Layer D was about 15 masl. This stratum measured approximately 80 cm in thickness with the upper 50 cm composed by extensive zones or lenses of dripstone varying from 5-8 cm thickness. These cemented layers were interbedded with thin layers of soft brown sediment that were very easy to excavate. Artifacts and faunal remains were encountered in both the cemented and non-cemented zones. The cemented horizons were felt to represent humid climatic periods and despite the absence of hearths were interpreted as in-situ occupational evidence. Burned flint and faunal remains were also abundant.

Encountered below the layers of dripstone was a dense sterile layer varying from 5-8 cm thickness and an areal extent of about 2 m. This layer also capped another cultural layer also containing abundant flint artifacts and faunal remains.

Layer E was encountered at an elevation of 14.1 masl and continued uninterrupted to the base of the excavations (13.4 masl). This deposit was dark red and very moist and damp and contained abundant lithic artifacts and faunal remains; almost twice as many as that encountered in Layer D. The abundance of cultural debris led the researchers to conclude that Layer E also represented an in-situ occupation horizon, even though no hearth features or distinct floors were identified. Faunal remains included rhinoceros teeth and large mammal remains and teeth.

In summary, the Central Gallery is characterized by deposits in which the abundance of sidescrapers is greater than other tool types. Denticulates and notched pieces and naturally backed knives are also present but less abundant. Levallois points increase in abundance dramatically from bottom to top with Mousterian points present but not frequent. Levallois flakes and cores were present throughout the deposits of the Central Gallery indicating that the full Levallois reduction sequence appeared to be present. The most common color of flint encountered varied from black to a blue black.

North Gallery

The North Gallery proved to contain deposits with the most abundant artifactual material at Nahr Ibrahim (Solecki 1970:121-122). Test Trench VI was excavated as an exploratory sounding that measured 4 m long by 80 cm wide. The greatest depth of excavation was 90 cm to bedrock. The test trench was excavated toward the back of the gallery at the south wall. The deposits of the North Gallery had a definite downward slope. During excavation it was also noted that the sediment matrix seemed to have been almost entirely washed away producing a very dense lag deposit of faunal remains and lithic material.

As excavation and field analysis progressed the excavators noted that a large proportion of the lithic material was composed of blades and burins manufactured from large blades. The lithic material from the North Gallery was of a decidedly different technological character than either the Main or Central Gallery, being reminiscent of Upper Paleolithic assemblages. The artifact inventory included elongated Mousterian points, burins, backed and naturally backed knives, and a variety of sidescraper types. The Levallois technique was applied during blade and flake production that also produced a large number of elongated triangular points.

There were two hypothesized interpretations that were felt to have produced the lag deposit of lithics and faunal material. First, the material in the North Gallery could be roughly in-situ with the sediment having been flushed out during the geologic past. Second, all of the material could have been washed into the gallery from a higher elevation outside the cave. Based on the absence of abrasion and wear on artifacts and faunal material, which might be present had the material washed into the cave, the first interpretation was believed to have stronger merit. Solecki (1970:122) interpreted the lagged deposit of cultural material to represent an in-situ sediment leaching and removal. No estimates of the amount of sediment removal or displacement from original position were possible and no other cultural features were observed in the test trench.

Chronology and Paleoenvironment at Nahr Ibrahim

A number of different lines of evidence have been utilized in an effort to reconstruct the chronology of Nahr Ibrahim. These include climatic indicators such as pollen profiles, artifact styles and technology, chronometric dating techniques, and granulometry analysis.

Erosional Formation of Nahr Ibrahim

As mentioned earlier, the cave of Nahr Ibrahim formed within a region of karstic topography dominated by Cenomanian limestones. The Cenomanian limestones (Cretaceous age) of the eastern Mediterranean coastline (inclusive of Israel) are remnants of the Cenomanian transgression that submerged much of the Middle East roughly between 90 and 100 mya. The Cenomanian transgression was a smaller event in a longer term transgression that lasted from Late Albian time until the Late Eocene. During this time period the sea spread much farther inland than previously (> 50-100 km inland) and reached as far as the Sinai during the Cenomanian. This major period of sea transgression ended during the Late Eocene when the sea retreated to about the present continental margin (Garfunkel 1988:19-20; Horowitz 1979:68-69).

The time of formation of the cave system at Nahr Ibrahim is felt to be comparable in age to other similar caves in Cenomanian limestone in Lebanon that have produced Levantine Mousterian industries. The geological history of Bezez Cave provides a point of reference from which the development of Nahr Ibrahim can be briefly depicted.

The cave of El Bezez has been interpreted to have originated during the earlier stages of the Tyrrhenian I transgression (pre-Enfeen). The joints and bedding planes in the Cenomanian limestone would have filled with phreatic water (groundwater) with active solution along the more pronounced bedding planes and joints (Sweeting 1983:12). The time and mode of formation of El Bezez Cave is also

felt to be broadly applicable to the formation of Nahr Ibrahim. Nahr Ibrahim developed within a small limestone "spur" which Stearns (1970:129) noted as forming a small bench at 20 masl which may also be associated with the Tyrrhenian transgression of pre-Enfeen times.

Chronology Indicated by Sea-level Stands

Previous research at Nahr Ibrahim has noted the presence of *Vermets* sp. molluscs representing former high sea-stands at the site (Solecki 1970, 1975; Stearns 1970). The *Vermets* sp. fossils were identified at the portal of the Main Gallery at an elevation of 14.2 masl (later found to be attached to an intrusive limestone block) and on the southern wall of the Main Gallery at elevations of between 15.5-16 masl. Two lower patches of *Vermets* sp. were later found attached to the bedrock at elevations of 13 and 13.5 masl. Therefore, multiple sea-level stands between 13 and 16 masl were predicted to have periodically flushed out the cave prior to habitation. The sea levels represented by *Vermets* sp. are interpreted as dating to a Würmian Interstadial during the Last Interglacial period predating human occupation of the cave.

Referring to the South Gallery (unexcavated), Stearns (1970:130) noted the presence of remnant patches of *Vermets* sp. along the sill at 14.3 masl. Patches also were encountered along the cliff face south of the South Gallery between 14 and 14.5 masl. The *Vermets* sp. in this locality was reported to have formed a veneer covering over the cave breccia. Stearns identified a small notch (wavecut?) in both the cave breccia and limestone at this same locality. All of this evidence indicates that the main cave deposits (not those associated with later occupation which were not the original deposits of the cave) accumulated during a period of emergence following a period of submergence associated with a rise in sea level to about 16 masl and prior to a later rise to 14 masl.

Chronology as Indicated by Pollen Analysis

Detailed pollen analysis of sediment samples from Nahr Ibrahim has been conducted by A. Leroi-Gourhan (1971). Sediment samples from the Main Gallery were taken every ten centimeters from 13.0-13.9 masl and from the Central Gallery every ten centimeters from 14.50-16.10 masl (Leroi-Gourhan 1971:255). The results of the pollen analysis can be summarized by the following points:

(1) All samples contained some pollen;

(2) The pollen spectra of two samples taken from the cave floor (13.0 and 13.30 masl) are very different in character from two other samples taken from the Breccia unit I and Breccia unit 2 in the Central Gallery (16.10 masl). The upper brecciated unit appeared to contain an industry clearly more recent in character offering a different interpretation of the vegetation. In the same geographic locality, the climatic fluctuations indicated by the flora could be expected to provide an interpretation of these oscillations since the occupation associated with the assemblage had ended.

(3) In several spots at the base of the cave, the breccias contained a very old lithic industry that remained attached to the walls. The reoccupation of the gallery by the sea, after the first of these human occupations, is indicated by the presence of patches of *Vermets* sp. which were recovered from the walls at different elevations. The presence of *Vermets* sp. alternating with the geological deposits poses a very complex geological problem, but perhaps certain pollen relationships could answer some of the questions (Leroi-Gourhan 1971:256).

The two main samples from the base of the cave are of interest because they are dominated by Graminae, of which a good number are cereal types (Leroi-Gourhan 1971:256). The rarity of oak at 13.3 masl and its total absence at 13 masl is also significant. Trees and shrubs that are present are mainly those which grow along the fringes of water courses; *Salix*, *Ulmus*, ash (*Fraxinus* etc.) and myrtle

(*Myrtus communis*). Cedar (*Cedrus*) is present in the oldest sample which appears to represent a very cold period.

The pollen assemblage from the upper portion of the Central Gallery and the breccia is very different. These deposits are dominated by Liguliflorae (as much as 73 percent of the total) and asphodeles (*Asphodelus*). The assemblage displays a trend toward a dryer period, corroborated by the very low abundance of humid adapted shrubs (Leroi-Gourhan 1971:256).

The upper breccia with shells, still attached to different parts of the ceiling or lower portions of the walls, presents a botanical assemblage that can only be interpreted as indicating a dry climatic period. The spiny plants are greater than 34 percent, Graminae more than 15 percent, some *Artemesia*, *Theligonum*, *Chenopodaceae* all indicate a semi-steppe (where the dominant shrub is the carob (*Ceratonia siliqua*). This is an indication of a very warm phase during the Wurmian. The associated vegetation is close enough to that which was found at Naame, being chronologically very early (Leroi-Gourhan 1971:256).

Farrand (1982:107) also noted that, although pollen is not generally well preserved in Near Eastern prehistoric sites, both Tabun and Nahr Ibrahim contained abundant tree pollen species in the Middle Paleolithic deposits. Tree pollen types at Nahr Ibrahim are illustrated to have reached a peak by about 50,000 B.P., with a modal distribution from about 60,000 B.P. to 40,000 B.P.(Farrand 1982:Figure 2).

Granulometry Analysis

As part of the interdisciplinary research conducted at Nahr Ibrahim, Steve Kopper conducted a granulometry analysis of a soil column from the Central Gallery between the 12-16 masl levels. The resulting climatic curve was derived from an analysis of thirteen different sediment samples (Solecki 1975:293-394). The results of this analysis demonstrate that there were three cold/wet periods that were interspersed between warmer periods that were not as cold and wet (Table 3.1). The

travertines of the Central Gallery have also been interpreted as periods of wetter or more humid climatic conditions.

Table 3.1 . Environmental and climatic interpretations of Nahr Ibrahim based upon results of granulometry analysis.

12 masl	very cold and wet, permanent, Cold 1
13 masl	very cold and wet, seasonal, Cold 2
	warm and dry
	cold and wet
	warming dry
	cold and wet, seasonal
15 masl	very cold and wet, permanent, Cold 3
15-16 masl	increasing warming
15.60 masl	cool and wet, seasonal

Faunal Assemblage

There has as yet been no analysis of any detail conducted for faunal material from Nahr Ibrahim. Consequently, very little is known regarding the environmental, subsistence, and procurement aspects often reconstructed from faunal remains.

Tentative field identification of faunal remains from the Main Gallery, primarily teeth, indicate that *Bos* sp., *Equus* sp., cervids, and rhinoceros were present throughout the deposits associated with Layer D (Solecki 1971:111). Rhinoceros was also present in Layer F. Solecki (1975:293) noted that faunal remains of rhinoceros were present predominantly in the basal and lower deposits of the Central and Main Galleries. Their scarcity in the upper levels at Nahr Ibrahim has been interpreted as either extinction or regional absence.

The abundance of fallow deer (*Dama mesopotamica*) within the deposits suggests that it may have been the most important game animal at the site (Solecki

1975:291). This is also suggestive of specialization or specific targeting of this resource. However, only a more detailed study of the faunal assemblage will demonstrate this. The importance of this species is further demonstrated at Nahr Ibrahim through the discovery of a ritual fallow deer burial (Solecki 1983). The feature was encountered in Layer 3 (Layer C) of the Central Gallery at an elevation of 15.2 masl. The burial included numerous foot bones, long bones, much of the vertebral column, and a relatively complete upper portion of the skull; much of it in relatively anatomically correct position. Abundant small fragments or flecks of red ochre were also recovered from throughout the feature among the bones. It has been interpreted that this feature represents some type of ritual activity that involved the entire carcass of the animal (Solecki 1975:290-291).

The general character of the faunal assemblage at Nahr Ibrahim is that of very poor preservation. There was a high degree of both fragmentation, breakage, and apparent random scatter throughout the deposits.

The nearby site of El Masloukh produced a similar faunal assemblage with extinct rhinoceros, *Bos* sp., fallow deer (*Dama mesopotamica*), *Equus* sp., and other equids (Gautier 1970). The deposits from Masloukh also produced very early occurrences of the rock hyrax (*Procapra capensis*) and wild goat (*Capra aegagrus*) that are dated to pre-70,000 B.P. (Garrard 1984; Gautier 1970). Gautier has interpreted the Masloukh assemblage as reflecting preferential species specific hunting (in the case of larger fauna) or tied to climatic factors. There has, as yet, been no comparative study of the Nahr Ibrahim and Masloukh faunal assemblages or correlation with the climatic data from either site.

Lithic Assemblages and ESR Dates from Nahr Ibrahim

All three major galleries at Nahr Ibrahim produced Levantine Mousterian lithic assemblages from their deposits. During the three seasons of investigations at Nahr Ibrahim, over 325,000 lithic artifacts were retrieved from the deposits (Solecki

1975:293). It must be remembered that a certain proportion of the total was recovered from secondary or derived context. This includes a large percentage of material recovered from the interior of the Main Gallery, a smaller proportion from the previous excavations of Zumoffen, and other material obtained from parts of the deflated deposits of the North Gallery (upper portion).

Solecki has made general comparisons based on technology with the assemblage recovered from Ras el Kelb, which also has produced a single C-14 date in excess of 52,000 years (GrN 2556). The general similarity of the lithic technology between Ras el Kelb and Nahr Ibrahim has been used to infer a similar age for the Nahr Ibrahim material (Solecki 1975:293).

Recently, a pair of chronometric dates have been produced for the deposits at Nahr Ibrahim, providing additional data on the temporal position of some of the deposits (Porat and Schwarcz 1991). These dates were derived by application of signal subtraction methods of the electron spin resonance (ESR) technique. The resulting dates were derived from burned flint from the basal levels (Layer 4) of the Central Gallery and range between 80-90,000 B.P. The Central Gallery also has produced a Tabun C-type lithic industry. Dependent upon the chosen k values, these dates are as follows in years B.P.:

Sample No.	$k=0.1$	$k=.05$
89191	75 ± 27	84 ± 30
89191a	66 ± 22	74 ± 25
89192	92 ± 23	110 ± 128

These dates were obtained from two flint samples, one of which was duplicated. Small sediment samples that were removed from the flint samples may not truly represent the sediments that contribute to the total dose used to derive the dates. The ages of the two samples lie within each other's standard error.

According to Porat and Schwarcz (1991:211), the resulting dates are comparable with other ESR dates from other Levantine Mousterian sites and with U-Series dates of cave formations from Nahr Ibrahim.

Farrand (1994) has noted that a number of Levantine sites have produced chronometric dates on the order of 80-90,000 B.P. There is also some indication that the ESR dates derived by EU (early uptake) methods may be more reliable than ESR dates produced by LU (linear uptake methods), especially for sites that are located in a region that has experienced climate change. The Levantine Mousterian coastal site of Naame in Lebanon has produced a Tabun C-type industry that is interstratified between marine deposits U-series dated between 90-92,000 B.P. (Farrand 1994:44).

The dates from Naame and other Levantine Mousterian assemblages that have been dated on the order of 90,000 B.P. are in good agreement with other TL and ESR dates from Skhul and Qafzeh, as well as the preliminary dates from Nahr Ibrahim. Farrand also noted that the Lebanese dates are comparable with other C-14 and AAR dates for Tabun D deposits at Tabun (Farrand 1994:44). It is important to recall that Tabun D industries occur primarily in areas of the Southern Levant such as the Negev and in the Syrian Desert with only a few other exceptions: Nahr Ibrahim (North Gallery), Tabun D, Hayonim, and Bezez. There is also the problem of the spatio-temporal discrepancies (Chapter II) concerning both Tabun C-type and D-type industries. Consequently, even though there is some general agreement among the chronometric dates for Levantine Mousterian industries, it is extremely difficult and perhaps tenuous to establish a general sequence for the Middle Paleolithic industries of the Near East. Accordingly, following Farrand's warning (1994:44), it is also possible that there may been contemporaneous Tabun C-type and D-type industries in the Near East. This is supported by recent synthesis of the regional literature (Clark and Lindly 1989).

Other Sites Providing Comparative Data

Although Nahr Ibrahim represents the major focus of this study, comparative datasets from other sites in the Levant are also used. The majority of this comparative data comes from Shea (1991) and primarily reflects functional rather than technological information. The dataset from Shanidar Cave was derived by the same functional methodology applied in this study. The discussion below provides a brief synopsis and chronological information for each site contributing to the dataset. The sites providing comparative data are listed in Table 3.2.

Kebara Cave (Mugharet el-Kebara), Israel

Mugharet el-Kebara is situated on the western scarp of Mount Carmel, roughly 13 km to the south of Wadi el-Mughara. Kebara lies at 60-65masl (Bar-Yosef et al. 1992:498). The Mousterian sequence is contained within units XII to VII and forms a continuous geological section. These deposits have been TL dated between 48-60 kya (Bar-Yosef and Meignen 1992; Valladas et al. 1987). Schwarcz and others (1988) have provided an ESR Early Uptake date of 60 ± 6 kya and a Linear Uptake date of 64 ± 4 kya for Unit XI. The Kebara lithic assemblages, especially units IX and X, have been identified as a Tabun B type industry (Meignen and Bar-Yosef 1988a).

Tabun Cave, Israel

Tabun Cave is 63 masl on the southern face of Wadi el-Mughara/Nahal HaMearot on the western slope of Mount Carmel (Shea 1991:125) and is 13 km to the north of Kebara Cave. Jelinek (1982a, 1982b) has suggested that the Tabun assemblages from Units II-IX represent an early phase of Levantine Mousterian (Tabun D); Unit I contained a late phase of Levantine Mousterian (Tabun B-C). These phases have been defined based upon technological variability in core preparation and flake dimensions.

Table 3.2. Levantine Mousterian sites contributing to the comparative dataset.

Site	Provenience	Reference
Kebara Cave	Units IX-XIII	Shea 1991
Tabun Cave	Units I, II, IX	Shea 1991
Hayonim Cave	Unit E	Shea 1991
Qafzeh Cave	Units XV, XVIII, XXIV	Shea 1991
Tor Faraj	Level C	Shea 1991, 1995a
Shanidar	Layer D	Dockall 1993

Hayonim Cave, Israel

Hayonim Cave is an inland site 17 km from the Mediterranean coast at 250 masl in the Nahal Yitzhan. The Levantine Mousterian assemblages were identified in Layer E (Shea 1991:127-128). Layer E has been subdivided into an early and late Mousterian based on microfaunal species differences (see Tchernov 1989). A single U-Series date of 163 kya on a stalactite within Layer E is of little utility for dating the Levantine Mousterian assemblage and the technological and typological character of this assemblages has not been fully published (Shea 1991:128-129).

Qafzeh Cave, Israel

Qafzeh Cave is located 200 masl in the Wadi el-Hadj outside the city of Nazareth. Sediments from Units XVII-XXIV were quite rapidly deposited around 92.5 kya (Shea 1991:131; Valladas et al. 1988). Schwarcz and others (1988) have ESR dated burnt teeth from the same deposits at about 110 kya (Shea 1991:131). Lithic assemblages from Units XVII-XXIV resemble Tabun C assemblages while Unit XV is typologically and technologically like Tabun B (Boutie 1989:221-222; Meignen and Bar-Yosef 1988b:85; Shea 1991:131).

Tor Faraj/Tor Sabiha, Jordan

Tor Faraj and Tor Sabiha are situated on the southern rim of the Jordan Plateau in southern Jordan. Both sites are separated by 17 km; Tor Faraj is located in the Judayid Basin at an elevation of 900 masl while Tor Sabiha is at an elevation of 1300 masl (Henry 1995a; Lee 1987). There is some indication that both sites participated in the same settlement/subsistence system based on paleoenvironmental, chronometric, and artifactual evidence (Henry 1992:146-147, 1995a:49-83, 107-132; Henry et al. 1996). Based on technological and typological studies, Tor Faraj and Tor Sabiha are assigned to a Tabun D-type industry. Amino acid racemization of ostrich eggshell yielded D/L ratios that place occupation of both sites at about 65 kya (Henry 1992:147). Only data from Tor Faraj is included in the present study.

Shanidar Cave, Iraq

Shanidar Cave is roughly 400 km north of Baghdad within the Zagros Mountains and 2.5 km from the Greater Zab River. The cave is at 765 masl. The Middle Paleolithic deposits are contained within Layer D and have been technologically and typologically characterized as Zagros Mousterian (Solecki 1963, 1971; Solecki and Solecki 1993). Based on radiocarbon and geological data the Layer D Middle Paleolithic represents a timespan from about 40-80 kya (Solecki and Solecki 1993:120).

Summary

Nahr Ibrahim Cave contains Levantine Mousterian industries of Tabun C and Tabun D types. Pollen analysis and granulometry analysis indicated that the paleoenvironment of Nahr Ibrahim was characterized by alternating periods of cold and warm that varied in moisture intensity. Occupational and archaeological data from the site indicate that it primarily served as a habitation or base camp for groups of Middle Paleolithic hominids employing a Levantine Mousterian technological

system. ESR dates and technological similarities indicate that the Central Gallery assemblages range in age between 80-90,000 B.P. These dates are comparable with ESR dates from other Levantine Mousterian sites.

A series of Levantine Mousterian cave sites previously analyzed by Shea (1991) have been selected to provide additional convergent tool comparative data. These sites include Kebara, Tabun, Hayonim, Qafzeh, and Tor Faraj. A small sample of convergent tools from Shanidar Cave is included to represent the Zagros Mousterian as an additional comparative dataset. The technological and functional variability of convergent tools from Nahr Ibrahim is compared to functional data from these sites to investigate patterns of functional similarity and difference. Aspects of stone tool design and function are directly related to patterns of technological organization associated with particular groups. Chapter III provides the theoretical background of technological organization and the adaptive significance of technology for human groups. This framework provides the theoretical model to investigate technological and functional aspects of Levantine Mousterian convergent tools discussed in later chapters.

CHAPTER IV

TECHNOLOGICAL ORGANIZATION AS AN ADAPTIVE FACTOR

Technology is one of a number of human responses to environment, resource conditions and distribution, and economic and social needs. Technology is a subgroup of the cultural system that is composed of economics, religion, language, art, social organization, and political structure. To speak of technology as a system, one must understand the definition of technology. Technology is conceived as a facilitator whereby humans are enabled to do what they were originally unable to do by their own unaided means (Ellul 1980:34). Ellul emphasized the mediatory role that technology serves between humans and the natural environment. This infers that technology is much more than a collection of tools or facilities that allow work to be performed.

The technological system is composed of various components. Jonas (1979:6) provided a unique mental image of technology and identified two major variables in developing his philosophy: formal dynamics and substantive content. Formal dynamics encompasses the abstract realm of technology: the processual aspect composed of decisions, behaviors, ideas, and values. These are the factors that allow humans to develop, manipulate, and adapt technologies to meet needs and desires. The substantive content of technology comprises "those things it puts into human use, the power it confers, the novel objectives it opens up or dictates, and the altered manner of human action by which these objectives are realized" (Jonas 1979:34). Technology can and does lead to the development of a "range of economic and ecological possibilities" for human groups (Potts 1991:153).

Formal dynamics and substantive content differ in regard to archaeological visibility. Ideas, decisions, and values are present only indirectly in the archaeological record. Substantive content, or the material aspect of technology, is present in the form of artifacts and other material by-products. For these reasons, an

analysis of prehistoric technology must rely heavily on the archaeological record to reconstruct behaviors associated with the formal dynamics of that technology. The substantive content, based on a set of general assumptions, can be used to formulate inferences regarding the formal dynamics. The assumptions regarding technology that are employed in this study are:

- (1) Inferences can be made about decision-making.
- (2) Inferences about behavior and knowledge required for the technology in question can be made.
- (3) The interrelationship of the technological system with other parts of the cultural system and the environment can be inferred.
- (4) Any changes noted within the technological system can potentially affect other systems and these can be detected.
- (5) Conversely, changes in other systems can affect the technological system and these can be detected.

Technology forms only a portion of the complete adaptive strategy of hominid groups. The term "technology" incorporates not only the tools and facilities constructed to meet certain needs and desires but also such intangible aspects as technical knowledge and the value of that knowledge. In some way, the technical knowledge may be valued more than the actual possession of the technology. Ultimately, it is technical knowledge, its value, and the opinions and understanding of that knowledge that enable a group to organize their technology as part of an overall biological and psychological adaptive framework.

Technological Organization

Technological organization involves the planning and strategy that operationalizes the technological component of hominid behavior (Nelson 1991:57). The level of organization is a direct reflection of the variability observed in a technology. Recently, Nelson (1991:Figure 2.1) provided a detailed discussion of

research issues concerning technological organization used to illustrate the range of research areas. This graphic presentation (Figure 4.1) can be adapted to provide a model of variables and levels of interaction in the organization of technology.

The organization of technology is a multi-level process that can be analyzed from either macrolevel to microlevel or from microlevel to macrolevel. The macrolevel of organization can be considered as the impetus or trigger for initiating the process or the cause of change. The process of technological organization is not a linear phenomenon but is more usefully pictured as dynamic or in a state of flux or change as conditions and strategies change. Macrolevel variables for change can be broadly included within environmental, and social, and economic conditions.

The link between the microlevel and macrolevel of technological organization can be considered to be the technological and social or economic strategies for coping with present and changing conditions at the macrolevel. It is at the strategic link that options are weighed, knowledge is put into action relating to methodology and planning, and decisions are made based upon the consideration of all relevant information pertaining to the conditions in question. Knowledge and perceptions of environmental, social, and economic conditions are used to develop ideas, options, and techniques (strategies) that can be used to meet or exceed the conditions.

Once strategies have been developed in an attempt to meet or exceed the conditions or adapt to changing conditions then the strategies are used to develop tools, weapons and facilities (at the microlevel of technological organization) that will be used to cope with the conditions. It should also be stressed that the knowledge of environmental and social/economic conditions is not always complete, thoroughly understood, or perceived correctly or the same way. This can vary at an individual and group level. Consequently, the strategies that are developed to meet conditions may not be entirely appropriate or efficient, and may also vary at the individual and group level.

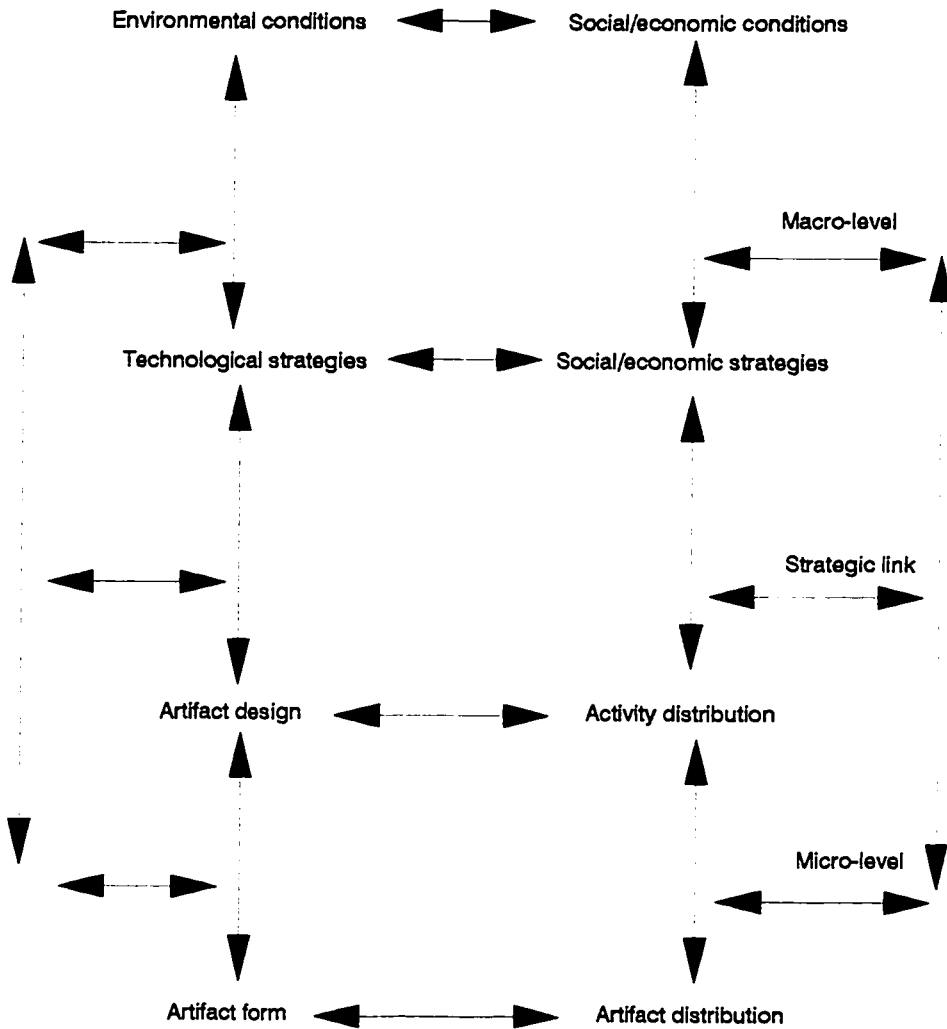


Figure 4.1. Schematic model of lithic technological organization (adapted from Nelson [1991:Figure 2.1]).

Responses to the same stimuli (conditions) between groups or individuals both strategically and organizationally can also vary; these differences are reflected in both artifacts and sites. Differences in artifact form, design, and the distribution of artifacts and activities on sites can be used effectively to reconstruct the strategic link between the external and internal conditions and technological organization.

The view of technology expressed in this study is that it forms only one part of a group's framework of adaptive strategies. World view and beliefs play a significant role in the operation of adaptive strategies (Ridington 1982).

Ethnographic data suggest that nomadic hunter-gatherer groups value knowledge of technical systems over and beyond the actual material items (Ingold 1993a, 1993b; Ridington 1982; Wynn 1993). Technology and technological organization are products of the accomplishments of the tool maker and user, not a property of the tools themselves (Ingold 1993b:342).

The concept of technological organization was developed in a seminal paper on the processes that contribute to stone tool assemblage formation (Ammerman and Feldman 1974). The authors took a diachronic approach in which the formation of stone tool assemblages was dynamic, resulting from the type and frequency of activities, tool types, and discard/loss rates.

The model developed by Ammerman and Feldman (1974:610) consists of five principal components:

- (1) the set of tasks or activities performed by a group through the year.
- (2) the frequency that each task or activity is conducted during the year.
- (3) the range of tool types utilized by the group.
- (4) the interrelationships between tool types and activities performed.
- (5) abandonment rates of stone tools.

Application of this model to the study of technological organization involves an estimation of the appropriateness of the technology to the situation. Several indices or variables have been developed as quantitative or qualitative measures of

appropriateness (Oswalt 1973, 1976; Shott 1986, 1989; Torrence 1983, 1989). These variables or indices include: (1) **diversity** (the number of different classes or types of tools); (2) **versatility** (the number of tasks for which a particular tool type is utilized); (3) **flexibility** (the substantive range of tasks in which a tool type can be utilized); (4) **curation** (the degree of utility obtained from tools or tool types).

Diversity, versatility, flexibility, and curation can be considered at the tool, toolkit, or assemblage level. These variables are dynamic and vary with mobility and subsistence strategies among hunter-gatherer groups (Binford 1979, 1982; Nelson 1992; Oswalt 1973, 1976; Shott 1986; Spier 1970). Recent studies by Hayden et al. (1996) and Odell (1996a, 1996b) will undoubtedly lead to a refinement and deletion of some of these terms (see below).

Mobility and Technological Organization

The relationship between group mobility patterns and assemblage composition was examined by Binford (1982) in "The Archaeology of Place". Previously, in another contribution, Binford (1980) provided a distinction between collector versus forager mobility patterns. In this article Binford examined the organizational variability of different site types among collector and forager groups. The same principles can be applied to technological organization. Studies by Shott (1986, 1989) and Binford (1978a, 1979, 1980, 1982) demonstrate that settlement mobility imparts constraints on technological organization that can be measured by the variables described above.

The concept of scheduling is directly related to mobility patterns and technological organization. Torrence (1983, 1989) has convincingly argued that "time-stress" is a significant organizational factor of hunter-gatherer technology. Procurement, manufacture, and maintenance tasks are scheduled as part of the overall mobility and subsistence strategy.

Binford (1978b, 1982) has developed the concept of economic zonation from his study of the Nunamiut. This concept is useful in consideration of the exploited territory of a group. Binford's (1982) discussion of economic zonation can be simplified as a distinction between a home base or residential locality and more distant special purpose camps (i.e. hunting or quarry camps). Each type of site has special logistic and provisioning needs and corresponding provisioning challenges that must be met. Mobility is defined as the manner in which economic zones surrounding a home base or residential camp are exploited in relation to the distribution of resources. Expected differences exist in regard to technological organization, assemblage variability, and activity distribution associated with settlement mobility (Binford 1980, 1982; Nelson 1991; Oswalt 1973, 1976; Shott 1989).

Binford (1980) distinguished between forager and collector in reference to the abundance and seasonal distribution of resources utilized by a group. It is ultimately the abundance and distribution of resources that is viewed as the significant factor of variability of social, economic, settlement, and subsistence organization. Binford postulated a series of logistical, technological, and site differences between collector and forager groups that have been widely referenced in studies of technological organization.

Earlier, Oswalt (1973) had conducted an ethnographic study of a number of hunter-gatherer groups in which technology was shown to co-vary with habitat and environment. Technological complexity and organization are portrayed in his study as being directly related to environment. Considering subsistence (food-getting) technologies of these groups, Oswalt depicted a trend toward increasing technological and technical complexity between forager and collector and arid-tropical-temperate-northern habitats. Both studies by Binford and Oswalt apply ideas of habitat and environmental variation as critical factors of subsistence, settlement, and technological patterning and variation.

These initial studies stressed the environment as a causal factor of variability. But variation also results from differing skill levels and social factors. Regardless of which factor or set of factors we select as the "trigger" for technological variation, group mobility can be singled out as being of equal significance, and perhaps more readily visualized.

Scheduling, time stress, toolkit portability, and tool resources are crucial factors that hunter-gatherers must consider as part of the logistical framework of group mobility regardless of environment, although patterns will vary. Of these, tool resource abundance, distribution, and quality govern, to a large extent, other factors.

Mobility (Bamforth 1985; Binford 1978a, 1979; Nelson 1991; Parry and Kelly 1987; Shott 1986; Torrence 1983) and time scheduling (Bamforth 1985; Binford 1979; Nelson 1991) of technological activities such as procurement, manufacture, and maintenance can be tied to the distribution of tool resources. These factors must be constantly weighed against each other by hunter-gatherer groups and adjusted to settlement mobility and subsistence complexity.

Settlement mobility and subsistence complexity impose constraints upon a technological system (Bousman 1993; Kelly 1988; Odell 1994; Shott 1989; Torrence 1983, 1989). Technological responses to these constraints could include upper limits on the number of tools in the inventory or a decrease in tool inventory size. Toolkits may be influenced by a shift in manufacture to smaller, lighter tools or through increased functional variability. Tool design patterns should reflect transportability (Nelson 1991; Shott 1989:20; Torrence 1983:17, 1989:60-62). Ethnographic observations tend to largely confirm the theoretical expectation that increased mobility is correlated with decreased technological diversity. The character of decreased technological diversity can vary with either a deletion of some tool classes from the tool inventory or by restructuring the toolkit into a smaller array of tool classes that have broader functional applications (Shott 1989:23-36).

Tool and Weapons Design

The cognitive factors associated with technological organization include anticipatory behavior, cognitive "mapping", and tactical and planning depth. These variables have been discussed in some detail in Chapter I. The organizational pattern of lithic technology is the net result of a set of decisions and strategies related to the structure of settlement mobility and subsistence. The design and complexity of tools and weapons is influenced by these variables and can readily change in response to fluctuations in any of them (Ammerman and Feldman 1974; Bousman 1993; Gunn and Weir 1976; Keeley 1982; Kelly 1988; Odell 1994; Torrence 1983, 1989). The major factors of tool design that are discussed here include reliability, maintainability, versatility, flexibility, and transportability (Bleed 1986; Bouseman 1993; Hayden et al. 1996; Nelson 1991).

Design Defined

Design includes those variables that influence the morphology of tools, weapons, and toolkits (Nelson 1991:66). Bleed (1986) and Bousman (1993) have identified efficiency as the primary goal of tool and weapon design and listed four measures: (1) decreased manufacture time, (2) extended use-life, (3) greater task suitability, and (4) higher production rates. It is seldom possible (or practical) to try to translate all of these aspects of efficiency into tool design. Each of these efficiency criteria can be correlated with distinct technological strategies (Bousman 1993:69; Nelson 1991:66).

Design Reliability and Reliable Technologies

Bleed's (1986) concept of reliability of implement design and technology incorporates the factors of redundancy and dependability. Dependability is associated with overdesigned, strengthened, and reinforced parts constructed for an exact fit. Redundancy is present in the form of spare parts and back-up systems (Bleed 1986;

Bousman 1993:70; Nelson 1991:66-67). Reliable implements and technologies are employed during encounter hunting of large game which is associated with a high risk of failure. Increased risk of failure makes reliability a necessity. Costs in terms of materials and scheduled maintenance and repair time are necessary in order to ensure efficient use of pursuit and search time and tool usage (Bleed 1986; Bousman 1993; Nelson 1991; Torrence 1983, 1989).

Hayden and others (1996:12-13) argued forcefully that only certain of Bleed's (1986:739) criteria for reliable tools and technology can be directly inferred from archaeological data: overdesign of parts, good craftsmanship, careful fit of implement components, and maintenance beyond the use event. Also, a number of other researchers (Odell et al. 1996:378-379) have expressed both discomfort and dissatisfaction with such terms as reliability. They argue that the distinction between reliable and maintainable is too abstract and that the concepts are difficult to operationalize; primarily because a tool or technological system can possess aspects of both reliable and maintainable systems.

Design Maintainability and Maintainable Technologies

Bleed's (1986:73) definition of maintainability of design and technology emphasized a number of specific traits: lightness and portability of tools, specialized repair kits, modular or series design (Nelson 1991:70), user maintenance, co-occurrence of repair and use, and "serviceability". Accordingly, maintainable tools and systems are considered most efficient for mobility and settlement systems in which the technology is under fairly constant use with an unpredictable scheduling and lower failure costs (Bleed 1986:741; Nelson 1991:71; Torrence 1989:62). These authors emphasized that maintainability is an effort to increase the longevity of tools and weapons beyond the times in which they are employed.

Nelson (1991:70-73) noted that the terms "flexibility" and "versatility" have been applied as equivalent terms for maintainability (Cammilli 1988; Goodyear 1989;

Parry and Kelly 1987; Shott 1986). Nelson (1991:70) expanded Shott's (1986:6-10) original perception of flexibility to include changes in artifact form to meet changing needs. Flexibility and versatility are viewed as two different tool design alternatives to achieve maintainability. Versatile tool designs do not change form but can be employed in a variety of different tasks (Nelson 1991:70). This concept of the term is similar to Shott's (1986:19) definition. Two methods of achieving (and measuring) versatility include multiple functional edges per tool or the use of "generalized" edge forms (Knudson 1973; Nelson 1991:71; Odell 1977; Shea 1991).

Some researchers have recently discouraged use of terms such as flexibility and versatility (Hayden et al. 1996:13; Odell et al. 1996:379). Concerns were expressed that versatility, as defined by Shott (1986:19), combined different types of tool use or the same use but on different parts of the same tool. There is no clear means of distinguishing between edges that were resharpened and used for different tasks or the same edge used for the same task numerous times (Hayden et al. 1996:13). Utilizing the number of employed units (EU) per tool is considered an inadequate method of measurement. Recording the number of different types of retouch per tool or different types of use-wear may perhaps be better measures (Hayden et al. 1996:13). Versatility and flexibility incorporate aspects of tool design and function that are already included under the rubric of "multifunctionality" (Hayden et al. 1996:13) and "recyclability" (Hayden et al. 1996:14; Odell et al. 1996:379).

Transportability of Tools, Weapons, and Toolkits

Implicit in most discussions of implement design, technological organization, and toolkit composition is the relationship between group or individual mobility and transport of gear (Ammerman and Feldman 1974; Binford 1977, 1979; Bleed 1986; Bousman 1993; Gunn and Weir 1973; Hayden et al 1996; Kelly 1988; Shott 1986; Torrence 1983). A key characteristic of transportability is that the tools for a task

can be moved to the locus of the activity instead of being made on the spot (Nelson 1991:73). Tool design or toolkit composition should not be a hindrance in movement between locations or the acquisition and transport of various resources (Binford 1980; Nelson 1991:73). The emphasis on transportability means that tools must be small (but large enough to efficiently perform the intended task) and toolkits must consist of few components (inclusive of the maintenance portion). Increased individual and group mobility generally means greater emphasis on transportability (Bamforth 1991; Bleed 1986; Bousman 1993; Hayden et al 1996; Kelly 1982; Shott 1986; Torrence 1989). This observation has been noted in ethnographic studies (Binford 1977, 1978; Forde 1957; Lee 1979; Lee and Devore 1969; Oswalt 1976; Service 1979).

Toolkits composed of few items used by mobile groups must, of necessity, have some aspect of conservation measures associated with transport and use (Nelson 1991:74). This is usually indicated by such behaviors as resharpening, recycling, scavenging, and adapting reduction strategies to increase utility of limited raw material. Resource abundance has an obvious role in the design and use of tools and toolkit composition. Nelson (1991:77) and Bamforth (1986) separately emphasized social decisions (such as settling at locales of material scarcity) and the distribution and abundance of raw material as key factors in tool and weapons design and toolkit composition. Whichever cause is selected, the behaviors listed above all emphasize the desire to extend the use-life or "longevity" (Hayden et al. 1996:14) of stone tools, also referred to as curation.

Conservational Behaviors and Technological Organization

Binford (1973:242-244) was perhaps the first to apply the concept of curation in his interpretations of Mousterian functional variability (Odell 1996b:54). In this seminal article, Binford defined "curated technology" in relation to the foresighted transport of tools between locales in advance of use. Later, Binford (1977)

investigated curation versus expediency in relation to Nunamiut conceptions of what assemblages of personal gear were appropriate for particular forays. Curational strategies were also examined as a response to tool use, discard, recycling, and settlement mobility (Binford 1979). Clearly, Binford's perceptions of curation as an adaptive strategy or set of strategies included much of what he later considered characteristic behavior of anatomically modern humans: planning depth and tactical depth (Binford 1989:19).

Subsequent to the inauguration of curation as a theoretical archaeological phenomenon there has been a plethora of research addressing different aspects of curatorial behavior (see Bamforth 1986; Keeley 1982; Kelly 1988; Kuhn 1989, 1990; Odell 1996; Shott 1986, 1989; Torrence 1983, 1989). Simply, the term curation has enjoyed free application to a wide range of prehistoric behaviors; some of which include the advanced manufacture of tools, caching strategies, tool design for multiple functions, recycling, resharpening, and tool or blank/core transport (Bamforth 1986; Odell 1996b). Each of these is in turn discussed below in relation to the concept of curation and lithic technology.

Premanufacture of Implements Prior to Use

Binford (1977; 1979:269) was the first to propose that the manufacture of implements prior to use represented an aspect of curated technologies. In the earlier paper, he (Binford 1977) distinguished Middle and Upper Paleolithic assemblages on the basis of this curational behavior; the latter being curationally organized. Torrence (1983:11-13) applied the concept of curation as an effort to efficiently schedule time. Nelson (1991:62-63) considered the prefabrication of stone tool material prior to use as a distinguishing factor between expedient and curated technologies.

In relation to premanufacture of cores, blanks, and tools, Odell (1996:54-56) included caching, workshops, and hafting as illustrative of possible curational

behaviors. He (Odell 1996b:56) considered all of these to be somewhat equivocal in their utility as indicators of curational behavior. Sites such as workshops and caches can be a variable of the mobility strategies and settlement and subsistence patterns. Odell (1996b:56) is more positive regarding the evidence of hafting; hafting should increase with greater technological complexity and increased group mobility.

Multifunctionality

Hayden et al. (1996:13) recently argued that the concept of multifunctionality is more appropriate than versatility or flexibility. These design variables are usually associated with maintainable technologies. Tools capable of performing multiple functions (including multiple tools) are more generalized in design but are useful when the scheduling and locus of tool use are not always known or when an array of tasks or resources is expected (Nelson 1991:71). Bamforth (1986) associated tools designed for multiple functions with curational behaviors. Kelly (1988:718) considered bifaces as a generalized tool form that could be modified into other tool types. The use of bifaces as cores and extended-use implements has been associated with curation and multifunctionality (Hayden et al. 1996; Kelly 1988).

The association of curation and tools designed for multiple tasks is difficult to perceive (Odell 1996b:57). If the two can be associated with curation, should emphasis be placed on the design of the implement or multiple functions? Emphasis has been placed on the design of multifunctional tools because it is more directly indicative of a distinct preference on the part of the toolmaker (Hayden et al. 1996; Odell 1996b:57).

Transport of Raw Material, Cores, and Implements

Binford's original research regarding curated technologies among the Nunamiut included the transport of personal gear from one location to another (1977, 1979). Nelson (1991:65) and Kuhn (1992:189) considered the transport of tools

from one locality to another as a form of curation. However, the transport of cores, blanks, and tools should not be considered as equivalent in behavioral significance because there is always the question as to whether it is the tool, core, or raw material that was conserved. If it were the raw material, presumably, this would place raw material in a role of greater significance within the technology than certain aspects of the technology itself (tools or blanks). Torrence (1989:3) considered raw material as a limiting factor on technological organization.

Bamforth (1986:40) perceived a close link between raw material availability and other behaviors such as tool maintenance, recycling and the transport of tools. In fact, it can be argued that he placed a greater emphasis upon raw material availability as a preconditioning factor of technological organization than the behaviors of maintenance, recycling, and tool, blank, or core transport. Nelson (1991:77) considered the unavailability of raw material to be the result of conscious decisions made on the part of groups that chose to settle at localities away from resources. These choices are argued to have imposed a greater influence on tool, core, and blank design. Ultimately, these decisions influence patterns of tool and core transport, maintenance, and recycling.

Considerations of artifact transport must include patterns of artifact discard (Bousman 1993:74). Ammerman and Feldman (1974) emphasized the artifact droppage rate as a key factor influencing the frequency of artifacts at sites. The droppage or discard rate refers to the likelihood that a tool becomes an inclusion into the archaeological record. Discard influences the use-life of a tool or core which is related to use-intensity, maintenance, raw material, and other variables (Bousman 1993:74). Transport of stone tools and variable droppage rates contribute to the formation of archaeological assemblages. If droppage rates are not addressed to some degree then the behavioral significance of tool and core transport will remain unclear (Ammerman and Feldman 1974; Bousman 1993:74; Nelson 1991; Schiffer 1987; Shott 1989). This is especially significant if the researcher is attempting to

relate the transport of artifacts to settlement and group mobility strategies (Odell 1996b:58).

Recycling

Bamforth (1986:40) associated both maintenance and recycling of stone tools primarily with raw material abundance; only indirectly were these measures related to settlement or mobility strategies and time constraints. The rates of recycling should decrease when there is an abundance of raw material and when the costs of repairing and making new tools are low. Binford (1977, 1979) applied the variable of recycling to broken implements that were transported back to a campsite for reuse in different tasks.

Odell (1996b:59) considered recycling as a chimerical concept that is both difficult to employ and of questionable utility. His feelings are clear when he stated: "Since I have virtually exhausted the logical ways that recycling can be measured and have failed to find one that works, I conclude that we would be better off acknowledging the concept but working on something else."

The questionable utility of recycling as a conceptual tool is apparently the result of different perceptions of the concept and how it is reflected in the archaeological record. It may be possible to record recycling if it could be demonstrated that one tool was transformed into a separate functional type (Odell 1996b:59). One way of doing this may be to record the number of different tasks evidenced by either technology or use-wear. Evidence of multiple functions can be the result of either deliberate tool design or recycling. Observed wear on broken portions of tools is considered as questionable evidence of recycling but Odell (1996b:59) is not clear on how it could be considered otherwise. Presumably, this could include the deliberate reuse of tool fragments as ad-hoc or expedient tools because of suitability for different tasks.

Schiffer (1987:29) defined recycling as the "return of an artifact after some period of use to a manufacturing process." Although this definition is quite general it does indicate the transformation of an artifact into some other functionally distinct implement. The distinction between recycling and "secondary use" (Schiffer 1987:29-30) is one of degree of modification. Recycled implements are subjected to more remanufacture or alteration of the original artifact form. Objects of secondary use need less alteration from original form to be employed in other functions. There is potential for much confusion between secondary use and multifunctionality. The occurrence of different types of use-wear on an artifact is not sufficient to infer secondary use (contra Schiffer 1987:31).

Robust and highly patterned evidence of recycling has been documented for the northern Maya Lowlands of Belize (Dockall and Shafer 1993; McAnany 1989; Shafer 1983). These studies document the return of broken and exhausted implements into the manufacturing process as a source of raw material within a system of lithic technology characterized by indirect procurement of manufactured tools and blanks. These robust patterns are associated with highly formalized hafted bifacial and unifacial implements with a set of precise design attributes and primary functions. In this instance it is possible to segregate the manufacture and use/recycling phase of tool use-life. If one is dealing with expedient or maintainable toolkits and technological systems there is the problem of similar tool morphologies being produced from a variety of circumstances that masks any evidence of recycling.

Maintenance and Resharpenering

Maintenance and repair of tools have come to be associated with conservational behaviors because these measures extend tool use-life (Bamforth 1986; Bleed 1986; Shott 1989). Extractive tools (implements and weapons) were not used and maintained in the same ways as maintenance tools (implements specifically used

for manufacture and repair of extractive tools) (Bousman 1993:76-77). Collector groups seem to invest greater care in the use and maintenance of repair kits whereas forager groups invest lower energy input into repair kits; foragers are more inclined to use expedient maintenance tools. Differences in risk-level between collector and forager suggest that foragers are less structured concerning tool manufacture, repair, or maintenance. Three other factors that can potentially influence patterns of maintenance and resharpening include raw material durability, access to suitable raw materials for replacement, and traditions associated with a group's lithic technology (Bousman 1993:77-78).

The primary measure of tool maintenance and repair has been the presence and amount of retouch along an artifact edge (Odell 1996b:60). Bamforth (1986) has proposed that tool maintenance could be a local response to lithic resource materials in addition to being a type of behavior to extend tool use-life. The problem with using retouch alone as a measure of tool maintenance is that there are a number of reasons for its presence on a tool: shaping for haft or hand prehension, creating a working edge or point, to blunt an edge, or resharpening (Odell 1996b:60).

Due to the difficulty of using edge retouch as a measure of tool maintenance, archaeologists have applied a number of other measures of stone tool longevity. Shott (1986:44-45) employed a total artifact length:haft element length ratio for hafted bifacial implements from the Plainview and MacHaffie sites. This ratio rests on the assumption that tools that are shorter in comparison to maximum length of the haft element have been more intensively resharpened. This resharpening ratio is based on the inference that closely equivalent ratios were characteristic of assemblages being compared. Lower ratio values are indicative of increased resharpening or maintenance.

The above assumptions will not be true in all cases. Manufacture or use breakage and subsequent repair can accelerate the rate at which a tool reaches a ratio indicative of intensive resharpening. Limitations of this measure include the

applicability to only whole pieces with a haft element and insensitivity to actual behavioral processes that produced the ratio whether it be repeated episodes of use and maintenance, manufacture breakage and repair, or re-employment of previously discarded implements.

Odell (1996b:61) briefly discussed alternate beveling of bifaces as a second measure of implement resharpening. Other researchers have employed edge-beveling as an indicator of lithic resource availability and temporal changes in raw material use through time (Goodyear 1979; Wiant and Hassen 1985).

Another means of documenting both tool use-life and maintenance has been to reconstruct reduction sequences of implements (Dibble 1984, 1987, 1988; Kuhn 1990, 1992). This measure of tool transformation has been applied primarily to Mousterian unifacial scraper types. Dibble (1987:37-38) developed two models of scraper reduction based on changes in scraper morphology; 1) single-biconvex to double-convex convergent forms; 2) reduction through repeated resharpening of a single tool edge. He also utilized four ranked categories of retouch intensity: light, medium, heavy, stepped. In his analysis of unifacial implements from the Pontinian Mousterian of Italy, Kuhn (1992) demonstrated that differences in modes of scraper resharpening actually influence overall scraper morphology to a small degree. Other variables included the original morphology of the flake and the amount of dorsal cortex (Kuhn 1992: 125).

Other methods of investigating use and maintenance of unifacial tools include comparison of mean metric attributes of unused and discarded tool specimens (see Shott 1995) and the detailed analysis of microdebitage samples containing uniface retouch flakes (Baumler and Downum 1989; Shott 1995:63-66).

A number of methods have been developed for assessment of the presence/absence and degree of resharpening and maintenance in an assemblage. These techniques are generally not applicable to entire assemblages and if so applied then the results do not realistically reflect either resharpening or maintenance (Odell

1996b:62). Odell suggests that these measures be applied to specific sets of tools such as projectile points and unifaces. He also called for specificity in definition of what is being measured.

Getting What You Need: Technological Provisioning and Technological Organization

Lithic technological organization is ultimately tied to the establishment and maintenance of a suitable source of both tools and raw material (Kuhn 1995:21). One of the primary objectives of technological systems is to provide tools and materials at specific times and locations as the needs arise (Kuhn 1990:70).

Binford (1973, 1977, 1979, 1989) has stressed that variables such as mobility, resource distribution, and tool/task relationships are integrated with tactical and planning depth (Binford 1989; see Chapter I of this study). The concept of planning depth includes artifact manufacture, tool transport and maintenance, and tactical strategies to assure that technologically related needs are met (Kuhn 1990:70, 1995:21). Planning suggests that technology is not "peripheral" to hominid survival (Kuhn 1995:21).

Kuhn (1990:69-76, 1992:188-190, 1995:21-23) has developed a model of technological provisioning based on three levels of planning complexity: activities, individuals, and localities. It should be emphasized here that a particular technological system may not exhibit all three levels or the system may reflect some degree of each level of planning.

Activities

Activity-level provisioning means that tools are manufactured as they are needed and then discarded when the need ceases or the tool is no longer useful. The provisioning of activities requires the lowest amount of input into planning and is equivalent to Binford's (1977, 1979) expedient technology. This level of technological planning can occur only in areas where suitable raw material is present

in sufficient quantities. The time-scheduling limits of the activities also limit the amount of time that can be devoted to tool manufacture (see Torrence 1983).

Individuals

Kuhn's second type of provisioning is at the individual level. The equipping of individuals with suitable toolkits or personal gear (Binford 1977) requires tactical and planning depth (Binford 1989) well beyond the provisioning of activities since people are limited in what they can transport. Although transportability is a key factor in limiting toolkit size and variability the technology is kept at a ready state and can be implemented immediately as needed. This also enables individuals to quickly replenish tools quickly in the field. Transport and toolkit size does limit the number of backup and extra repair parts that can be carried. The continual demands on personal gear often result in higher attrition rates for both extractive and maintenance portions of the toolkit. The personal toolkit can be furnished with specialized tools, generalized tool forms, or raw material in the form of cores and tool blanks, but the composition is dependent upon anticipated needs (Henry 1995a:111).

Places

Behaviors associated with the provisioning of places are also related to the anticipation of future needs. In order to successfully supply locations with needed material there must be some advanced information of the future location and scheduling of activities. Caching strategies that rely on furnishing places with tools and raw materials decrease the restrictions of transportability associated with provisioning of individuals (Kuhn 1992:189). Locality provisioning is not as sensitive to raw material distribution, transportability, or time required for manufacture as activity or individual provisioning. Kuhn (1992:189) predicted that there should be an emphasis on raw materials as opposed to tools in the provisioning

of places. At provisioned places there may be less emphasis on tool maintenance or resharpening and it may be just as easy to retool (replacement of the tool itself). This may be reflected in the archaeological assemblage by numbers of minimally worn or damaged tools that could otherwise have been repaired (also see Kuhn 1990:79-80).

The utility of Kuhn's model is that it allows the archaeologist to assess the importance of mobility strategies, tool manufacture and use, and raw material in technological organization (Henry 1995a:111). It also provides a measure of the degree of tactical and planning depth associated with a technological system.

Summary

The theoretical framework presented in this chapter emphasizes the dynamic relationship between technology and other facets of the cultural system such as settlement and subsistence. A group's technology is composed not only of the physical aspects, being the tools and raw materials, but also the intangible, being the knowledge, conventions, and ways of learning, that serves to provide cohesion to the technological system. As a part of a group's repertoire for adaptability, the technology must be integrated and flexible with the remainder of the adaptive package. Maintainability, flexibility, and reliability of technological systems are influenced by variables such as raw material quality, availability, procurement methods, and the situations encountered which require the technology to be put into action. Tool design parameters and tool transportability are crucial aspects of functional and flexible technological systems.

Tool design and tool complexity will vary with the nature of the events that put the technology into use. One important attribute of tool design is reliability: every tool must be reliable to some degree. The tool must perform when and where needed and tool design may vary depending upon the perceived cost of failure for the group or individual. There are a number of ways in which prehistoric groups could

achieve reliability and continued service from tools and toolkits. These include premanufacture prior to use, use of tools for more than one function, tool or material recycling and various methods of tool repair and replacement. Archaeologists have attempted to employ these concepts to measure the degree of curation among lithic technological systems to varying degrees of success.

An alternative method of addressing technological organization is to approach technology from the concepts offered by design analysis (Hayden et al. 1996). Design analysis allows the archaeologist to consider several different parameters that contribute to the tool as a unit that are associated with tool manufacture and use . When technological, task, and raw material constraints upon the technology are incorporated into a technological analysis of a lithic assemblage, certain factors of tool design begin to make more sense in terms of why stone tools are manufactured and designed in certain ways. The ways in which people equip themselves and groups for certain tasks are also key concepts that should be considered in studies of tool design and function. Chapter V provides the background to sample composition and selection and the analytical framework for data collection to address Levantine Mousterian convergent tool manufacture and use patterns.

CHAPTER V

SAMPLE SELECTION AND RESEARCH METHODOLOGY

The material utilized in this study was selected primarily from the North and Central Galleries at Nahr Ibrahim. A smaller sample was selected from Shanidar Cave, Iraq. Published data from Shea (1991) was also included and is further discussed below.

The selection of convergent tools from the North and Central Galleries at Nahr Ibrahim involved a complete inspection of all pieces from both galleries. All material was systematically examined by Lot # and gallery and specimens meeting the criteria for inclusion in this study (see below) were pulled for cleaning and later analysis.

Convergent tools from Shanidar Cave that were included in the study were selected from small collections of material at Texas A&M University and on loan to Drs. Ralph and Rose Solecki from the Smithsonian Institution, Washington D.C.. Arguably, the Layer D material included in this study from Shanidar reflects the selectivity of the excavators and what they were allowed to remove from Iraq after completion of fieldwork. Only use-wear related variables were recorded for the Shanidar material as no detailed technological study had been developed at that time.

Attributes Used to Define Convergent Tools

The entire sample selection and data collection/analysis phase of this study was guided by what may be considered a broad definition of convergent tools. The use of such broad criteria is believed to have provided enough latitude in sample selection so that the full range of convergent tools was sampled from Nahr Ibrahim.

The following criteria were used to identify convergent tools in the various lithic assemblages:

- (1) Distal convergence of lateral edges.

(2) Convergence may be either a property of the flake or blade tool blank, a product of retouch, or both. Also, one lateral edge may be modified distally by retouch and the other can remain unmodified.

(3) Convergent tools are generally broader at the proximal than the distal end. An exception may be a blade in which the medial and proximal width may be fairly equal or a flake or blade in which the medial width is greatest.

Established type names and criteria of identification that have been established for Lower and Middle Paleolithic tools (Bordes 1961, 1972; Debenath and Dibble 1993) were employed only as an aid in sample selection. These type names were applied only as comparative morphological terms. No inferred functional interpretations were associated with these type names during the analysis. For instance, if a tool was identified as a convergent convex sidescraper, this name was retained during analysis based only on morphological criteria. The presentation of the data in Chapters VI and VII does not incorporate these typological distinctions. The nature of my research, which involved the use of Shea's (1991) comparative data, did not lend itself to the determination of functional variability among established traditional types. Shea's data was not presented in this form and there would have been no basis for intersite comparison with Shanidar and Nahr Ibrahim.

A particular set of criteria was applied to distinguish blades and flakes and Levallois from non-Levallois pieces. Blades were identified as having a width/length index of .50 or less (see Crew 1976:83). Ronen (1992:222) has also noted that the majority of Middle Paleolithic blades have faceted platforms and fewer dorsal scars than Upper Paleolithic blades. Middle Paleolithic blades are also predominantly distally convergent and were manufactured by identical techniques used to produce flakes. These general criteria were used in conjunction with Crew's criteria (1976:83) to identify blades in the various assemblages. Distinctions between Levallois and non-Levallois points, blades, and flakes, were also made based on

previously established characteristics and traditional type descriptions following Bordes (1961).

Physical Criteria of Sample Selection

The selection of specimens for inclusion in this study required a certain degree of physical integrity. The samples from Nahr Ibrahim and Shanidar were not influenced by excavator selectivity unlike a number of Paleolithic sites in the Near East. The research design for this dissertation incorporates both technological and use-wear analysis which can accommodate some post-depositional alteration before a piece is considered as not acceptable. Several criteria were followed in the selection of specimens from Nahr Ibrahim. In order to be selected the specimen must not have been heavily altered by post-depositional changes and mechanical damage. Post-depositional changes include abrasion, patination, and desilicification. Mechanical damage included storage and transport breakage/nicking, and severe thermal stress such as crazing and potlidding. It should be emphasized that these criteria often served as an ideal rather than a practical means of sample selection.

To add to the difficulty of sample selection, the material from the Central Gallery at Nahr Ibrahim was significantly less geologically compromised than artifacts from the North Gallery. Given the different geological histories of deposition (Chapter III) this is not surprising. Patination and abrasion were more intensive among the North Gallery material. There was also a greater number of specimens rejected for use-wear due to desilicification than in the Central Gallery. Shanidar specimens were suitable for use-wear analysis but were not available during the technological analysis phase. Much of the technological discussion of Shanidar pointed tools is derived from Solecki and Solecki (1993).

Theoretical Background and Analytical Methods

This study is based upon a specific theoretical approach to lithic technological systems and assemblages. The favored approach in this study can be considered as processual wherein lithic technology is perceived as a reductive phenomenon that can be usefully studied in a series of stages (Collins 1975). This is a crucial aspect of an analytical framework that Driskell (1986:5-8) has termed the integrated approach to lithic analysis.

The integrated approach combines the technological (production) aspects of an assemblage with the use-wear (function) aspects into a more holistic approach for interpreting morphological variation in a lithic assemblage (Driskell 1986:5). The range of variability observed within an assemblage is a culmination of several processes which include the methods of tool manufacture, tool use, breakage and discard patterns, and post-depositional effects. There is a very strong economic emphasis in Driskell's model. Production and use in lithic technology are related to behaviors associated with economic and other strategies to meet subsistence and maintenance needs.

The use of the integrated approach to determine the stone tool production/use cycle is dependent upon four interrelated datasets. These include (1) determination of the stage of manufacture, (2) status of the artifact (whole, broken, abandoned in manufacture etc.), (3) tool type, and (4) use characteristics (Driskell 1986:8). Where possible broken convergent tools are included to provide data pertaining to patterns of breakage associated with use.

Technological Analysis

This phase of the analysis was an in-depth techno-morphological study that included some data from the functional study. Important aspects of this analysis include dorsal scar patterns, dorsal cortex, platform characteristics, and metrical

attributes. Technological analysis provided correlational data for the manufacture and use aspects of tools in the sample.

The various aspects of tool design, maintenance, and reliability are addressed through analysis of a number of variables: platform type and dimensions, metric dimensions of tool blanks, edge-angle/spine-plane angle (see Odell 1979), platform modification, and retouch. Retouch includes such variables as intensity and location.

Fracture pattern analysis and fragment type are used to develop hypotheses regarding tool maintenance, retooling, and dependability (Ahler 1992; Dockall 1991a, 1994, 1997; Dockall and Shafer 1993). Patterned fracture schemes for particular blank types can be used to argue for some degree of functional specificity and standardization of the manufacturing process. Such data can also be used to infer whether the tool was broken during manufacture or use and thus evaluate the status of the artifact (Ahler 1992; Dockall 1991a, 1994; Dockall and Shafer 1993; but see also Holdaway 1989, 1990).

Blank Shape and Blank Technology

Shea (1991:165) referred to blank shape as the plan view outline of a utilized tool. The categories of shape variation follow those included by Shea (1991) except that proximal and distal flake fragments are also included. These categories are necessary to include fragments that show evidence of wear through use or hafting/prehension. Breakage patterns associated with these fragments are then utilized to formulate inferences of tool use. The major categories of blank shapes include points, blades, oval flakes, and fragments.

Previous studies have attributed particular functions or ranges of functions to points, flakes, and blades based largely on morphology, technology, location and extent of secondary modification, and ethnographic analogy. Pointed implements have traditionally been interpreted as either hand-held multipurpose tools (Bordes 1968; Bordaz 1968; Debenath and Dibble 1994) or components of hafted hunting

weaponry (Binford and Binford 1966; Braidwood 1967; Coon 1962; Singer and Wymer 1982). Blades have taken on a more evolutionary significance rather than having specific functional connotations. The presence and increasing abundance of blades as components of Middle Paleolithic assemblages has been interpreted as either the beginnings of modern behavior patterns or as the presence of anatomically modern humans (Bordaz 1971:50-51; Braidwood 1967:58-62; Deacon 1989:560; Fagan 1995:127-128; Klein 1989:356, 421; Ronen 1992). Specific interpretations pertaining to oval flakes are also quite general being interpreted as potentially useful for expedient and multi-purpose tools with functional inferences being based largely on location and type of retouch (Shea 1991:166).

Blank technology includes the presence and abundance of dorsal cortex on the tool blank. This attribute is related to blank shape and specific core preparation techniques. The extent and position of dorsal cortex can be used as a general indicator of the position of the tool blank in the reduction sequence.

Analysis of Dorsal Scar Patterns

The pattern of dorsal scars on flakes, blades, and other tool blanks is important in understanding variation among different core reduction strategies. Scar pattern analysis was first employed by Crew (1975) in a study of Levallois flakes from assemblages in Nubia, the Levant, and the North African Mousterian. The Levantine Mousterian was found to be dominated by uni- and bi-directional core preparation, a high frequency of laminar (blade-like) pieces, and the presence of Levallois flakes. The Nubian and Libyan Mousterian was dominated by centripetal (radial) preparation.

Baumler (1987, 1988, 1995) noted that the general conditions of core reduction can be determined through analysis of unused flakes and flakes used as tools. Baumler (1988:262-266) used dorsal scar and cortex patterns of complete

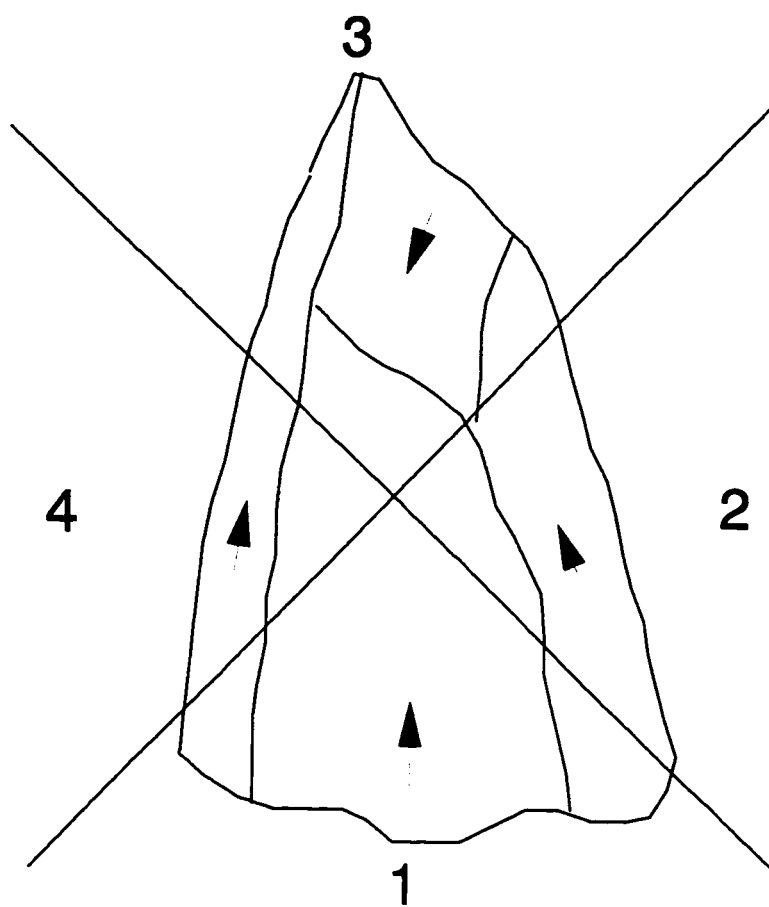
flakes and tools to isolate reduction patterns and stages at the Middle Paleolithic site of Zobiste, Yugoslavia.

Research concerning the Mousterian indicates that there were two main Levallois methods; lineal and recurrent (Bar-Yosef and Meignen 1992; Boëda et al. 1990). The lineal method involved the removal of only one preferred Levallois blank from each prepared platform, after which the core was reflaked and subsequent flake, blade, or point removals. The recurrent method involved a series of flake, blade, or point removals from each prepared surface. Continued reduction resulted in sequentially smaller sizes of blanks and cores (Bar-Yosef and Meignen 1992:166-167).

The analysis of dorsal scar patterns allows an understanding of the relationships between tool blank production, tool blank selection, modification, tool design, and tool use. The methodology in this study follows Baumler (1987:243-244, 1988:263). The number of flake scars (excluding small platform preparation scars) and scar patterns were recorded using a 4-quadrant grid (Figure 5.1). Quadrant 1 quantifies the number of flake removals from the same basic platform or flaking direction from which the flake itself was removed. Quadrants 2 and 4 document the number of flakes removed from the right and left lateral edges, and Quadrant 3 represents the number of flake removals opposite from the direction to those in Quadrant 1; the distal end.

Analysis of Dorsal Cortex

The presence and amount of dorsal cortex has been interpreted as an indicator of the various stages of reduction. Logically, it is expected that larger amounts of cortex will be removed earlier in the reduction sequence. Different methods of Levallois core reduction will yield different patterns in the percentage and location of dorsal cortex. This data is useful in the reconstruction of core reduction techniques and tool blank production. A method applied by Baumler (1987:67-68,



DORSAL SCAR PATTERN

3010

Figure 5.1. Format for recording the dorsal scar pattern of convergent tools.

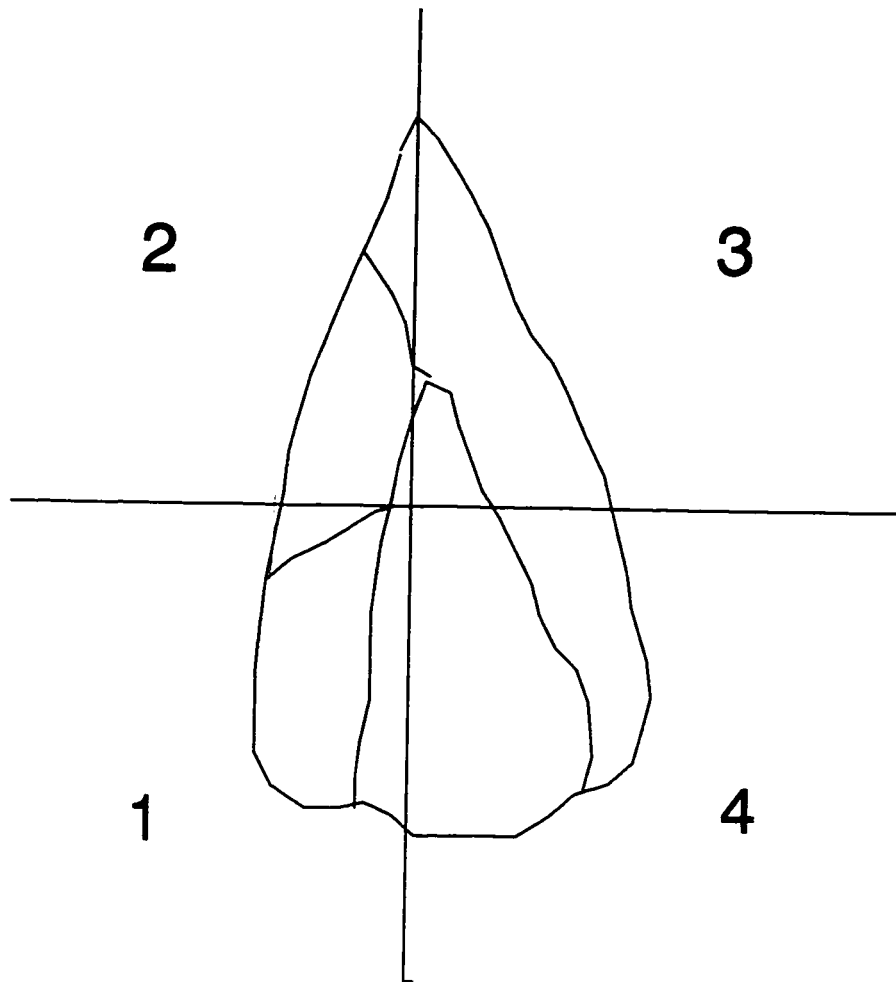
1988:262-263) during an analysis of the lithic assemblage at Zobiste, Yugoslavia is also employed in this study.

The dorsal surface of each specimen was again divided into four quadrants (Figure 5.2). These quadrants were defined by the longitudinal (flaking) axis of the flake and a second axis perpendicular to the longitudinal axis and crossing it at midpoint (Baumler 1987:68). The four quadrants are referred to as left proximal, left distal, right proximal, and right distal. The presence or absence of cortex was recorded for each quadrant (1=absent; 2=present). This recording scheme, following Baumler (1987:68) provided a four digit numerical code for cortex position on the dorsal surface of each specimen.

A fully cortical flake would be recorded as 2222 and a flake with no cortex would be coded as 1111. Also, following Baumler (1987:241), for cortex-bearing flakes with cortex mainly in one quadrant with an overlap in another quadrant(s), then more than 20% of the other quadrants had to have cortex to be recorded as present.

Platform Variation and Platform Modification

Shott (1994:80-81) emphasized that a variety of basic platform types should be recorded. Obviously, platform type is related to core platform preparation prior to flake removal. Studies of Middle Paleolithic tools and lithic assemblages have identified a variety of platform types. There were 14 discrete platform states that were included in this study. The first seven types (Figure 5.3) are based on types identified by Fish (1979). These include plain, dihedral, multiple facet, chapeau de gendarme, transverse preparation, and dihedral with one transverse flake. Other types included cortical, partial cortical, modified/removed, crushed, absent, partial, and lipped/soft hammer.



DORSAL CORTEX PATTERN

1211

Figure 5.2. Format for recording the dorsal cortex pattern of convergent tools.

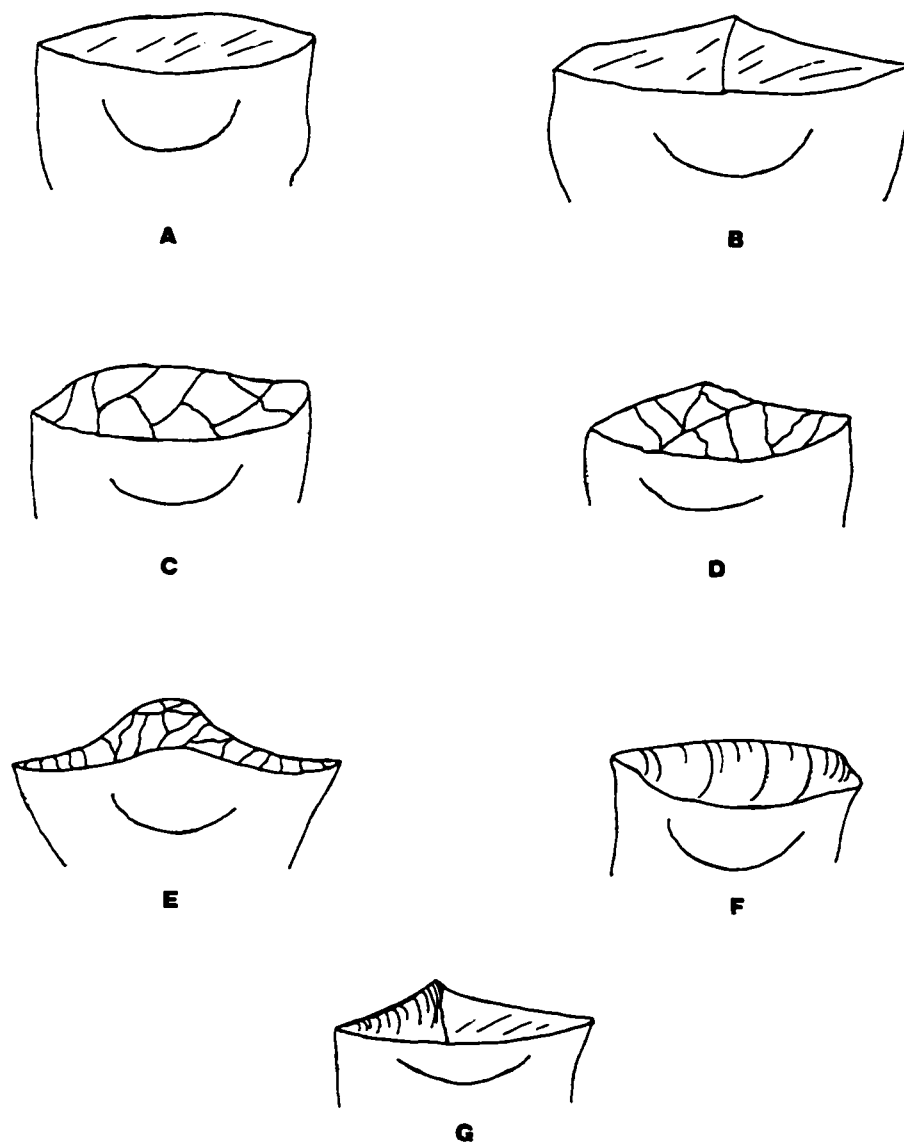


Figure 5.3. Seven major platform types recorded for convergent tools. (A) flat, (B) dihedral, (C) multiple-facet, (D) triangular multiple-facet, (E) chapeau de gendarme, (F) transverse preparation, (G) dihedral with one transverse flake.

Platform modification was recorded to determine the range of post-flake removal alteration that was present and if modification patterns varied with tool type. There were eight different types of platform modification states that were included based on a previous study of sidescrapers from the Central Gallery at Nahr Ibrahim (Panagopolou 1985:19-20). These types are identified by differences in purpose of modification, technique used, and location. One of the main reasons for coding variation in platform modification is to examine the presence/absence of hafting and other modes of tool prehension (see Keeley 1982).

Retouch Location and Variability

The characteristics and variation of secondary modification of tools are related to tool design, basic tool function, and prehension. Tool modification also must be studied in an effort to relate variability with use-wear patterns. The types of retouch included in this study are those initially defined by Bordes (1961) for Middle Paleolithic assemblages. These types were also used by Panagopolou (1985:88) in her study of sidescrapers from Nahr Ibrahim. In addition, other types are also included that were identified in this study.

Retouch intensity was recorded to determine the presence/absence and degree of resharpening of the various tool types. This assumes that the amount of material removed from the edge corresponds, in some degree, to the amount of resharpening that actually occurred (see Panagopolou 1985:88). This assumption can be problematic for highly retouched assemblages in which the initial size of the raw material is small. In these cases the amount of retouch may be more a reflection of the amount of secondary shaping necessary to produce a suitable tool. Tools can also be retouched merely to regularize an edge or the overall shape of an implement and may have had little to do with function (to produce a functional edge).

Retouch position recorded the location of retouch for each modified tool edge. Location of secondary retouch is related to the conventions of tool design, prehension

and function. Therefore, understanding the interrelationships of these attributes is a crucial aspect of studying the technological organization of convergent tools.

Fracture Patterns

Each tool was recorded as to condition: complete or incomplete. Incomplete tools were further coded as to fragment portion and fracture type represented. Occasionally, more than one break type was present in which case the most relevant was recorded. The recognition of various fracture types is based on Ahler (1992), Cotterell and Kamminga (1987), and Crabtree (1972). Fracture pattern data is useful to determine the cause(s) of tool breakage: manufacture, use, or post-depositional factors. The importance of fracture pattern studies of Middle Paleolithic assemblages has been demonstrated recently by Shea (1988a, 1989a, 1989b, 1990, 1991) and Holdaway (1989, 1990). Recent debate in the literature between Shea and Holdaway regards the possible distinction between Mousterian points and convergent sidescrapers that are broken distally. Holdaway (1989:80) contended that if a particular tool category also included some that were additionally used as hafted projectile points, then there should be a greater number of proximal fragments at habitation sites. Holdaway suggested this as a method of testing for the presence of "true" projectile points (1989:80). Such data is further used as an indication of the degree of projectile point use during the Mousterian and as an assessment of overall hunting efficiency (Holdaway 1990:115). Relatively equal proportions of proximal and distal fragments in an assemblage are interpreted as evidence against the significant presence of hafted projectile points.

Holdaway's arguments, while provocative, do not consider the morphology of the fracture as Shea's studies have (see 1991) in which aspects of fracture size, termination, scar morphology, and fracture trajectory are used as bridging data to infer various functions. This approach has recently been applied by Solecki (1992) to argue against Holdaway's interpretation of pointed tool fracture patterns. The

present study uses this data in conjunction with fragment type to further understanding of breakage pattern/tool use relationships for a category of tools from a Middle Paleolithic assemblage.

Functional Analysis

The functional analysis and recording of microwear data follows closely the methodology previously established by Tringham et al. (1974) and Odell (1977, 1979) and later adapted to a functional study of Levantine Mousterian lithic assemblages by Shea (1991). The methodology applied considers the attribute to be the fundamental analytical unit (Odell 1979:334-335). There are several advantages in consideration of the attribute and not the type as the unit of analysis. The attribute enables the analyst to be more objective and to apply more sophisticated methods of database management and statistical analysis. Even in lieu of the application of complex statistics, the increased precision and lucidity of definition and description of microwear is considerable. There is no need to resort to convenient, ill-defined, and unclear terminology.

The disadvantages of the type approach (see Odell 1979:334-335) are not encountered at the attribute level of microwear recording. Types are defined and originate with the researcher and are assigned directly to the data. The attributes that are used to define the type may also vary from case to case and researcher to researcher. A type-level analysis inhibits study of the interrelationships between individual microwear elements and between tool segments. Perhaps most importantly, if significant progress is to be continued in microwear recording and interpretation then the attribute must be considered. It is the element and attribute that allows the researcher to proceed from observations of microwear characteristics, to explanations of mechanics of use-wear formation, to the behavioral reconstruction of tool use.

Elements of Tool Pretreatment and Microscopy

All tools were cleaned prior to microscopic observation. Cleansing ranged from light rinsing in plain water to a bath (ca. 10-30 minutes) in a 10 percent solution of HCL and water. The acid bath was immediately followed by immersion in plain water than a rinse in a mild detergent solution, followed by a last water rinse. The acid bath was necessary to remove dense breccia and carbonate deposits. Before microscopic analysis, each tool edge was lightly cleaned with ethanol (ETOH) and a cotton swab to remove any remaining residues and skin oils from the handling process.

All artifacts were initially scanned for use-wear with a Nikon Stereomicroscope with a magnification range of 7-30X. Final functional interpretations and microphotography were performed using a WILD Heerbrugg Stereomicroscope with a magnification range of 6-100X. An Erinreich MkII fiber optic light source was used in conjunction with both microscopes. All tool margins and surfaces were examined for use-wear. Assessments of use-wear were generally made between 40 and 100X. Cotton gloves were also worn during the use-wear analysis and microphotography.

The Spatial Recording Format for Microwear Analysis

It is important to conceptualize each tool to be analyzed for microwear as having constituent parts. The concept of a Polar Coordinate Grid as described for dorsal cortex and flake scar analysis is utilized in recording use-wear. The polar coordinate (PC) grid (Figure 5.4) is subdivided into eight (8) equal spatial segments. These segments are sequentially numbered 1 through 8 in a clockwise fashion. The tool to be analyzed is centered in the grid with the dorsal side up and the proximal end toward the observer or analyst. The ventral or bulbar surface is placed down.

This data retrieval system has three major advantages (Odell 1979:335). The entire tool is subdivided into equivalent comparative analytical units that are

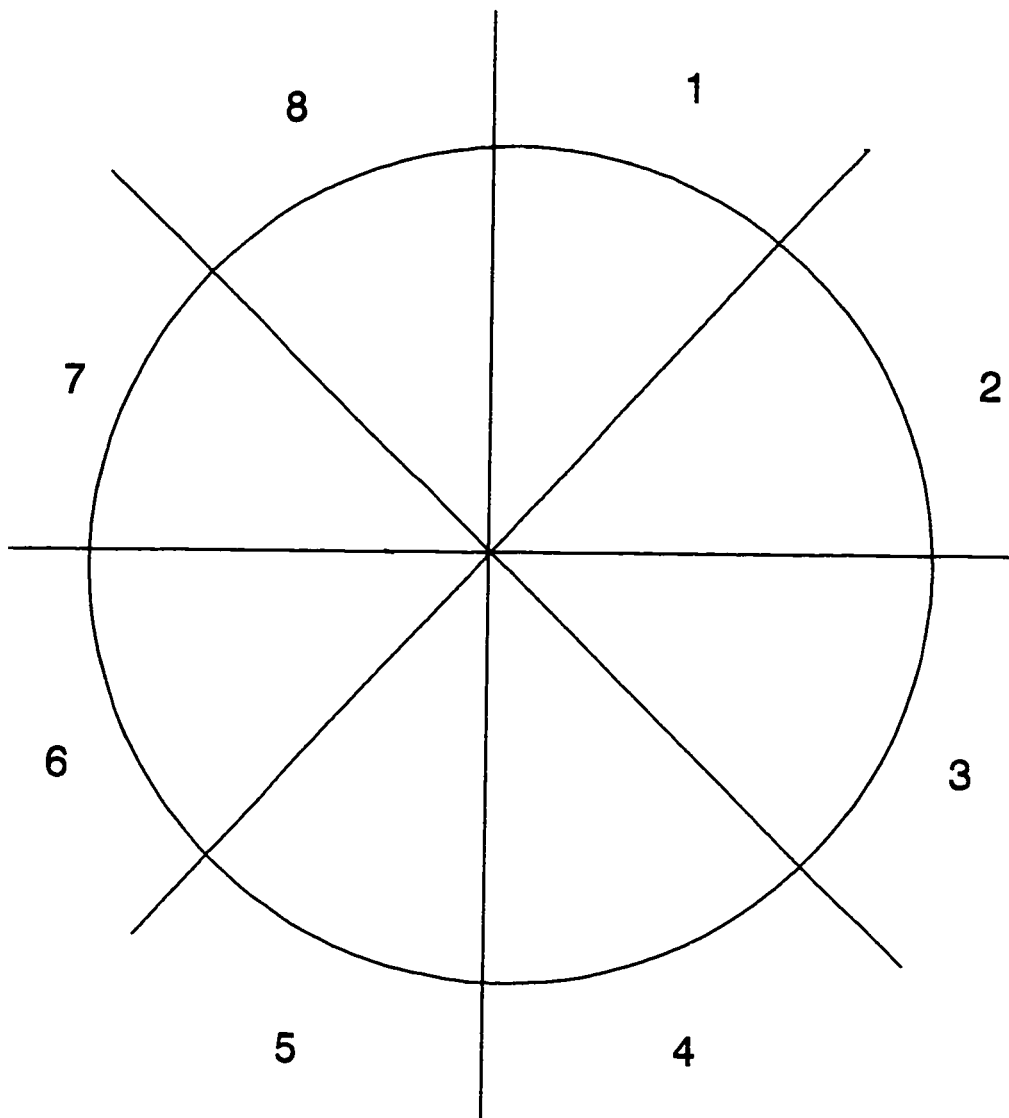


Figure 5.4. Polar coordinate grid for use-wear recording and employed unit (EU) calculation (adapted from Odell [1979:Figure 3]).

independent of tool size. It is also possible to record functional and technological data relative to discrete PCs.

Each PC can theoretically document a particular function of a tool (within the limits of tool morphology). It is also possible, and very useful, to combine multiple PCs into employable units (EUs) or a single PC with discrete wear traces can be considered an EU. The concept of an EU as it is used in this study was developed by R. Knudson (1973:viii) and defined as "those portions of an implement (edges or projections) deemed appropriate in performing specific tasks". EUs attributable to hafting/prehension and use can also be recorded separately. Polar coordinates can further be translated into conventional flake/tool morphological landmarks. For example, PCs 8 and 1 represent the distal end and 4 and 5 the proximal end. PCs 2-3 and 6-7 represent the right and left lateral edges, respectively.

Importantly, the selection of an 8 quadrant polar coordinate grid was based upon its success in previous detailed use-wear studies (Odell 1977; Shea 1991) and the need to maintain comparability with Shea's original work. Both of these studies tested the eight quadrant grid over a varied temporal and techno-morphological suite of lithic assemblages. Eight quadrants are also easier to combine into larger units of analysis. Odell (1979:336) found that this number of quadrants was sufficiently fine-grained yet neither redundant nor too time-consuming.

Basic technological information was recorded as an adjunct to the functional analysis (Shea 1991:494-501). Each PC and/or EU was described according to a series of values for sixteen variables or attributes. These variables include aspects of tool blank techno-morphology, EU modification and shape, spine-plane and edge angle, and edge-wear. Edge-wear was further recorded as a nine-digit wearcode (following Shea 1991) of observations concerning abrasive and fracture wear types and locations.

Theory of Use-Wear Formation

Lithic use-wear analysis represents the study of the formation processes of edge/surface damage on stone tools in reconstruction of tool functions. The ultimate goal of such studies should be anthropological; that is, the reconstruction of past human behavior within an adaptive framework. Microscopic damage traces are best interpreted in reference to the current body of knowledge regarding fracture mechanics (see below). Experimental programs also provide empirical comparative information for the interpretation of archaeological use-wear traces.

Macro- and microscopic use-wear traces can be divided into two broad categories: (1) microscarring damage and (2) abrasive or attritive damage. These broad categories can be further sub-divided into several types of microscarring and abrasive damage that vary with loading rate and loading type.

Static Versus Dynamic Loading

Just as the nature of the contact or worked material is an important variable in the formation of use-wear traces, so too is the type of loading upon the tool edge or surface. Load represents the external force that is applied to a solid material to produce a deformation. Static loading occurs when a fairly constant load rate is applied over a period of time or if the load rate is slowly increased. Dynamic loading is produced by the rapid application of force via impact (Speth 1972:36).

Bending and conchoidal initiations develop under distinctly different loading conditions and can also yield data regarding the nature of the applied force and the contact area (Hayden and Kamminga 1979:6). For simplicity, the rate of loading can be considered to vary from high to low and can be either static or dynamic. The rate and type of loading of a tool edge/surface can vary considerably according to the task performed. Activities such as scraping hides and cutting plant material have lower loading rates than adzing wood or the impact of a projectile point.

Higher load rates are commonly encountered in situations in which the tool is subjected to dynamic loading. Such tasks include chopping, adzing, pounding, wedging, and projectile impact. Static loading occurs during activities such as cutting, scraping, drilling/boring, planing, and shaving.

Shea (1991:39) has noted that the size of microscars covaries with the rate of loading and whether loading is static or dynamic. Static loading usually produces microscars that range from 2-4 mm in length. Dynamic loading produces scars that vary in length with the hardness of the worked material: <2 mm for softer materials to >10 mm for harder materials. Experimental data also indicates that there is significant variation in abrasive damage characteristics according to the loading rate of a tool edge in contact with grit particles or contact/worked material (Mansur 1982:225).

Micro-scarring, Edge-angle, and Worked Material

Micro-scarring involves the actual mechanical failure of a tool surface or edge. Edge failure results in the removal of small flakes due to applied stresses that surpass the tensile strength of the tool material. Stresses along the tool edge can be either static or dynamic, such as associated with cutting/scraping or projectile impact, respectively. Material failure begins at a point of maximum stress with crack initiation and propagation parallel to the direction of applied stresses (Cotterell 1972; Cotterell and Kamminga 1979, 1987, 1990; Faulkner 1972; Tsirk 1979).

Morphological variations and differences in flake initiation and termination types (Cotterell and Kamminga 1987; Ho Ho Nomenclature Committee 1979) are a reflection of such factors as the kinematics of tool use, loading variation (static or dynamic), direction(s) of tool use, worked material, tool material, use-angle, and spine-plane angle.

Cotterell and Kamminga (1987, 1990) have provided a model of flake formation directly applicable to the study of use-wear phenomena that is applied

in this study. This same variation can also be used to identify differences in tool motion and worked material (see Cotterell and Kamminga 1979:8-9, 1990:155-159; Dockall and Shafer 1993; Keller 1966; Lawrence 1979:119; Odell 1979:339-342, 1980:101-102; 1981; Shea 1991; Sonnenfeld 1962; Tringham et al. 1974).

Worked materials are any substances being acted upon by the stone tool. These materials react as hard or soft indenters against the stone tool during use. Worked materials that are quite yielding and/or enable a large contact surface with the tool (such as hide, meat, soft wood, vegetals) are prone to producing bending initiations and fewer conchoidal (Hertzian) initiations (Lawrence 1979:118; Odell 1981:199-200). The larger contact area of softer materials such as hide also result in decreased fracturing during tool use.

Soft contact materials mean increased tool penetration with less force or resistance. Odell (1977:435 and Figure XIV 33) has shown that edge angle generally increases with the hardness of worked material, on average. Acute edge angles are more commonly associated with bending initiations with tools used to work material of soft to medium hardness. Research has also demonstrated that feather terminations are common on stone tools that have been used to work soft materials (Lawrence 1979:119; Odell 1981:200).

Hertzian (conchoidal) initiated microscars are often produced along a tool edge by use against a hard material (stone, bone, antler, wood) or when a hard particle, such as grit, becomes embedded in a soft worked material. The embedded hard particle reacts as a hard indenter (Cotterell and Kamminga 1987:686, 1990:158). Hard contact materials also produce more hinge- and step-terminated flake scars even though initial scars are usually larger with feather terminations (Lawrence 1979:148; Odell 1981:200; Odell and Odell-Vereecken 1980:101; Shea 1991:39). Hard materials are less yielding and hence permit only a small amount of the tool to contact the surface (Lawrence 1979:118). This results in the

concentration of loading force on that area increasing the likelihood of conchoidal fracture.

Abrasive or Attritive Damage

Striations

Striations are microscopic grooves or scratches resulting from grit that comes in contact between a tool and the material being worked. Grit inclusions can be fragments of the tool that break away during edge failure in tool use, fragments of worked material or dirt (Del Bene 1979; Diamond 1979; Moir 1914; Semenov 1964; Shea 1991:41; Kamminga 1979:151).

A greater proportion of striations and other like phenomena develop under conditions of static loading (Del Bene 1979:169). Striation can also form as a direct result of tool surface deformation or crushing of the tool surface. Some striations also have a distinct morphology, being composed of a head and a tail. The formation of the head and tail seem to be contingent upon the angle of incidence between the tool surface and the particle or asperity of the worked material surface.

Odell (1976:229) cautioned against the use of striations as the only index of interpreting tool function, suggesting that these features actually inform us little about the type of worked material. They may indicate much about the activity and tool motion. In an effort to distinguish between those linear abrasion features associated with tool use from other causes, Keeley (1980:23-24) and Mansur (1982) applied morphological characteristics and size variation to distinguish striations from abrasion tracks. The association of these features with micropolishes was used to identify utilized tools and reconstruct tool functions.

The principle mechanism of striation formation is through the sliding contact between a particle and the tool surface (Lawn and Wilshaw 1975:21). Industrial materials and engineering research in the abrasion and wear of engineered materials has resulted in several models of the development of features associated with sliding

wear under static loading. This research is applicable to the formation of linear abrasion traces such as scratches and striations on stone tools. These models involve the removal of material and the resulting linear deformation (Buckley 1981:469-472; Samuels et al. 1981:13-34).

Striations and other linear surface deformation/damage features can develop under different conditions. The first involves the contact of an abrasive particle against the surface. The result is the development of microchips and plowing of the surface. The surface also becomes abraded. Surface irregularities can also abrade the second contact surface, behaving mechanically much like an embedded particle.

Adhesive wear is the second condition which has been proposed as a cause of striations on stone tools (Del Bene 1979:169). This wear type is the result of the transfer of fragments from the surface of one material to the surface of another. The theoretical model for the development of adhesive wear involves the following sequence.

- (1) A flattening of surface or edge prominences and the development of an interface characterized by a high shear strength.
- (2) Fracture occurs in one of the materials at some location distant from the interface. A fragment is removed from one material and is transferred to the other.
- (3) Detachment of the transferred fragment.

During the development of adhesive wear, two material solids are in contact. There is atomic bonding across the contact interface. As a static load is applied, the possibility of strong bonding occurs even in the presence of some type of lubricant because contact can occur through the lubricating film. Associated with this process is the transfer of material from that which has the weaker cohesive bond to that which has a stronger cohesive bond. Lawrence (1979:169) noted that the model of adhesive wear seems to have some power to explain why occasional instances occur where a softer material produces striations on a harder material.

One of the most important aspects of striations is that they are indicative of tool motion during use. Tasks in which the tool working edge is utilized transversely (scraping, planing, adzing) develop striations perpendicular to the edge-axis. Edges that are used in longitudinal motions (cutting, sawing, shaving) develop striations that are roughly parallel to the edge-axis. Shea (1991:42) observed experimentally that tools used in longitudinal motions in hard materials develop parallel striations when the entire length of the tool edge is in contact equally. Soft materials produce oblique striations when the angle of incidence of the cutting edge and worked material changes during use.

Polishes

Polishes are observed on tool edges and surfaces as changes in the light reflectivity and surface texture between used and non-used tool portions (Shea 1991:42). Microwear research has indicated that variation in polish reflectivity and smoothness can be indicative of specific tool functions and worked materials; especially when considered in conjunction with microscarring (Bamforth 1988; Bamforth et al. 1991; Dockall and Shafer 1993; Keeley 1980; Moss 1983; Odell 1979; Shea 1991; Vaughan 1985). The formation of polish on stone tools has been interpreted to involve mechanical and depositional factors (Del Bene 1979:170-171). Based on polish formation research, several differences can be observed microscopically that allow distinction between mechanical and depositional polishes. Depositional polishes are derived from residues of the worked material transferred to the tool surface. These residues can be either temporary or permanent. Mechanical polishes are produced by the continued abrasion of the tool against the worked material or contact surface (Del Bene 1979:170-171). That polishes can be grouped into the two above formation categories indicates that variables such as worked materials resistance, type and amount of lubrication and abrasives, and tool raw material microstructure are important elements of polish formation.

Experimental programs (Bamforth et al. 1990; Shea 1991) have illustrated the importance of considering the resistance of worked material. During the discussion of striation development it was noted that during the formation of adhesive wear, material from one surface is transferred to another (Del Bene 1979:169). Polishes associated with soft worked materials extend some distance onto the tool surface and are accompanied by extensive abrasion with intensive use. Those associated with harder materials are less invasive onto the tool surface and are usually accompanied by less abrasion but more edge-rounding and flattening (Shea 1991:43-44). The substrate or working surface can also influence the development and appearance of polish. Levi-Sala (1988:95) and Grace (1989:103-105) concluded from experiments that when a soft material is worked on a rigid surface that polish develops in a manner similar to use on hard materials in that it is limited to the tool edge. The working of hard or soft materials on a hard surface concentrates the process of polishing on the higher asperities of the tool surface microtopography. If a soft abrasive or soft working surface is used to work hard or soft materials then both high and low areas of microtopography develop polish (Grace 1989:103-105; Levi-Sala 1988:95).

Keeley (1980:63), Vaughan (1985), and Moss (1983) have noted differences in appearance and reflectivity of polishes associated with different worked materials (such as wood, dry hide, wet hide, meat, bone, antler, other stone, plants). Important properties of these materials that appear to be significant in polish formation and appearance are abrasives and moisture content (either natural or through added lubricants). Levi-Sala (1988) has identified the presence of water as an important agent in polish formation. Water both increased the invasiveness of the polish and the ease at which striations formed in the polish. The water content of various plants also influences the rate of polish development on tools (Unger-Hamilton 1983:246). The longer that plants (einkorn, grass, bulrush, reeds) were stored, the longer the period of tool use to develop polish.

Keeley's (1980:62-63) diffuse field and light field illumination of use polishes noted trends dependent on moisture during tool use. Microwear polish that developed from working greasy hides was less reflective than dry hide polish. Wood polish was even brighter still. Interestingly, Grace (1989:60-61) performed experiments on bone, antler, wood, and hide and discovered that polishes developed more rapidly on bone and antler than on wood and hide. In other words, a certain level of polish was developed on tools used to work these materials with increasing time intervals of polish formation from bone to hide. This suggests a relationship between polish development rate and reflectivity with increasing hardness and decreasing moisture content of the worked material.

The relationship between lubricant, temperature, and wear has been demonstrated in tribological (abrasion) studies (Buckley 1981:522). The net effect is that under a constant load and as the rate of sliding contact is increased, higher temperatures are attained which can be equated with increased friction and wear. Keeley also recognized that the silica content of certain cereal grasses also produced highly reflective polishes (1980:63).

The primary utility of polishes in microwear studies has been toward the recognition of various worked materials (Keeley 1980; Moss 1983; Vaughan 1985; Unger-Hamilton 1988). Debate regarding the diagnostic utility of polishes in microwear analysis continues to question the role of polish in the recognition of worked materials (Bamforth 1988; Bamforth et al. 1990; Grace 1989; Grace et al 1985; Newcomer et al. 1986, 1988). Even so, research does confirm that polishes can be used in conjunction with other aspects of microwear to reconstruct stone tool use and infer worked materials (Bamforth 1988; Bamforth et al. 1990; Hurcombe 1988; Shea 1991).

Summary

The sample selected from Nahr Ibrahim was taken from the North and Central Galleries. The major criteria for sample selection included distal convergence of lateral edges and a generally broader proximal end. Distal convergence could be either a natural attribute of an unaltered flake or due to deliberate retouch. Traditional Middle Paleolithic types of Bordes were employed only during the selection process but were not incorporated into the final analysis because the large comparative dataset of Shea (1991) did not include this data. A major theoretical and practical guiding principle of this study is that lithic technology includes the entire cycle of raw material procurement, stone tool manufacture, use, and discard. Consequently, multiple lines of technological, morphological, and functional investigation are employed to analyze convergent tools from Nahr Ibrahim. Technological attributes include blank shape, blank technology, dorsal scar patterns, dorsal cortex, and striking platform variability. Fracture patterns can provide information regarding manufacture and use of stone tools. The use of fracture patterns (other than impact fractures) in the analysis of convergent tools is not common and has only been attempted sporadically and with limited interpretive success (Holdaway 1989, 1990). The functional analysis employed a spatial recording format developed by Odell (1977, 1979) and later used by Shea (1991). The use of polar coordinates and employed units allows the tool to be discussed as isolated parts or as a whole unit. Use-wear was interpreted within a theoretical framework which included the fracture of brittle solids and tribological (abrasion) theory. Chapter VI provides a detailed analysis and discussion of technological variability of convergent tools from Nahr Ibrahim. Chapter VII incorporates the theoretical understanding of fracture mechanics and use-wear formation to interpret the functional variability of convergent tools from a series of Levantine Mousterian sites and one Zagros Mousterian site.

CHAPTER VI

TECHNOLOGICAL VARIABILITY OF CONVERGENT TOOLS

The purpose of this chapter is to examine the technological variability of convergent tools and blanks from the North and Central Galleries of Nahr Ibrahim. The goals of this analysis are to examine the potential relationships of convergent flake production, implement design and implement function. Experimental and archaeological analysis of debitage has amply demonstrated that variation in an array of technological attributes can be used to identify patterns of formal variability in reduction patterns related to the desired goals of the flintknapper (Ahler 1989; Callahan 1979; Collins 1975; Dockall 1994; Dockall and Shafer 1993; Holmes 1919; Shafer 1973; Shott 1994). The analysis of debitage incorporates a number of inherent assumptions regarding the behavioral information that can be retrieved; otherwise what would be the point of such time-consuming tasks as recording technological and metric data of extensive flake assemblages? Perhaps the most obvious, and yet one of the most elusive to achieve, is that we can, in fact, reconstruct technologically related human behaviors from large collections of flakes. A wide variety of attributes, attribute states, and measurements have been utilized by lithic analysts to identify technological pattern and change and assign behavioral significance to the debitage assemblage (see Shott 1994). According to Dibble (1981:57), "the study of lithic production proceeds on the assumption that not all observed variation is random, but instead that some aspects of it are the result of one variable or two or more variables acting together."

Experimental studies have provided archaeologists with an understanding of the formation of flakes associated with a variety of reduction trajectories and flaking techniques (see Cotterell and Kamminga 1987; Dibble 1985; Dibble and Whittaker 1981; Faulkner 1972; Speth 1971, 1972, 1981). Knowledge of fracture mechanics

and the interrelationships of various attributes enable both the knapper and the analyst to develop behavioral inferences regarding reduction trajectories.

Sample Composition and Condition

Before a discussion of the results of the technological analysis of convergent endproducts at Nahr Ibrahim some comments are necessary on the composition and condition of the sample. Sample composition is a basic enumeration of the technological and traditional Bordes types present within each sample and the abundance of each respective type. The condition of each sample includes basic data on heat alteration, patination, and geological processes. The condition of the samples differed between Central and North Galleries at Nahr Ibrahim. Condition was a limiting factor on both use wear and technology but to varying degrees at the intra- and inter-gallery level of comparison. Implements from the Central Gallery were in much better condition than the majority of the North Gallery material.

Heat damage was a minor post-depositional factor influencing both technological observations and use-wear analysis. The Central and North Galleries of Nahr Ibrahim had virtually identical proportions of unburned pointed convergent tools (81.3 percent and 83.3 percent, respectively). The Central Gallery had a slightly higher proportion of burned tools at 17.3 percent as compared to 11.1 percent in the North Gallery.

Patination of tool surfaces was more intensive and extensive on pieces from the North Gallery at Nahr Ibrahim. A total of 38.8 percent of analyzed tools from the North Gallery were patinated as compared to 18.7 percent from the Central Gallery. In a study of scrapers from the Central Gallery, Panagopolou (1985:103) noted 21.46 percent of her sample as patinated.

The effect of patina as a variable precluding use-wear observation is considered minimal for the Central Gallery with only 8 percent considered as too patinated or dehydrated for this analysis. Panagopolou (1985:103) noted a similar

trend among Central Gallery scrapers. However, for this study, 34.3 percent of the analyzed sample from the North Gallery was too patinated and dehydrated for use-wear analysis. For all samples, specimens not considered satisfactory for use-wear analysis had been sufficiently altered microtopographically such that areas of high and low relief were equally weathered and pitted (in the case of dehydrated specimens). The discrepancy between the North and Central Galleries of Nahr Ibrahim is explained by the in-situ leaching and removal of sediments from the North Gallery (Solecki 1970:122). Solecki also observed that neither tools, debitage, nor bones exhibited any evidence of abrasion that may be suggestive of rapidly flowing water. The sample structure at Nahr Ibrahim is presented in Table 6.1 and provides data for both the North and Central Galleries.

The convergent tool sample from Nahr Ibrahim included technologically variable specimens that served a limited array of functions. Convergent flakes and points were employed as hafted hunting weapons (Figures 6.1-6.3) and exhibit microwear associated with projectile impact and hafting. A majority of specimens were also utilized as hafted and unhafted cutting tools for butchery and light-duty woodworking (Figures 6.4 and 6.5). A smaller number of convergent implements were used in a variety of tasks which required a very pointed tip for drilling or awling (Figure 6.6). Another common use of convergent tools included scraping (Figure 6.7). Scraping wear is associated with a variety of worked materials and includes both hafted and unhafted specimens.

Methods of Blank Production: Central and North Galleries at Nahr Ibrahim

Although there has been no formal technological analysis of core reduction and flake production for Nahr Ibrahim, it is possible to place the Central and North Galleries in a broad technological perspective. Crew's (1975:68-70) analysis of Central Gallery material indicated that core preparation and blank production was highly centripetal. This degree of preparation resulted in the production of Levallois

Table 6.1. Totals of different convergent artifact types from the Central and North Galleries of Nahr Ibrahim.

Tool Type	Central Gallery	North Gallery
Levallois Point	20	16
Retouched Levallois Point	7	9
Pseudo-Levallois Point	3	8
Atypical Levallois Point	2	2
Mousterian Point	6	7
Elongated Mousterian Point	0	4
Converging Flake	10	15
Converging Levallois Flake	2	6
Converging Blade	5	12
Converging Levallois Blade	1	43
Converging Sidescraper	8	4
Double Convex Sidescraper	2	0
Single Convex Sidescraper	4	5
Percoir	0	4
Proximal Fragments	6	5
	75	108

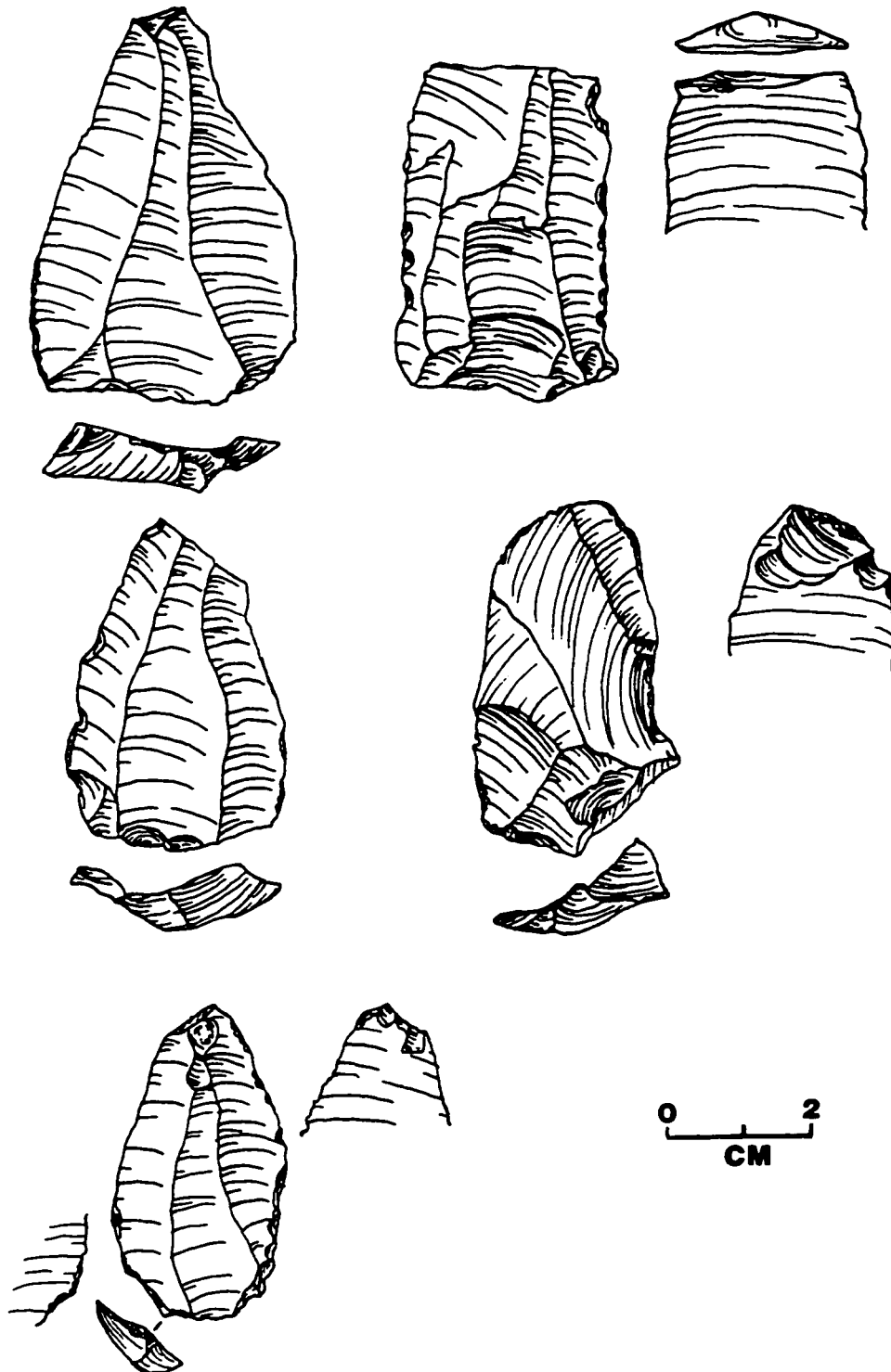


Figure 6.1. Convergent tools from the Central Gallery with impact damage from use as hafted hunting weapons.

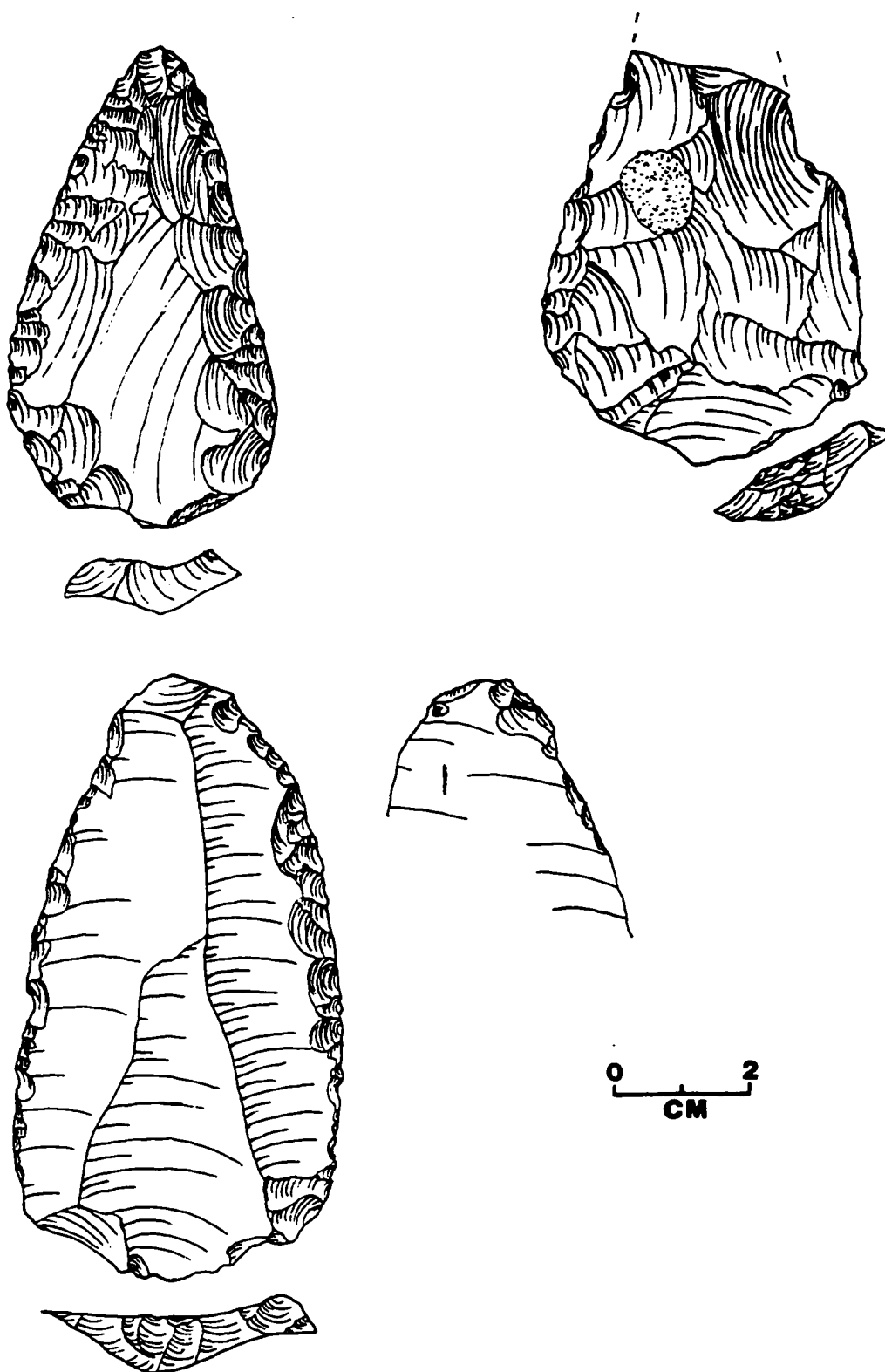


Figure 6.2. Retouched convergent tools from the Central Gallery with impact damage from use as hafted hunting weapons.

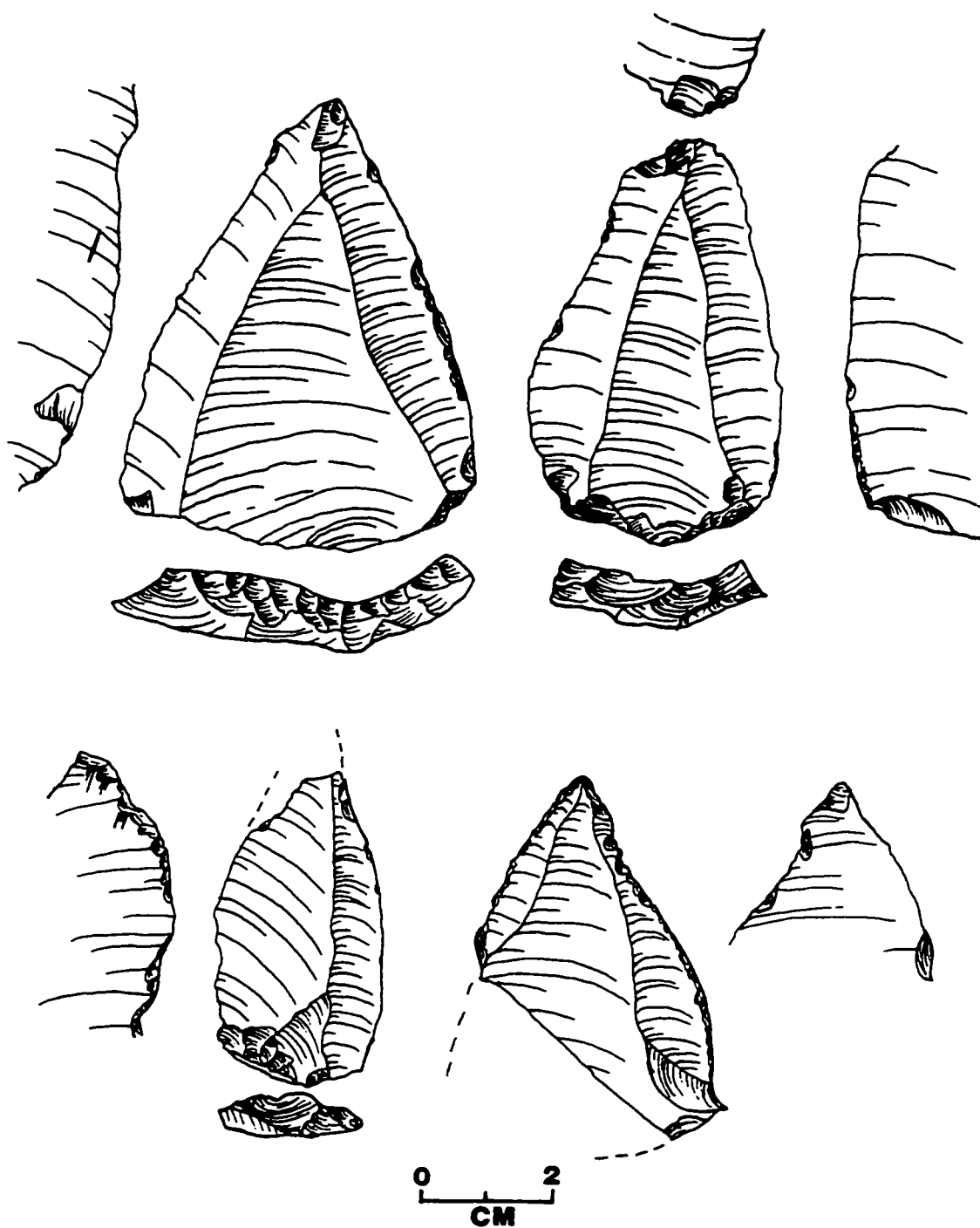


Figure 6.3. Retouched and un-retouched convergent tools from the North Gallery with impact damage from use as hafted hunting weapons.

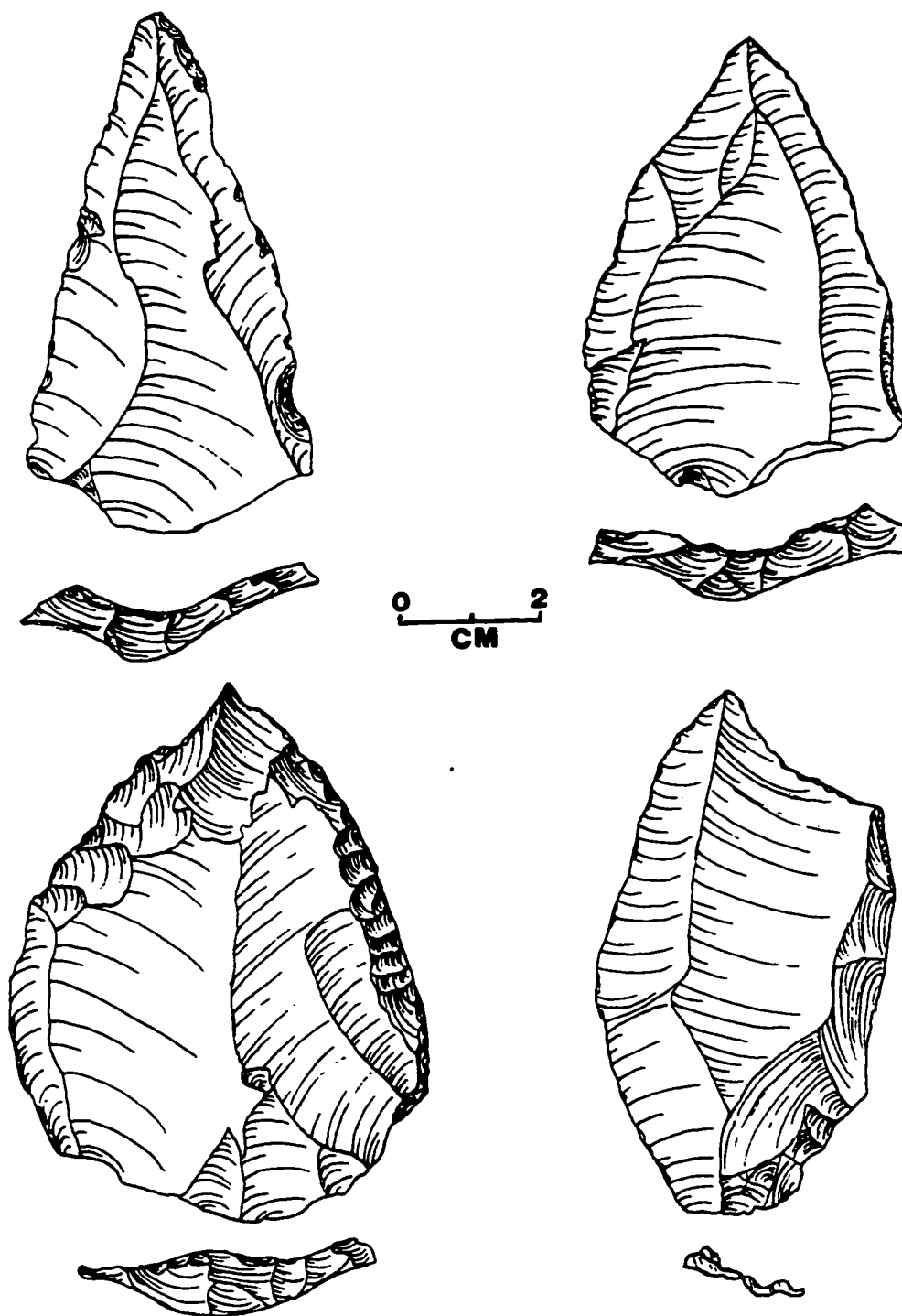


Figure 6.4. Convergent tools from the Central Gallery employed as hafted and unhafted cutting tools.

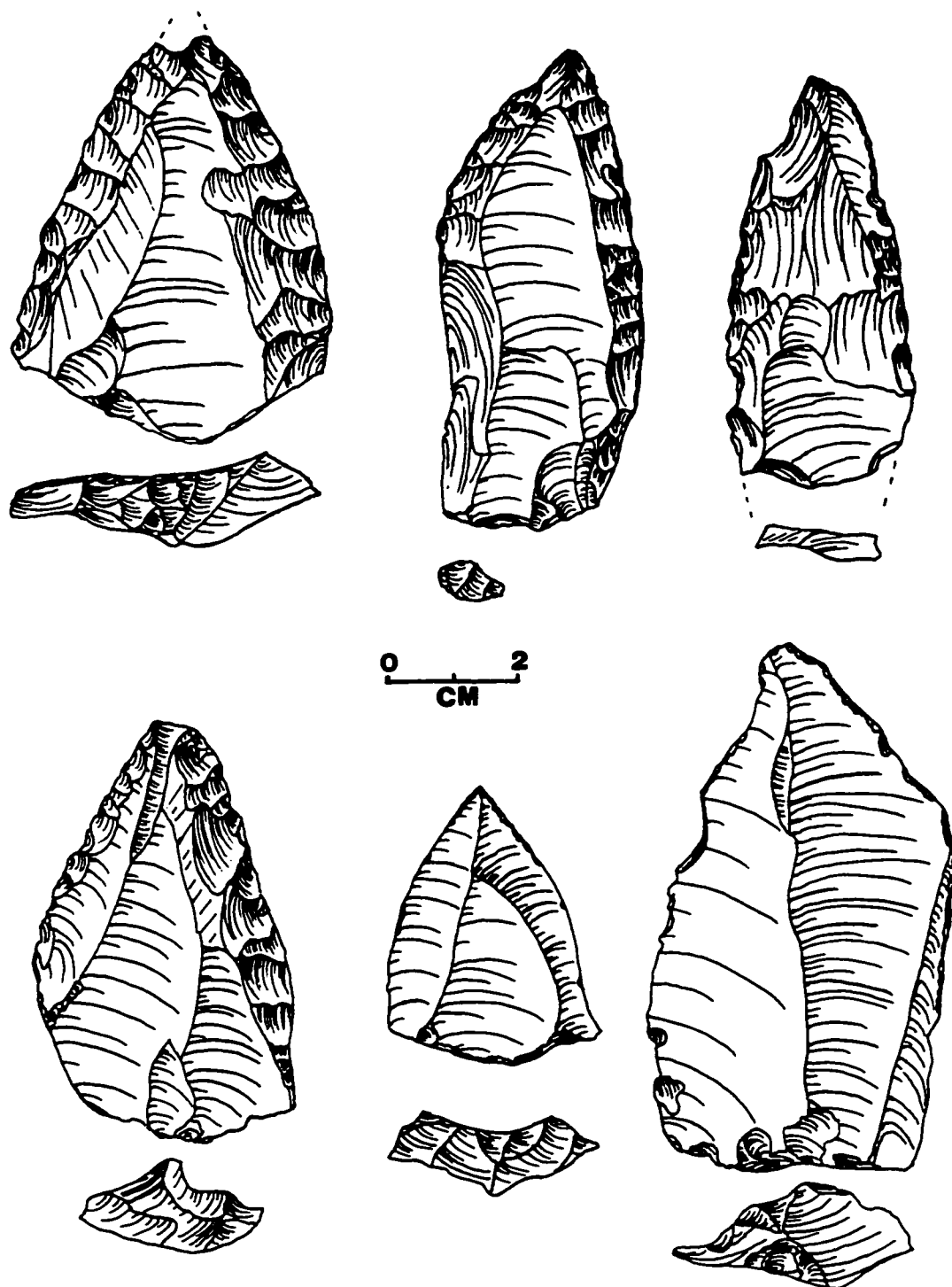


Figure 6.5. Convergent tools from the North Gallery employed as hafted and unhafted cutting tools.

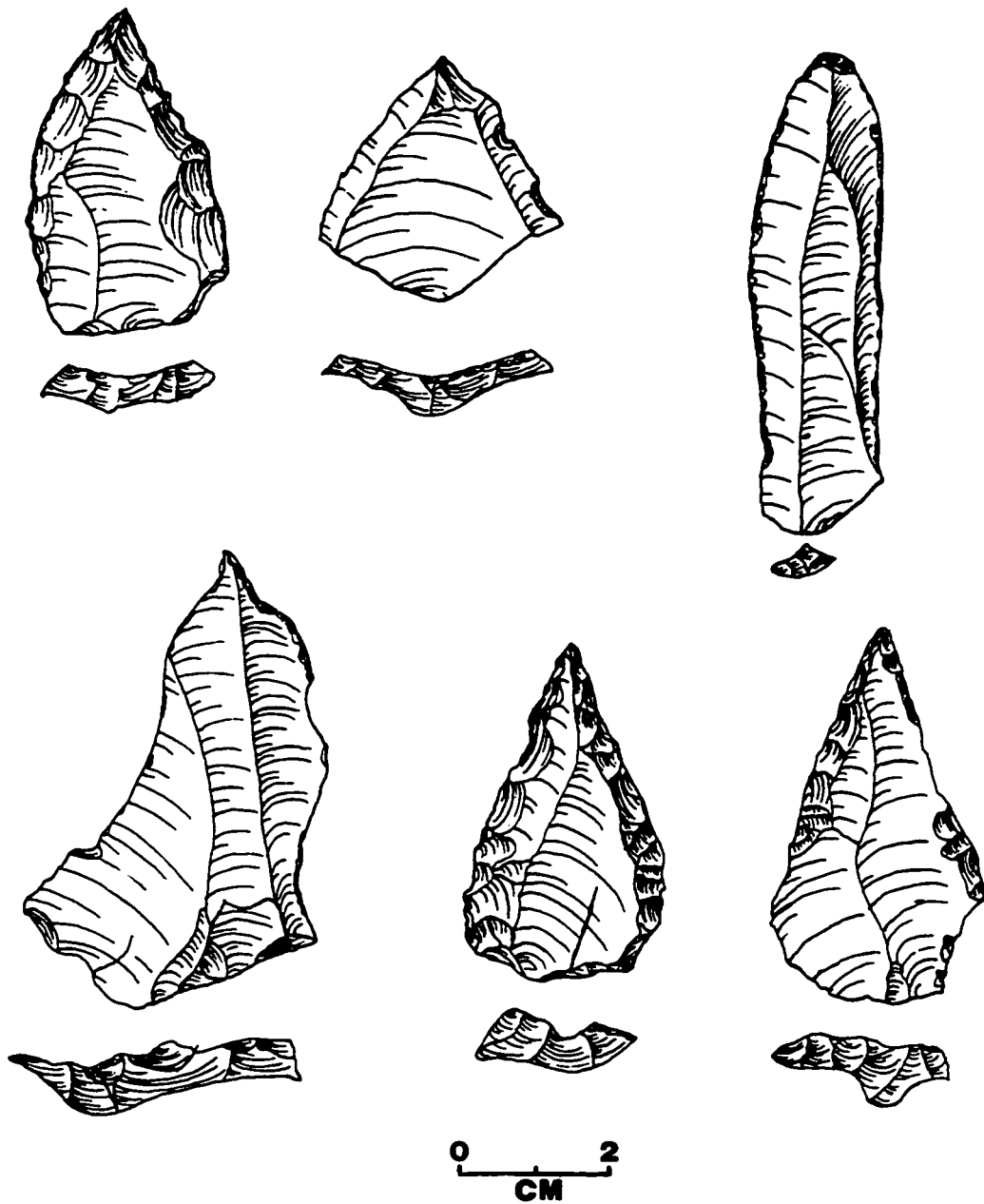


Figure 6.6. Convergent implements from the Central Gallery (top row) and North Gallery (bottom row) employed as drilling, boring, and awling tools.

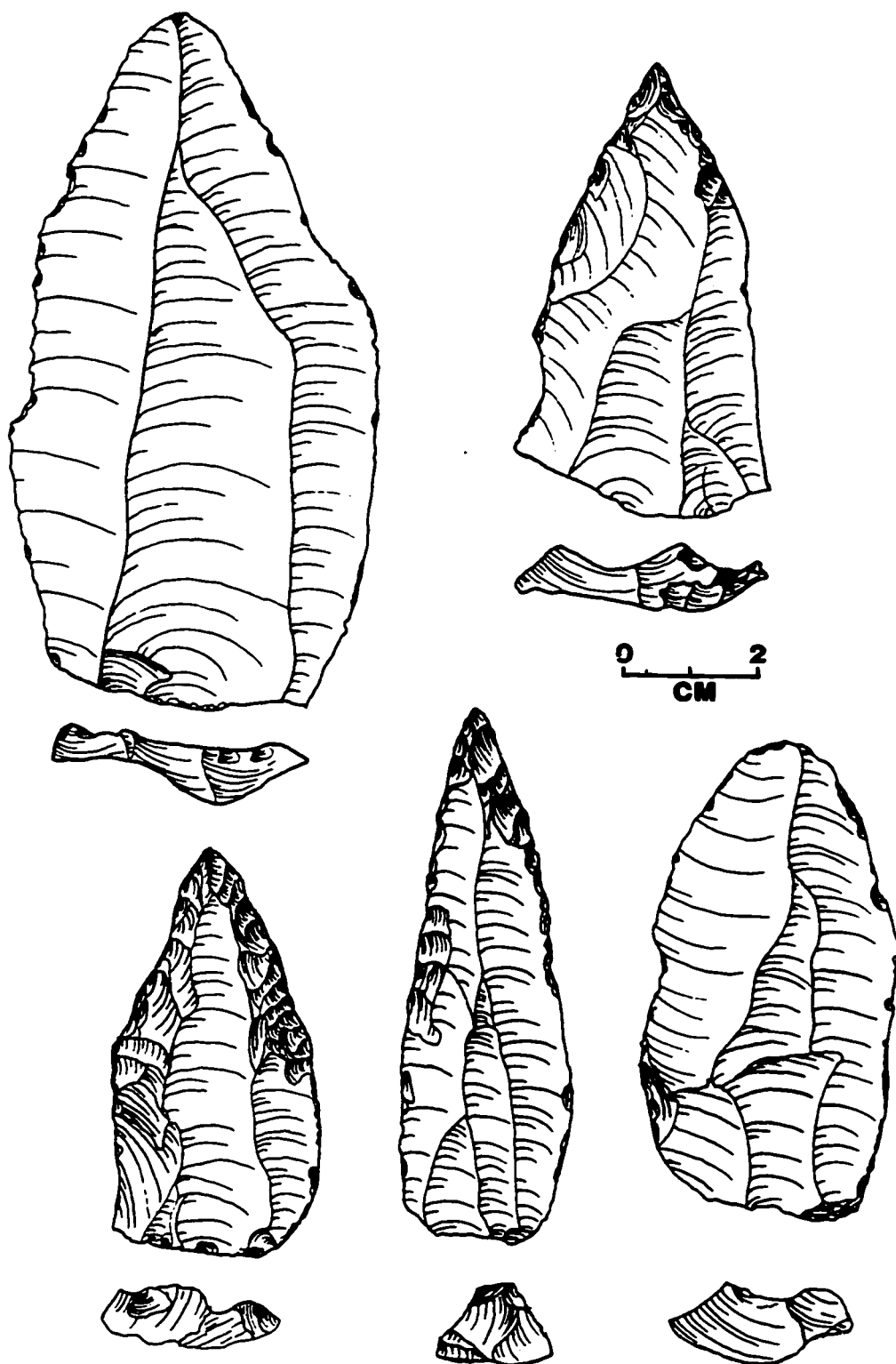


Figure 6.7. Convergent implements from the Central Gallery (top row) and North Gallery (bottom row) employed as hafted and unhafted scraping tools.

flakes with greater width. The noted increase in points from top to bottom (Solecki 1970:120) was not, however, associated with a change in core preparation. Crew also recorded a greater degree of distal preparation on the Central Gallery sample of Levallois points than among any other sample in his study. Other findings included the relative thinness of the Levallois points and the predominance (50 percent) of Pattern C preparation. This method is also the pattern first presented by Bordes (1961:18). Pattern C consists first of the removal of two somewhat convergent flakes or blades from the core flaking surface. This creates a longitudinal ridge along the flaking axis of the core. Next, a triangular flake is then removed along the longitudinal ridge created by the first two convergent removals. This flake represents a first order point prior to the removal of the prepared Levallois point. The effort represented in core preparation, width of Levallois points, and importance of Pattern C preparation led Crew to conclude that the Levallois points were a desired end product with a set of desired attributes.

The lithic material from the North Gallery is currently being analyzed by Katherine Monigal of Southern Methodist University. Her analysis to date has yielded the following preliminary conclusions. The assemblage is Tabun D in character. The cores are small and flat and exhibit radial or convergent unidirectional flake scar patterns. Point production also seems to have not been a significant aspect of North Gallery technology (Katherine Monigal, personal communication 1996).

The attributes of blank technology that are informative of both core preparation and desired flake shape include dorsal scar pattern, dorsal cortex, and platform morphology. Each of these attributes is considered in detail below in terms of Levallois and non-Levallois end-products.

Dorsal Scar Pattern

Van Peer (1992:36-38) has linked the pattern and orientation of dorsal surface scars to the use of transverse and longitudinal ridges as variables of control in flake morphology. These ridges create higher areas of topographic relief on the dorsal surface. During flake removal the most "peripheral" points of the flake edges will be created along the ridges. According to Van Peer (1992:37) the flintknapper achieves efficient control of flake shape by controlling not only the position of dorsal ridges but also their number and degree of incline. The repeated patterns of Levallois product surface preparation that have been observed are evidence of the repeated production of standardized end-products (Van Peer 1995:4). Preparation and morphology of upper and lower core surfaces and the volumetric relationship between these are intrinsically related to the production of standardized end-products (Boëda 1988, 1995; Boëda et al. 1990). Baumler (1988:262) has emphasized that tool blanks represent an original and acceptable core face and striking platform prepared just prior to flake removal.

Dorsal scar pattern and sector preparation data from Nahr Ibrahim is broken down according first to gallery and then Levallois versus non-Levallois end-products. This provides for an immediate comparison between Tabun C and D-type industries from the Central and North Galleries.

The proportion of convergent tools and tool blanks attributable to different scar pattern categories (Table 6.2) essentially corresponds to previous discussions of methods of blank production. Crew (1975) identified the radial/centripetal pattern of dorsal surface preparation most common among Levallois points from the Central Gallery. Among non-Levallois triangular tool blanks, both radial/centripetal and unidirectional convergent were equally represented (Table 6.2). The unidirectional convergent scar pattern is present on 50 percent of all Levallois triangular convergent tools followed by the radial/centripetal pattern at 31 percent. The North Gallery also exhibited both unidirectional convergent and radial/centripetal dorsal scar patterns.

Table 6.2. Percentage of convergent tools per scar pattern category for the Central Gallery of Nahr Ibrahim.

Blank Shape	No.	Dorsal Scar Pattern	Percentage
Non-Levallois Triangular	5	Unidirectional	41.7
	2	Bidirectional	16.6
	5	Radial/Centripetal	41.7
Non-Levallois Blades	2	Unidirectional	28.6
	2	Bidirectional	28.6
	3	Radial/Centripetal	42.8
Levallois Triangular	21	Unidirectional	50.0
	8	Bidirectional	19.0
	13	Radial/Centripetal	31.0
Levallois Blades	1	Bidirectional	50.0
	1	Radial/Centripetal	50.0

The major difference between the North and Central Galleries lies in the proportional representation of these two principal methods of preparation (Table 6.3).

Unidirectional convergent scar patterns are more abundant at 65.7 percent than the radial/centripetal pattern in the North Gallery. Also, 85.8 percent of non-Levallois blades analyzed in this study from the North Gallery exhibit the unidirectional convergent pattern. Among Levallois convergent tool blanks, the unidirectional convergent pattern is again dominant at greater than 70 percent. The Central Gallery is characterized by a greater abundance of the radial/centripetal method than the North Gallery.

Examination of the number of tools exhibiting preparation in each sector demonstrates similar differences between the North and Central Galleries (Table 6.4). Differences can be observed between these galleries in the degree of distal and

Table 6.3. Percentage of convergent tools per scar pattern category for the North Gallery of Nahr Ibrahim.

Blank Shape	No.	Dorsal Scar Pattern	Percentage
Non-Levallois Triangular	23	Unidirectional	65.7
	4	Bidirectional	11.4
	8	Radial/Centripetal	22.9
Non-Levallois Blades	12	Unidirectional	85.8
	1	Bidirectional	7.1
	1	Radial/Centripetal	7.1
Levallois Triangular	26	Unidirectional	78.8
	7	Radial/Centripetal	21.2
Levallois Blades	16	Unidirectional	76.2
	3	Bidirectional	14.3
	2	Radial/Centripetal	9.5

Table 6.4. Percentage of convergent tools with dorsal flake scars per sector for the Central and North Gallery of Nahr Ibrahim.

Blank Shape	Central Gallery				
	No.	Proximal	Right	Distal	Left
Non-Levallois Triangular	12	100	25	33.3	16.7
Non-Levallois Blades	7	100	14.2	42.9	42.9
Triangular Levallois	41	100	24.4	41.5	24.4
Levallois Blades	2	100	50	100	---
North Gallery					
Non-Levallois Triangular	35	100	11.4	17.1	14.3
Non-Levallois Blades	14	100	7.1	7.1	7.1
Levallois Triangular	33	100	9.1	---	18.2
Levallois Blades	21	100	9.5	14.3	---

lateral surface preparation of convergent tool blanks. The most discernible differences pertain to Levallois and non-Levallois triangular end-products from both galleries. Triangular tool blanks from the Central Gallery exhibit greater lateral edge and distal surface preparation. This is in keeping with the greater degree of radial/centripetal dorsal surface preparation of cores from the Central Gallery. From the North Gallery, triangular non-Levallois products also were prepared laterally and distally but these methods are not as common as the Central Gallery. There is no distal surface preparation represented in the sample of Levallois triangular convergent tools from the North Gallery.

Dorsal Cortex Pattern

The abundance and patterning of dorsal cortex provides supporting data for arguments in favor of standardization in Levantine Mousterian tool blank production. Cortex assessment is especially useful when dealing with assemblages having the entire range of lithic debris: cores, debitage, tools, and tool blanks. As emphasized earlier in Chapter V, cortical patterning will vary between different methods of Levallois core reduction. In regard to end-products, the assumption is that, given the degree of core preparation and end-product morphology, the amount of dorsal cortex should be minimal. Of course, we would expect this pattern to vary in relation to the size of the initial raw material and employed reduction strategies.

The proportion of cortex among convergent tools from Near Eastern Middle Paleolithic sites was assessed by Shea (1991) by a percentage estimate of primary = > 50 percent, secondary = < 50 percent, and tertiary = no cortex. The same scale was used in this study. These estimates of cortex provide a gross estimate of the influence or importance of cortex in blank production and selection for convergent tools. Cortex free blanks dominate the subsample of convergent tools from every site analyzed by Shea, as well as both North and Central Galleries at Nahr Ibrahim. The methodology provides a somewhat conservative estimate of

cortex on convergent tools because it is limited to complete tools for which cortex estimates could be accurately assessed. It does not include fragments. Shanidar Cave is not included due to the greater abundance of heavily retouched specimens. The only aberrant sample (Table 6.5) is Qafzeh XV where 69.1 percent of all convergent tools are non-cortical. This is compared to the other assemblages in which greater than 80 percent of all convergent tools are non-cortical. Some Middle Paleolithic implements can be considered as backed knives due to the presence of natural cortex along one edge. In these cases the position and amount of dorsal cortex reflect deliberate design decisions on the part of the flintknapper. However, no convergent tools exhibited this patterning.

The data in Table 6.5 tends to support the assumption that cortex was not a desired element of convergent tools and tool blanks for the Levantine Mousterian. This is applicable to both Levallois and non-Levallois products. By extrapolation, this could be applied as a concept to convergent tool design in situations in which raw material occurs in both abundance and sizes suitable for this type of selective behavior. There is indication based on Shea's (1991:230-231) research that the presence of cortex on tool blanks is linked to both function and curation behaviors. Shea noted that complete interior flakes were more frequently employed than cortical flakes in tasks usually occurring at a distance from the habitation site: animal hunting and butchery and other extractive tasks. Cortex-bearing flakes and flake fragments were more frequently employed in such fixed locus tasks as woodworking and hide-processing.

At the Middle Paleolithic site of Zobiste, Yugoslavia, Baumler (1988) noted that, even though 58 percent of all flake tools had no cortex, natural cortex backing was a desired attribute of many of the tool blanks. Also, 59 percent of all complete flakes placed within a category of "naturally backed knife" had use-damage or retouch.

Table 6.5. Proportion of convergent tools with dorsal cortex from selected Levantine Mousterian sites. All data except Nahr Ibrahim calculated from Shea (1991).

Site/Assemblage	Cortex		Non-Cortex	
	No.	Percent	No.	Percent
Hayonim E	4	5.8	59	85.8
Kebara X	16	7.7	187	89.9
Kebara IX	---	---	15	83.3
Kebara XD	4	10	34	85
Kebara XI	7	7	91	91
Kebara XII	---	---	28	100
Kebara XIII	---	---	3	---
Nahr Ibrahim, Central Gallery	6	9	57	85
Nahr Ibrahim, North Gallery	7	9.6	66	90.4
Qafzeh XIX	---	---	1	---
Qafzeh XV	12	12.4	67	69.1
Qafzeh XVII	3	---	3	---
Qafzeh XVIII	3	---	2	---
Tabun IB	---	---	5	---
Tabun IC	2	---	8	---
Tabun II	1	---	9	---
Tabun IX	5	9.0	49	87.5
Tor Faraj C	1	3.7	21	77.8

Even with the apparent importance of cortex as an attribute of backed knives employed in various maintenance-level tasks in certain Middle Paleolithic assemblages, Panagopolou (1985:104) has suggested that non-cortex Levallois flake blanks were selected at the Central Gallery of Nahr Ibrahim for sidescraper manufacture. She has argued that blanks produced by the Levallois technique were selected over cortex-bearing flakes. Broken Levallois flakes were even selected for manufacture of transverse scrapers indicative of a certain degree of economizing behavior of blanks produced by this technique. This selection for Levallois blanks seems to have been in operation at Nahr Ibrahim in spite of the fixed nature of tasks associated with sidescrapers and an abundance of suitable local raw material.

Cortex patterns at the North and Central Galleries of Nahr Ibrahim suggest a strong selection for both Levallois and non-Levallois cortex-free blanks for convergent tools. Only 9 percent of all convergent blanks from the Central Gallery and 9.6 percent from the North Gallery exhibit any dorsal cortex. All cortex-bearing convergent blanks from the Central Gallery are non-Levallois and only two from the North Gallery were Levallois blanks.

Platform Technology and Platform Modification

Surprisingly, Middle Paleolithic industries have been identified by some researchers as representing an expedient technology (Binford 1979, 1984, 1985, 1986, 1989) lacking planning depth and organization. Typically, the technology and morphology of core platform preparation has served as an indirect measure of expedient versus prepared core technologies, and by extension, a measure of foresight and planning (see Parry and Kelly 1987). One reason for this rather slanted view of core reduction has been the assumption that particular flake morphologies were the goal of the flintknapper (Baumler 1995:17). This view of core reduction leads the analyst to classify cores according to various flake types and masks the true dynamic of core reduction. So too, there has been the unfortunate association of the

terms “prepared”, “standardized”, and “predetermined” with strictly modern patterns of behavior. Such are the problems with the concept of the *chaîne opératoire* (Chase 1993 and Chapter I).

Certainly there is evidence for tool blank standardization in the Levantine Mousterian as evidenced by particular flake morphologies: oval, point, blade. That these were desired end-products and possess a discrete series of desired attributes is supported by the functional data (Shea 1989a, 1989b, 1991, 1993, 1995a, 1995b). Platform technology is a crucial variable for addressing tool blank production and uniformity (Dibble 1981; Dibble and Whittaker 1981).

Nahr Ibrahim, Lebanon

There are some interesting and significant differences in platform technology between the Central and North Galleries. These differences are linked to the greater degree of radial/centripetal core reduction in the Central Gallery and unidirectional reduction in the North Gallery (Table 6.6).

Both galleries exhibit a majority of various faceted platform types, especially among convergent tools with Levallois technology. Cortical and partial cortical platforms are virtually non-existent in either gallery. Multi-facet and triangular multi-facet platforms (triangular in plan view) are common in the Central Gallery at 26 percent of all Levallois convergent tools and 26.7 percent of all convergent tools in the Central Gallery sample. These values are even higher in the North Gallery being 56.8 percent of all Levallois convergent tools and 44.1 percent of all convergent tools in the North Gallery. The classic *chapeau de gendarme* platform is limited exclusively to Levallois products from both galleries: 56 percent in the Central Gallery and 31 percent in the North Gallery. Among sidescrapers from the Central Gallery, Panagopolou (1985:104-105) noted that the *chapeau de gendarme* represented 21.42 percent of all platform types in her sample. These values for the current study are 37.4 percent for the Central Gallery and 16.3 percent for the North

Table 6.6. Platform technology observed on Levallois and non-Levallois convergent tools from the North and Central Galleries at Nahr Ibrahim. Values equal number/percent.

Platform Technology	Central Gallery, Nahr Ibrahim	
	Levallois Convergent Tools	Non-Levallois Convergent Tools
Plain	2/2.7	7/9.3
Dihedral	3/4	3/4
Multiple Facet	8/10.7	6/8
Triang. Mult. Facet	---	1/1.3
Chapeau de gendarme	5/6.7	---
Partial Cortical	28/37.4	1/1.3
Dorsal Trimming	---	1/1.3
Dorso-Ventral Trim.	1/1.3	1/1.3
Crushed	2/2.7	2/2.7
Absent	---	3/4
Partial	1/1.3	---
	North Gallery, Nahr Ibrahim	
Plain	---	17/15.3
Dihedral	3/2.7	9/8.1
Multiple Facet	30/27	15/13.5
Triang. Mult. Facet	3/2.7	1/0.9
Chapeau de gendarme	18/16.3	---
Dihedral w/Trans.	1/0.9	1/0.9
Partial Cortical	---	2/1.8
Dorsal Trimming	---	1/0.9
Ventral Trimming	---	1/0.9
Dorso-Ventral Trim.	---	1/0.9
Crushed	1/0.9	2/1.8
Absent	1/0.9	1/0.9
Partial	1/0.9	1/0.9
Lipped/softhammer	---	1/0.9

Gallery. Table 6.6 also provides data pertaining to other minor variations in platform morphology between the Central and North Gallery.

Shanidar Cave, Iraq

Platform technology at Shanidar Cave, Iraq has been discussed in detail by Solecki and Solecki (1993). Their analysis indicated that the majority of platform types for pointed tools were plain and faceted at 21.2 percent and 33.1 percent, respectively. Cortex platforms are rare being only 1.3 percent of their entire pointed tool sample. The lack of cortical platforms among pointed tools is correlated with the use of a discoid core technique in which thick pointed flakes are produced (see Solecki and Solecki 1993:129). This is also related to the presence of so many retouched points at Shanidar. The Levallois technique could not be commonly applied to the small-size raw material to produce prepared flakes of a standardized shape. Trimming was conducted to produce a flake tool of the desired convergent morphology in lieu of special pre-preparation of the core to produce flakes of a desired shape.

Post-Removal Striking Platform Modification

Patterns of post-removal platform modification include breakage (manufacture or use), dorsal or ventral trimming, or dorso-ventral trimming. Previous studies of convergent tools from Middle Paleolithic and Middle Stone Age assemblages have suggested that the presence of proximal retouch and bulbar thinning has been to provide purchase for hafting (Mellars 1996:113; Singer and Wymer 1982:67; Solecki and Solecki 1970:137). Research also suggests that proximal thinning is not always a necessary indicator of hafting (Anderson-Gerfaud 1990:407-408; Beyries 1988; Shea 1995b:285-286). The total proportion of convergent implements from the Central Gallery, Nahr Ibrahim exhibiting secondary proximal retouch is 3.9 percent. One Levallois and non-Levallois blank were each dorso-ventrally modified by percussion.

A single non-Levallois convergent tool exhibits dorsal trimming. Only 2.7 percent of all North Gallery convergent tools were proximally modified. These include one each of dorsal, ventral, and dorso-ventral modification: all are non-Levallois convergent implements. At Shanidar Cave, 9.1 percent of all pointed tools were proximally modified. The majority of specimens modified from Shanidar (73.5 percent) were identified as various types of Mousterian points (Solecki and Solecki 1993).

It is significant to note that Panagopolou (1985:105) identified proximal platform modification on 26.2 percent (n=44) of her sample of sidescrapers from the Central Gallery at Nahr Ibrahim. She interpreted this proximal modification as preparation for hand prehension or hafting. Based upon microwear and metric analysis of these implements, Panagopolou (1985:172-173) argued that the majority were hand-held and not hafted. This provides some additional support for considering post-removal platform modification in conjunction with other lines of evidence (functional, metric, morphological) before the development of behavioral inferences related to stone tool technology and function.

Metric Variation Among Convergent Tools

The purpose of the metric analysis was to provide data pertaining to tool size for all samples as well as between Levallois and non-Levallois technology. The analysis of metric data is facilitated by the use of a series of standard indices employed in studies of Middle Paleolithic debitage. A set of descriptive statistics and statistical tests are also used to interpret metric variation.

Table 6.7 provides information on values of various indices for Nahr Ibrahim. These indices are broken down according to Levallois and non-Levallois tools. An examination of the length/width (L/W) index for all sites provides an indication of lamellarity of the tool blanks. In general, this index is higher for non-Levallois convergent tools at Nahr Ibrahim (except for the North Gallery). The higher values

Table 6.7. Metric indices for Levallois and non-Levallois tools from Nahr Ibrahim.

Nahr Ibrahim Central Gallery			
Index	Levallois	Non-Levallois	Difference
L/W	1.75	2.22	-.47
L/Th	9.11	7.47	1.64
W/Th	5.19	3.36	1.83
Size (LxWxTh/1000)	14.94	16.49	-1.55
Nahr Ibrahim North Gallery			
Index	Levallois	Non-Levallois	Difference
L/W	2.04	1.95	.09
L/Th	9.77	8.42	2.35
W/Th	4.77	4.30	0.47
Size (LxWxTh/1000)	12.41	12.02	.39

are influenced by the selection of elongate core surface preparation flakes for some tools and the greater variation in length of non-Levallois specimens. Levallois convergent tools from the Central Gallery of Nahr Ibrahim are broader and shorter than non-Levallois convergent tools (Tables 6.7 and 6.8). The L/W indices of Levallois and non-Levallois convergent tools from the North Gallery at Nahr Ibrahim indicate the production and use of more laminar tool blanks.

Length/Thickness (L/T) index values provide an understanding of the influence of these dimensions upon tool size. Higher values are associated with longer and thinner flakes while lower values are thicker in relation to overall length. L/T indices are higher for Levallois convergent tools from the North and Central Galleries at Nahr Ibrahim. Levallois blanks are thinner in relation to length than non-Levallois convergent tools which are thicker (Table 6.7). Thinner Levallois blanks are related to the efficiency of this technique and special platform preparation for controlling flake thickness.

Width/Thickness (W/T) indices portray the influence of these two dimensions upon tool size. Higher index values are indicative of wider and thinner flake dimensions. Again, for all samples, W/T values are higher for Levallois convergent tools than those of non-Levallois technology (Table 6.7). Non-Levallois convergent tools are greater in thickness for a given width than similar Levallois tools. This points to the use of the Levallois technique to produce flakes that are wide while controlling flake thickness.

The size index provides a measure of the overall size of a tool in three-dimensions. This index for the Central Gallery at Nahr Ibrahim is higher for non-Levallois convergent tools (Table 6.7). Levallois tools from the North Gallery at Nahr Ibrahim trend only slightly larger than non-Levallois tools.

Table 6.7 also provides data on the difference between these indices for Levallois and non-Levallois convergent tools. Most significant for our discussion is the greater similarity of index values for North Gallery specimens. These values are

influenced by the selection of elongate core surface preparation flakes for some tools and the greater variation in length of non-Levallois specimens. Levallois convergent tools from the Central Gallery of Nahr Ibrahim are broader and shorter than non-Levallois convergent tools (Tables 6.7 and 6.8). The L/W indices of Levallois and non-Levallois convergent tools from the North Gallery at Nahr Ibrahim indicate the production and use of more laminar tool blanks.

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Table 6.7 also provides data on the difference between these indices for Levallois and non-Levallois convergent tools. Most significant for our discussion is the greater similarity of index values for North Gallery specimens. These values

Table 6.8. Metric variability of convergent tools from the Central and North Galleries of Nahr Ibrahim, Lebanon.

Central Gallery	Levallois Convergent Tools					Non-Levallois Convergent Tools				
	Measurement	No.	Mean	Std. Dev.	Variance	No.	Mean	Std. Dev.	Variance	T
Levallois Convergent Tools	Length	38	62.06	15.05	226.42	19	64.98	14.57	212.37	-0.74
	Width	41	35.36	9.07	82.32	21	29.22	8.43	71.09	2.82
	Thickness	41	6.81	2.18	4.77	21	8.69	6.44	41.47	-1.88
	Weight	39	23.15	15.08	227.39	19	19.27	12.24	149.72	1.03
	Exterior Angle	47	84.45	8.91	79.31	19	82.84	9.87	97.40	0.66
Non-Levallois Convergent Tools	Interior Angle	47	96.34	9.70	94.05	20	98.10	8.90	79.19	-0.70
	Plat. Thick.	46	7.23	2.63	6.90	17	7.44	3.01	9.04	-0.29
	North Gallery	No.	Mean	Std. Dev.	Variance	No.	Mean	Std. Dev.	Variance	T
	Length	49	62.84	13.75	189.13	50	58.31	13.14	172.62	0.62
	Width	52	30.73	8.01	64.18	51	29.81	6.92	47.94	0.87
Central Gallery	Thickness	52	6.43	1.69	2.85	51	6.92	1.52	2.32	-2.22
	Weight	49	17.19	9.23	85.13	50	15.80	8.30	68.88	0.79
	Exterior Angle	56	84.34	7.42	55.12	48	81.81	9.50	90.19	0.95
	Interior Angle	56	99.77	7.05	49.64	47	101.34	9.68	93.71	-1.09
	Plat. Thick.	57	7.23	2.41	5.82	48	7.99	2.83	8.03	-1.68

support the inference that there is little variability in size between Levallois and non-Levallois pointed tools from the North Gallery.

The results of these indices indicate that there is some level of difference between Levallois and non-Levallois convergent tools. In order to test the significance or strength of these indices as size indicators, the standard deviation and variance were computed for each measurement. In addition, a series of fourteen Student's T tests were computed for all metric and non-metric measurements (Table 6.8). All T-tests were evaluated at a .01 confidence interval to reduce the chance of making a Type I error (that the null hypothesis is falsely rejected). The chance of making a Type I error for 21 T-tests is .2. The null hypothesis tested is that there are no significant differences among metric measurements and platform angles between Levallois and non-Levallois convergent tools. At a .01 confidence interval, none of the T-tests conducted for Nahr Ibrahim were significant.

At this level of analysis the standard deviation and variance indicate considerable within-group variability. The only dimensions that show little variability are thickness and striking platform thickness. It is not surprising that the dimension of thickness and striking platform thickness are not as variable as other measurements given the narrow margin for variability inherent in these measures. Thickness dimensions are not considered as strongly diagnostic in this study given the selective pressures that resulted in each flake being selected for use. Tables 6.7 and 6.8 do illustrate a consistent narrower range of variability for Levallois convergent tools for thickness and striking platform thickness, but again the pattern is not statistically significant. The results do however correlate with experimental and analytical results from Tabun regarding thickness control during application of the Levallois technique (Dibble 1981).

It is felt that the selection criteria associated with convergent tools were operating to dampen any significant differences between Levallois and non-Levallois flakes. Selection criteria included overall flake convergence, suitable thickness, and

sufficient size (inclusive of length, width, and thickness). Flakes, whether produced by Levallois or another technique would have to meet the same minimum tool design criteria to be selected for use. Size and shape constraints for convergent tools would produce an assemblage of tools with a high degree of homogeneity within each site group that can be isolated as a distinct tool class composed of flake blanks produced by a variety of techniques.

Additionally, a series of graphs also illustrates the absence of significant variability between Levallois and non-Levallois convergent tool blanks from Nahr Ibrahim. The logarithm plots, regression lines, and associated R-square values support previous statistical tests which suggested that there are no significant differences. R-square values associated with each graph indicate that little of the observed variability can be based upon differences that can be attributed to technological variability between Levallois and non-Levallois specimens. It is suggested here that the homogeneity and overlap between groups is the result of the application of a uniform set of criteria for selection of convergent tool blanks. The result is that any significant technological variability is masked or greatly dampened when examining a sample of culturally selected items that served a narrow range of identical tool functions. The technological origin of the tool blank becomes less important than the actual functional and morphological attributes that make the flake a suitable candidate for tool use.

Regarding the scatterplots of length and width (Figures 6.8 and 6.9), Central Gallery convergent tools have a trend of increasing length with an increase in width becoming somewhat greater for Levallois specimens. There is no good separation of Levallois and non-Levallois for the North Gallery but rather a loosely packed clustering.

Width and thickness (Figures 6.10 and 6.11) reveal similar patterns. Nahr Ibrahim, Central Gallery non-Levallois implements exhibit greater thickness with increasing width than Levallois convergent tools. This suggests that the Levallois

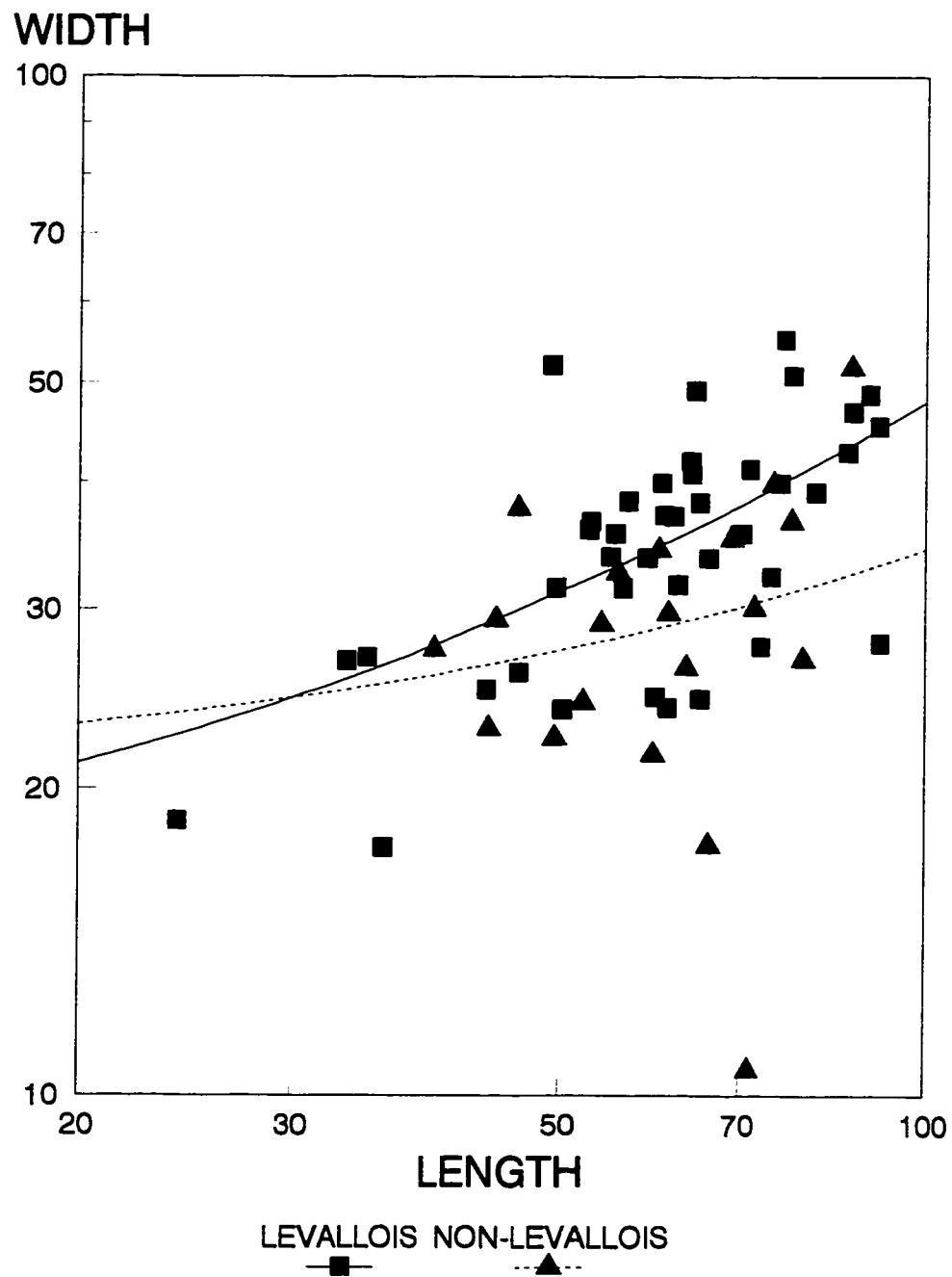


Figure 6.8. Log plot of length and width of convergent tools from the Central Gallery of Nahr Ibrahim.

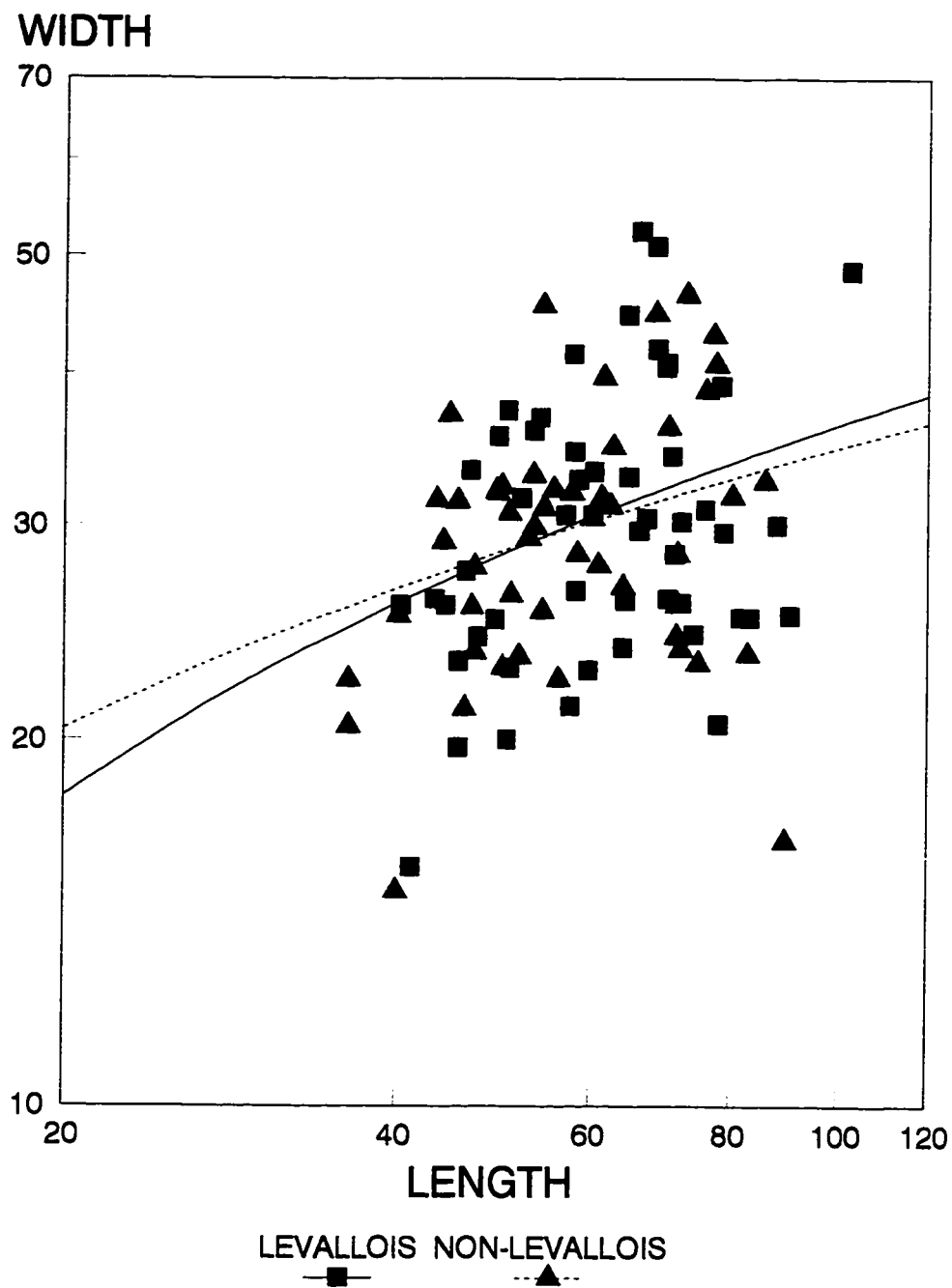


Figure 6.9. Log plot of length and width of convergent tools from the North Gallery of Nahr Ibrahim.

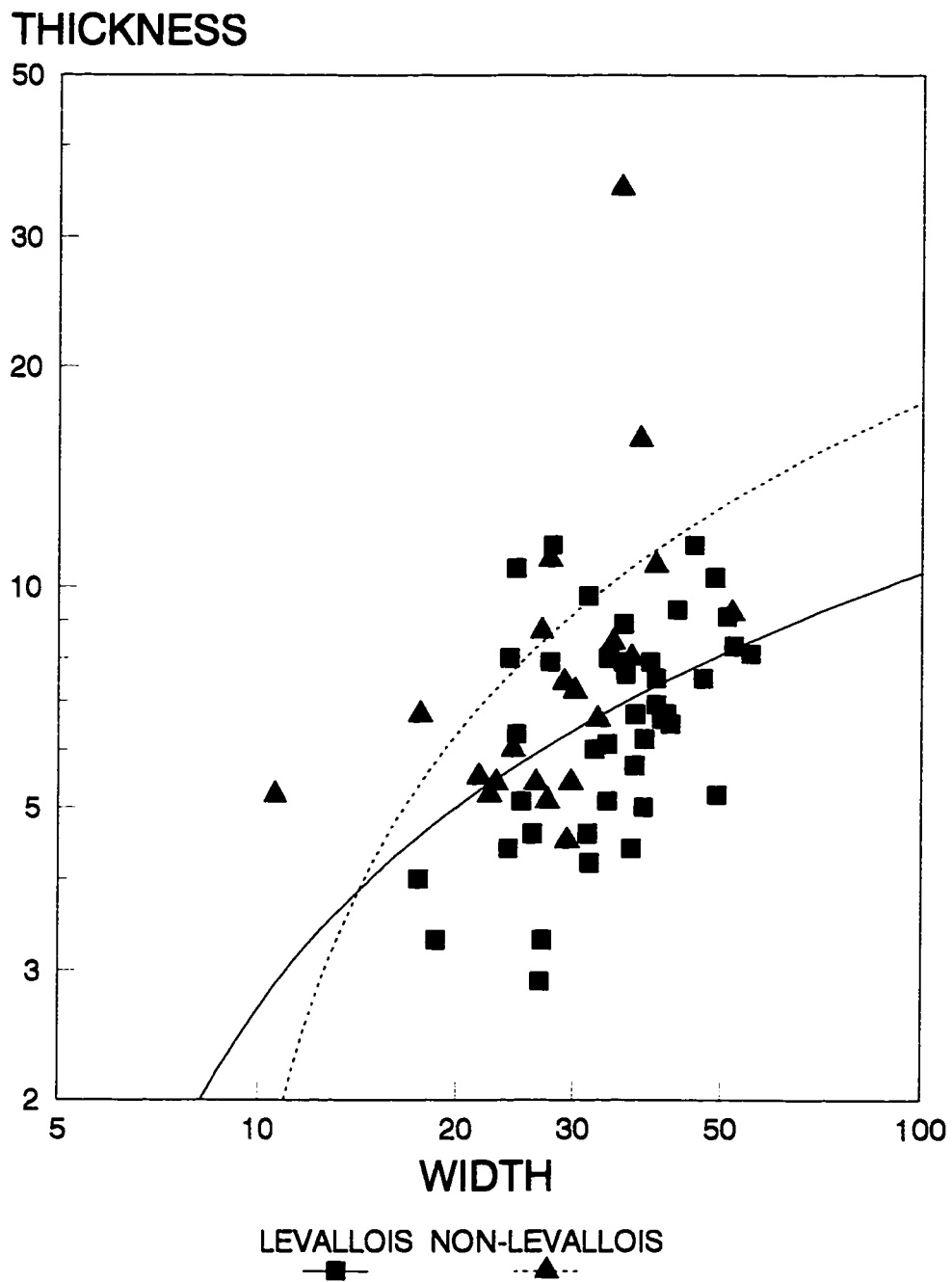


Figure 6.10. Log plot of width and thickness of convergent tools from the Central Gallery of Nahr Ibrahim.

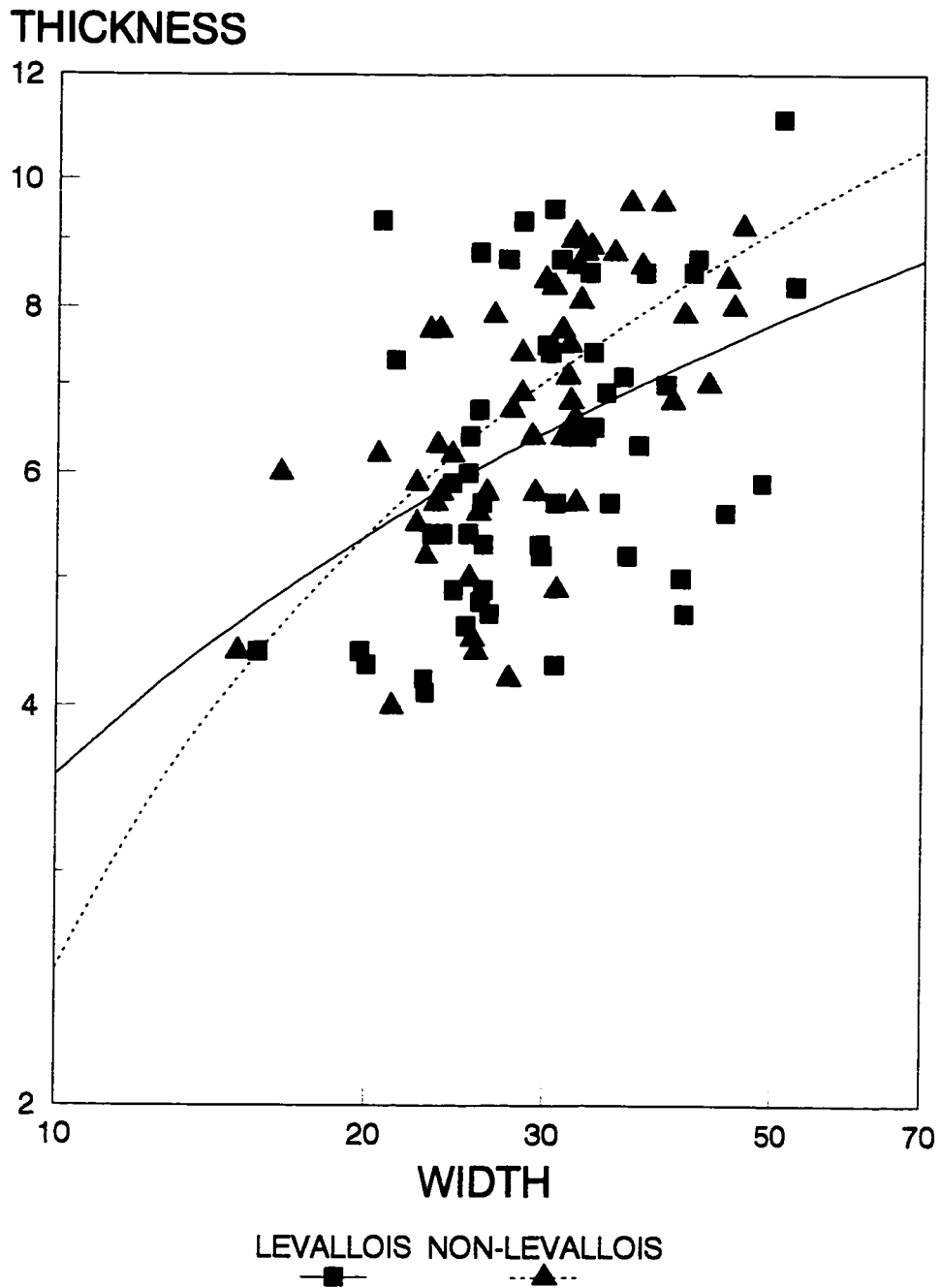


Figure 6.11. Log plot of width and thickness of convergent tools from the North Gallery of Nahr Ibrahim.

technique is efficient in producing convergent flakes with a greater basal width with no significant increase in thickness that would hinder hafting or necessitate basal thinning. The North Gallery displays a similar pattern as the Central Gallery but not as strong. Neither pattern from the Central or North Gallery is statistically significant but the difference between Levallois and non-Levallois may be more apparent in a larger sample composed of debitage.

The length and thickness scatterplot (Figures 6.12) for the Central Gallery of Nahr Ibrahim exhibit an easily recognizable pattern of increasing thickness with increasing length, but the trend is for non-Levallois blanks to be thicker compared to Levallois specimens of similar thickness (again, however, note the overlap between groups). As with the comparison of length and width, there is an advantage in using the Levallois technique to maintain greater control of flake thickness during the production of longer convergent tool blanks. The North Gallery of Nahr Ibrahim yields a pattern similar to the Central Gallery (Figure 6.13).

Dibble (1981:62) noted that there was a strong negative correlation between interior and exterior striking platform angle (henceforth, IPA versus EPA) for experimentally produced flakes such that with increased EPA there was a corresponding decrease in IPA. Dibble further noted that the attributes of length and thickness are also correlated with exterior platform angle. EPA and IPA were examined for each group of convergent tools from Nahr Ibrahim to observe this phenomenon in an archaeological setting (Figures 6.14 and 6.15) controlling for artifact type. A scatterplot of exterior and interior platform angle for the Central Gallery of Nahr Ibrahim (Figure 6.14) supports Dibble's experimental observation of a decrease in IPA with an increase in EPA. Regression lines for both Levallois and non-Levallois specimens follow the same path and there is only slight overlap between the plots for each group. The relationship between IPA and EPA of convergent tools from the North Gallery (Figure 6.15) is not as easily discerned.

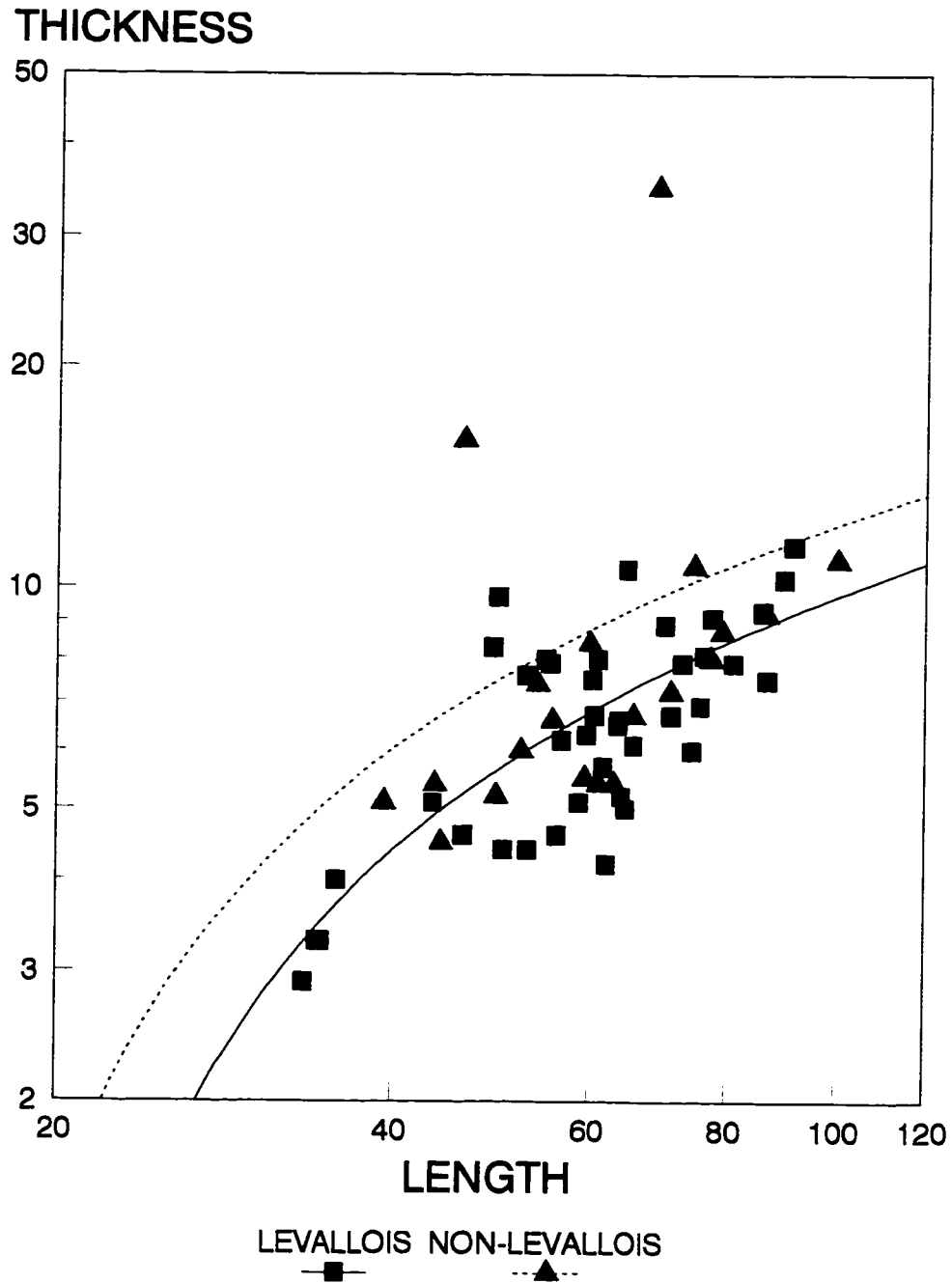


Figure 6.12. Log plot of length and thickness of convergent tools from the Central Gallery of Nahr Ibrahim.

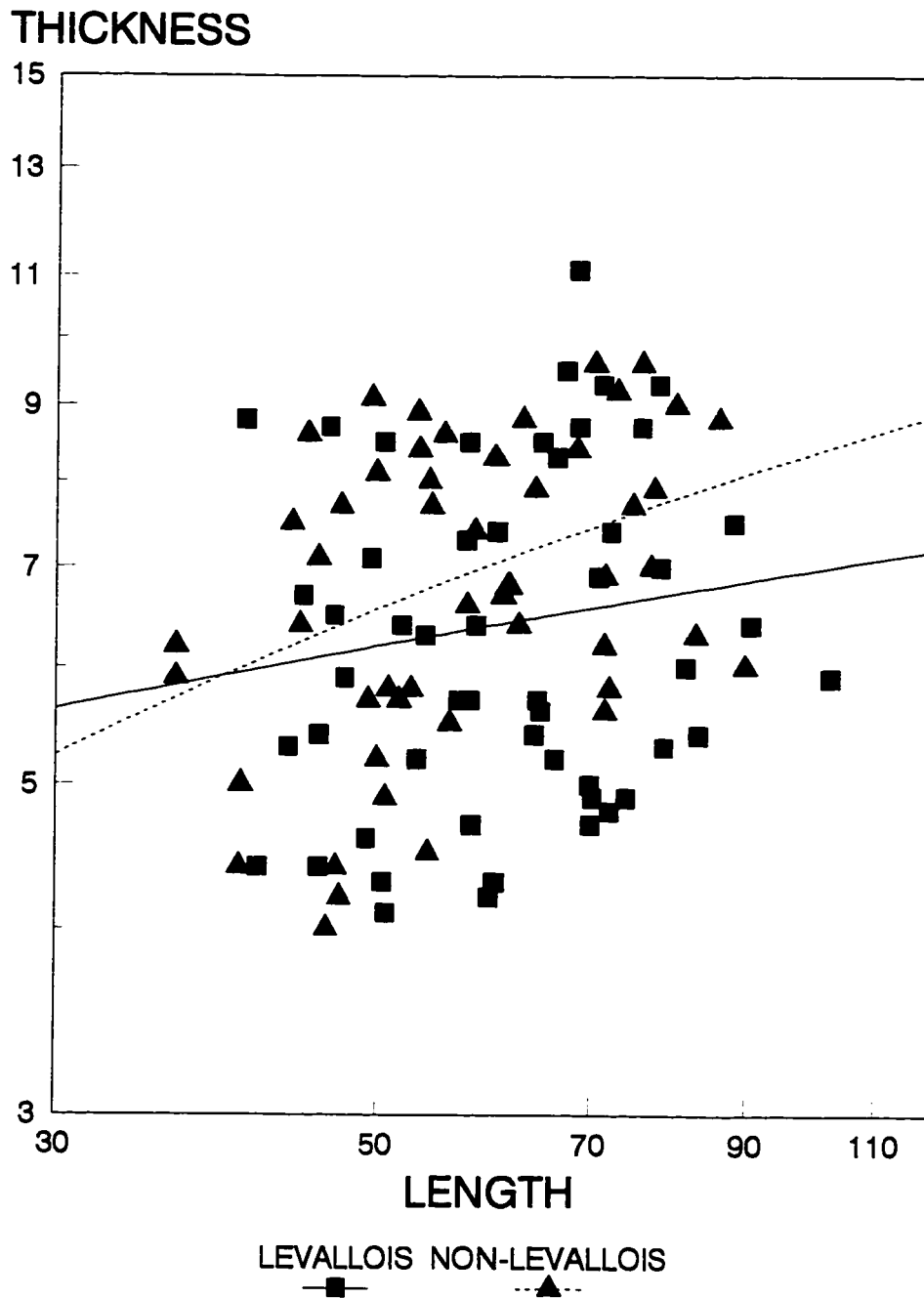


Figure 6.13. Log plot of length and thickness of convergent tools from the North Gallery of Nahr Ibrahim.

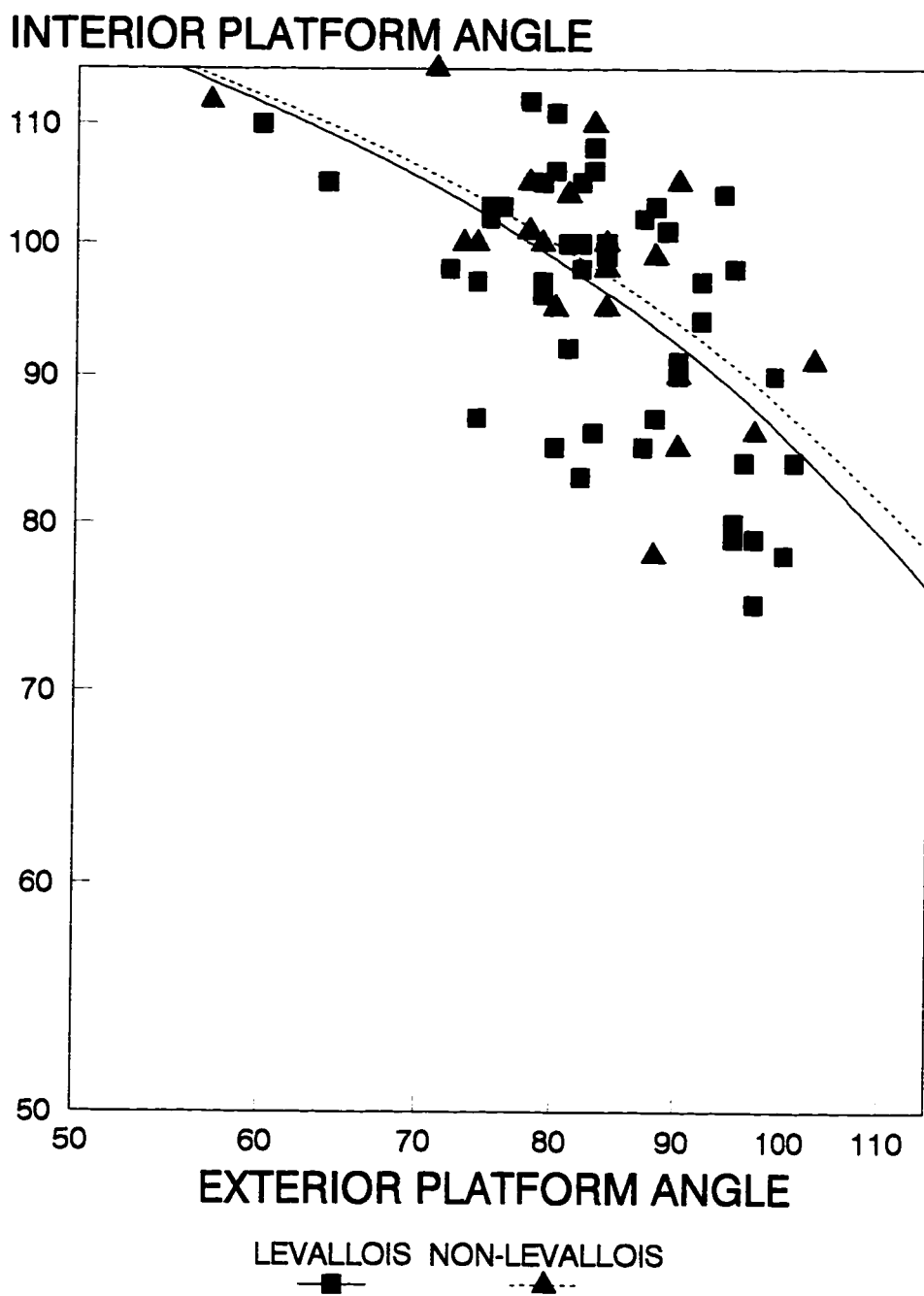


Figure 6.14. Log plot of exterior and interior platform angles of convergent tools from the Central Gallery of Nahr Ibrahim.

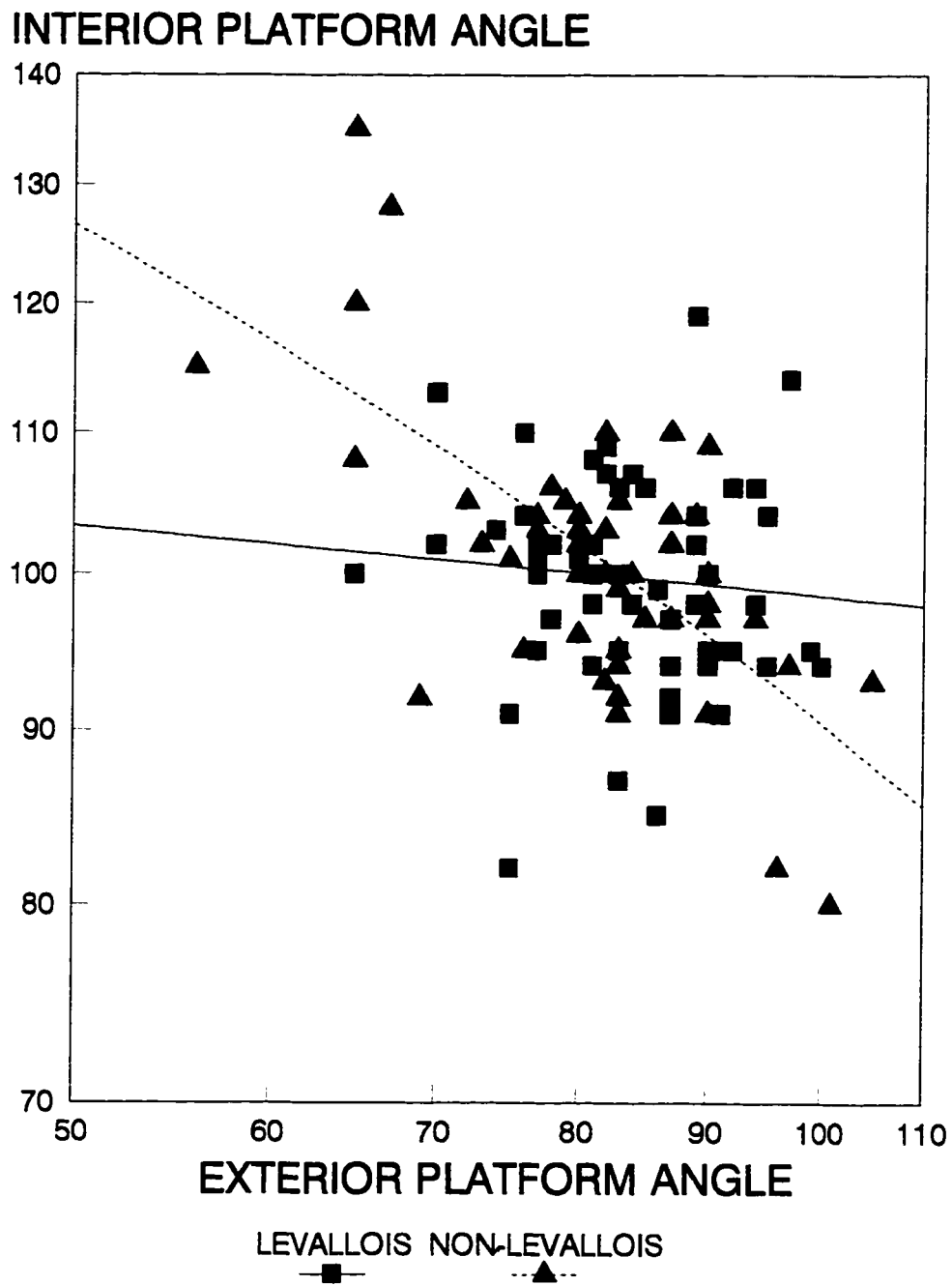


Figure 6.15. Log plot of exterior and interior platform angles of convergent tools from the North Gallery of Nahr Ibrahim.

A loose cluster is observed with a significant degree of overlap between groups. Observing each regression line separately, there is a similar relationship for both groups as that for the Central Gallery although the differences between Levallois and non-Levallois are more dramatic and do not follow the same trajectory. Comparisons of EPA and flake thickness (Figures 6.16 and 6.17) also do not exhibit clear differences between Levallois and non-Levallois for Nahr Ibrahim. As with other scatterplots, the R-square values for the regression lines indicate that differences between Levallois and non-Levallois do little to explain the patterning.

It is suggested here that the technological link between IPA, EPA, thickness (and other dimensions) is key to producing flakes of desired size for tool use. The employment of a set of uniform criteria to select appropriate convergent flakes will also mask differences between these morphological and dimensional attributes producing a relatively homogenous grouping; even when some flakes are typologically Levallois and others non-Levallois.

Summary

The technological analysis of convergent tools from Nahr Ibrahim indicated that there were metric and dorsal surface differences between Levallois and non-Levallois specimens although the results were not statistically significant. The Levallois technique seems to have been applied to increase the flintknappers control over the relationship between flake size and shape. Levallois convergent tools from the Central Gallery, on average, are longer, wider, and thinner than non-Levallois specimens. The trend for North Gallery convergent tools is for a greater similarity between Levallois and non-Levallois specimens which is probably due to the greater degree of unidirectional convergent surface preparation associated with both techniques. The flintknapper exercised control over flake shape and dimensions by varying the exterior platform angle and platform width in conjunction to dorsal surface preparation. The effort apparent in the manufacture of Levallois and

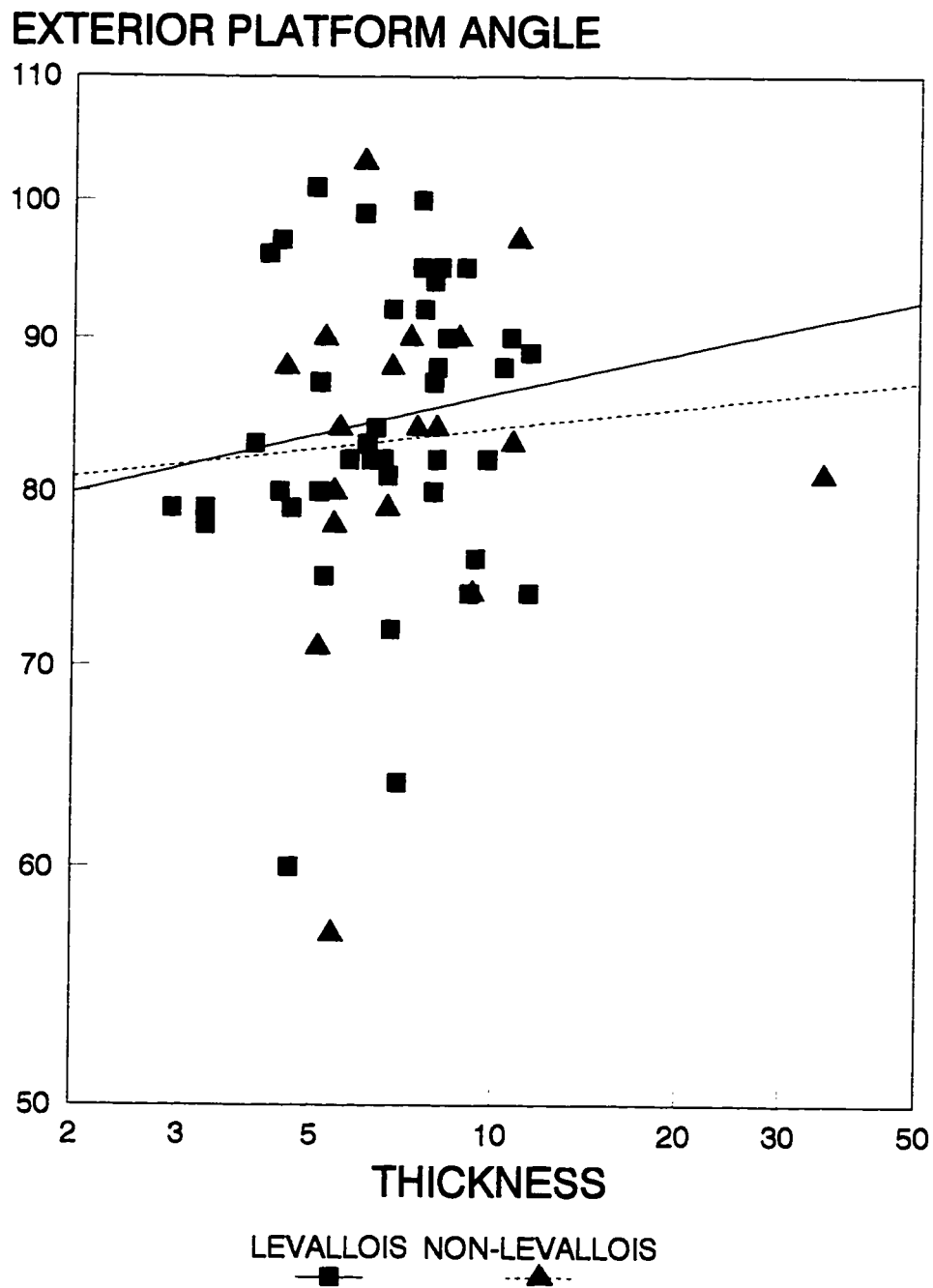


Figure 6.16. Log plot of thickness and exterior platform angle of convergent tools from the Central Gallery of Nahr Ibrahim.

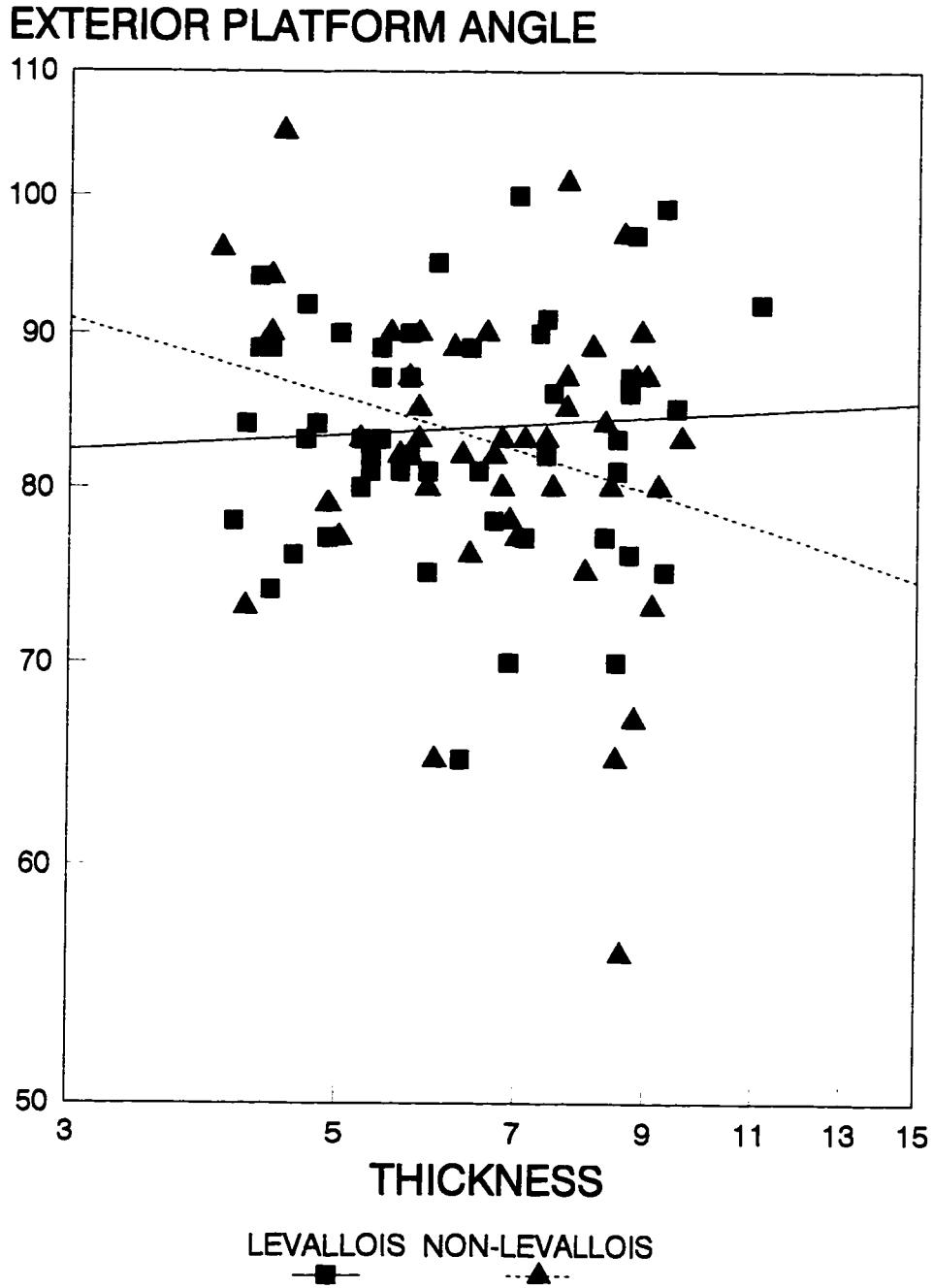


Figure 6.17. Log plot of thickness and exterior platform angle of convergent tools from the North Gallery of Nahr Ibrahim.

non-Levallois convergent flakes that were selected as tools is indicative of a high degree of standardization in both manufacture and blank selection. The parameters of convergent tool production provided tool blanks of fairly consistent in morphology which was ultimately associated with the design and use of convergent flakes as tools. Chapter VII provides detailed discussion of the relationship between design criteria, constraints of convergent tool manufacture, and patterns of use for the Levantine Mousterian.

CHAPTER VII

FUNCTIONAL VARIABILITY OF CONVERGENT TOOLS

The functions of flaked stone tools are inevitably related to the morphology and overall design of those tools. Recently, Hayden and others (Hayden et al. 1996) have applied the concepts of design theory to explain lithic assemblage technological organization and tool morphology. Their study identified tasks to be performed, availability of suitable raw material, and the amount of material to be processed as key variables in determining technological organization and tool design. Hayden and his colleagues (Hayden et al. 1996) proposed a variety of macrolevel possibilities that also can be factored into the relationship between tool design and function. The pertinent variables include task, material, technological and socio-economic factors. Even if not all of these can be addressed with the data at hand, it is important to acknowledge that they exist as a source of variability. Below I will briefly provide discussion of these key variables as they might perhaps relate to Levantine Mousterian convergent tools.

Constraints Upon Levantine Mousterian Convergent Tool Design

Task

Previous functional and technological studies have indicated that Middle Paleolithic convergent tool forms were typically employed in a range of cutting, scraping, and piercing tasks and consisted of both unhafted and hafted forms. The tool is subjected to a variety of stresses when employed in these tasks. Piercing tasks, whether as projectile points or drills/perforators, subject the tool to both dynamic and static loading factors. Cutting and scraping are associated with static loading primarily along an edge in addition to torsional (twisting) stresses across the body of the tool. The presence of a haft serves to isolate twisting and bending

stresses across the proximal end. Convergent tools must also be efficient in use. The primary requisites for a tool to be employed in cutting and scraping are a suitable edge of sufficient length, regular shape (either naturally or obtained via retouch), and sufficient size to be conveniently held and used. Piercing tasks add another dimension to tool design not necessary for most cutting and scraping tools: a sharp and durable tip. Convergent tools essentially contain elements necessary to be employed in all of these tasks and can be considered potentially multifunctional; a feature often associated with thick bifaces or bifacial artifacts (see Hayden et al. 1996; Kelly 1988; Parry and Kelly 1987).

Material

The manufacture of Levantine Mousterian convergent tools is dependent upon adequate supplies, size, and quality of raw material. These are the only material requirement for manufacture of these implements. There is considerable latitude in convergent tool variation between the Zagros Mousterian and the Levantine Mousterian, in part due to variability in size of available raw materials.

Technological

There is considerable technological variability that is to be observed in Levantine Mousterian convergent tools. Both Levallois and non-Levallois blanks were selected for use based on similar morphology. It is probable that the selection of a variety of blank types reflects both the deliberate manufacture of specific blank types (Levallois points and convergent Levallois flakes) and the ad hoc selection of suitable flakes from debitage from Levallois and discoidal flake production. This places less emphasis on the technological origin of the tool blank and places it squarely in the realm of flake morphology. Studies by Odell and others have shown that suitable unmodified and unifacial flakes selected from debitage are just as employable as hafted projectile points, cutting, and scraping tools as their bifacial

counterparts (Odell 1977, 1988, 1996a; Odell and Cowan 1986; Patterson 1994). The technological variability between Levallois and non-Levallois convergent tools from Nahr Ibrahim suggests that non-Levallois blanks have a roughly equivalent functional value as their Levallois counterparts. Shea (1991, 1995a, 1995b) demonstrates that Levallois points, blades, and flakes were frequently selected for use as hafted projectile points and knives but whether this selectivity is based on cultural constraints or greater technological suitability is unclear. Certainly, technological studies (Crew 1975; Dibble 1981; Fish 1979; Jones 1985; Munday 1979; Ronen 1995) indicate that the Levallois technique can be used to produce longer, wider, and thinner flake blanks than flakes not produced by this technique. Ronen (1995) has provided an intriguing proposition for the Levallois technique representing a cultural constraint upon technological variability that was significant in spite of raw material shortages in the environment. The advantages of increased blank size while maintaining a reasonable thickness were important for the continued use of the Levallois technique regardless of the apparent waste of raw material and increased production time of such prepared core techniques (see Hayden et al. 1996:37). Once produced, Levallois flakes, blades, and points represent an efficient package of raw material with more usable cutting edge per given amount of raw material than non-Levallois tool blanks. The use of non-Levallois convergent flakes in functions similar or identical to Levallois blanks reflects the ability of Middle Paleolithic hominids to evaluate the suitability of those flakes for tasks at hand, representing a form of economizing behavior (Odell 1996).

Socio-economic

Socio-economic constraints, according to Hayden (Hayden et al. 1996) include mobility, transport capacity, potential labor, and storage. These factors are difficult to translate to convergent tools. Nahr Ibrahim and Shanidar are located in areas characterized by abundant suitable chert resources except that size differences

of nodules influenced the size of convergent tools. The lithic assemblages from these sites indicate that the entire sequence of reduction was occurring on-site with little evidence of the importation of distant materials. Transport constraints would be associated with tools that were carried away from the site to other localities because of the limited amount of gear that an individual can or should carry (depending upon the purpose of the foray). The issue of transport cost of raw material versus tools in the Levantine Mousterian has been addressed by Henry (1992, 1995a, 1995b). His studies indicate that raw materials or flake blanks will be transported depending upon the abundance of raw material in areas of other critical resources (shelter, water, food). Although it has not been specifically addressed in Levantine Mousterian studies, the idea of a midden serving as an expedient source of raw material is one response to raw material shortage and ad-hoc long-term storage of material for tool use. The middens of both Nahr Ibrahim and Shanidar certainly would have provided ample material for the expedient selection of flakes as convergent tools at times negating the need for manufacture of specific flakes. The degree to which this type of behavior was practiced during the Middle Paleolithic in the Near East is currently unknown.

Employable Units and Reconstruction of Tool Use

Some researchers have noted that differences in blank shape present different opportunities for tool use (Knudson 1973; Odell 1979; Shea 1991). Blank shape or tool shape directly influences the mode and type of hafting that can be employed in the manufacture of composite tools and the manner in which an unhafted tool is gripped during use. By extension, shape is also a factor in the manner in which the tool is employed in a given task. In his initial study, Shea (1991:167-168) noted that points, flakes, and blades differed little in overall pattern of employable unit (EU) location except for two instances. Polar coordinates 8 and 1 were more frequently worn on points than blades or oval flakes. Points and blades presented a higher

proportion of lateral edge asymmetry in the presence of wear than oval flakes. He concluded that there were basic similarities in the manner in which points, flakes, and blades were used as tools. Shea (1991) investigated this issue by lumping all assemblages according to blank type to provide a general profile of each flake type. I have chosen to examine the issue according to technology (Levallois versus non-Levallois) at the assemblage or sample level. Additionally, ratios of Levallois to non-Levallois tools (LV/NLV) and point and oval flakes to blades (PO/B) are employed (Table 7.1) to evaluate a series of line graphs for samples of suitable size which measure the proportion of wear for each polar coordinate (PC). Each sample is discussed briefly below with reference to LV/NLV and PO/B ratios and appropriate graphs. It will be noted that the trend of asymmetry tends to decrease or disappear altogether when examining specific tool types and Levallois versus non-Levallois.

Differences in Rates of Observed Wear on Polar Coordinates

Hayonim E displays some concordance between Levallois and non-Levallois tools (Figure 7.1) in this feature. The PC wear distribution pattern is also fairly symmetrical with 8 and 1 having more wear. There are also slight peaks at PC 3 and 6 which for the Levallois sample which correspond with a greater abundance of these tools with hafting wear and a high PO/B ratio of 10.3 (Table 7.1).

Both Levallois and non-Levallois convergent tools from Kebara X have similar rates of wear for each PC (Figure 7.2). The patterns are quite symmetrical in trend. Kebara X is also a point heavy sample (PO/B=11.1) with a moderate LV/NLV ratio (2.1). Kebara IX displays a somewhat different pattern with less concordance between Levallois and non-Levallois implements (Figure 7.3). The Kebara IX LV/NLV ratio is low (Table 7.1) at 1.6 and the sample is composed entirely of points. The Levallois PC wear pattern is fairly uniform but there are anomalies at PC 5 and 7 associated with the non-Levallois pattern.

Table 7.1. Ratios of Levallois to non-Levallois convergent tools (LV/NLV) and points-oval flakes to blades (PO/B) for sites included in the functional analysis. All data calculated from Shea (1991) except for Nahr Ibrahim and Shanidar.

Site or Assemblage	LV/NLV ratio	PO/B ratio
Hayonim E	2.4	10.3
Kebara X	2.1	11.1
Kebara IX	1.6	---
Kebara XD	3.4	19.0
Kebara XI	2.7	7.2
Kebara XII	4.6	8.3
Kebara XIII	2.0	---
Nahr Ibrahim Central Gallery	1.7	5.6
Nahr Ibrahim North Gallery	1.0	1.6
Qafzeh XV	4.7	6.3
Qafzeh XVII	1.0	---
Qafzeh XVIII	1.5	---
Shanidar	.2	16.0
Tabun IB	4.0	---
Tabun IC	1.8	2.6
Tabun II	4.5	2.6
Tabun IX	1.9	6.0
Tor Faraj C	2.9	12.0

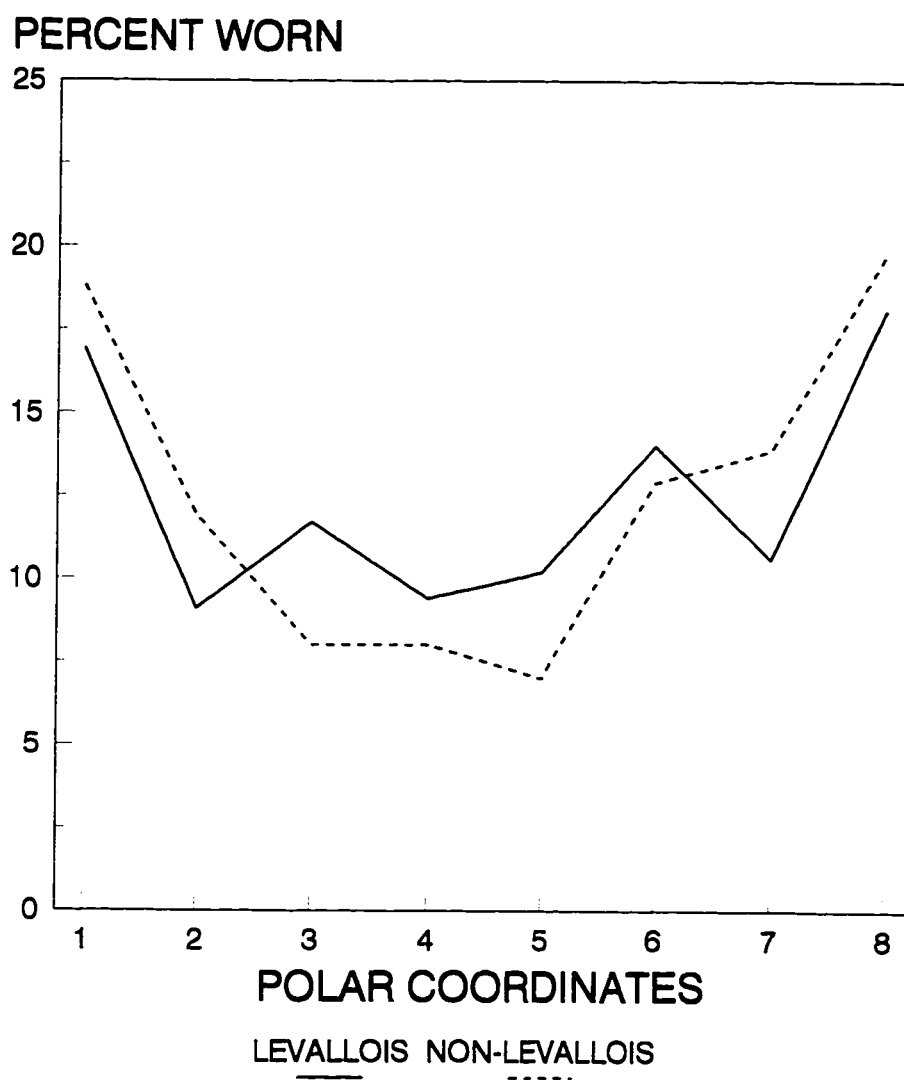


Figure 7.1. Frequency of wear on polar coordinates of convergent tools from Hayonim E. Data calculated from Shea (1991).

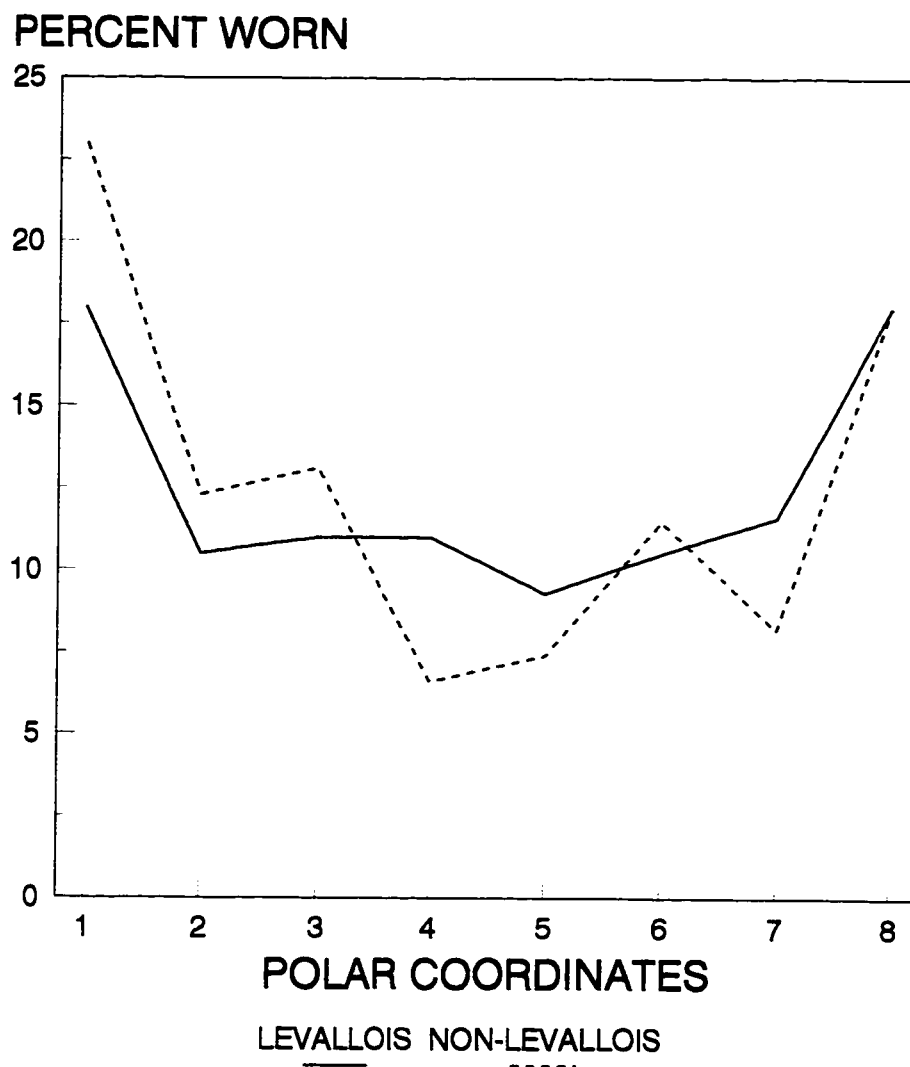


Figure 7.2. Frequency of wear on polar coordinates of convergent tools from Kebara X. Data calculated from Shea (1991).

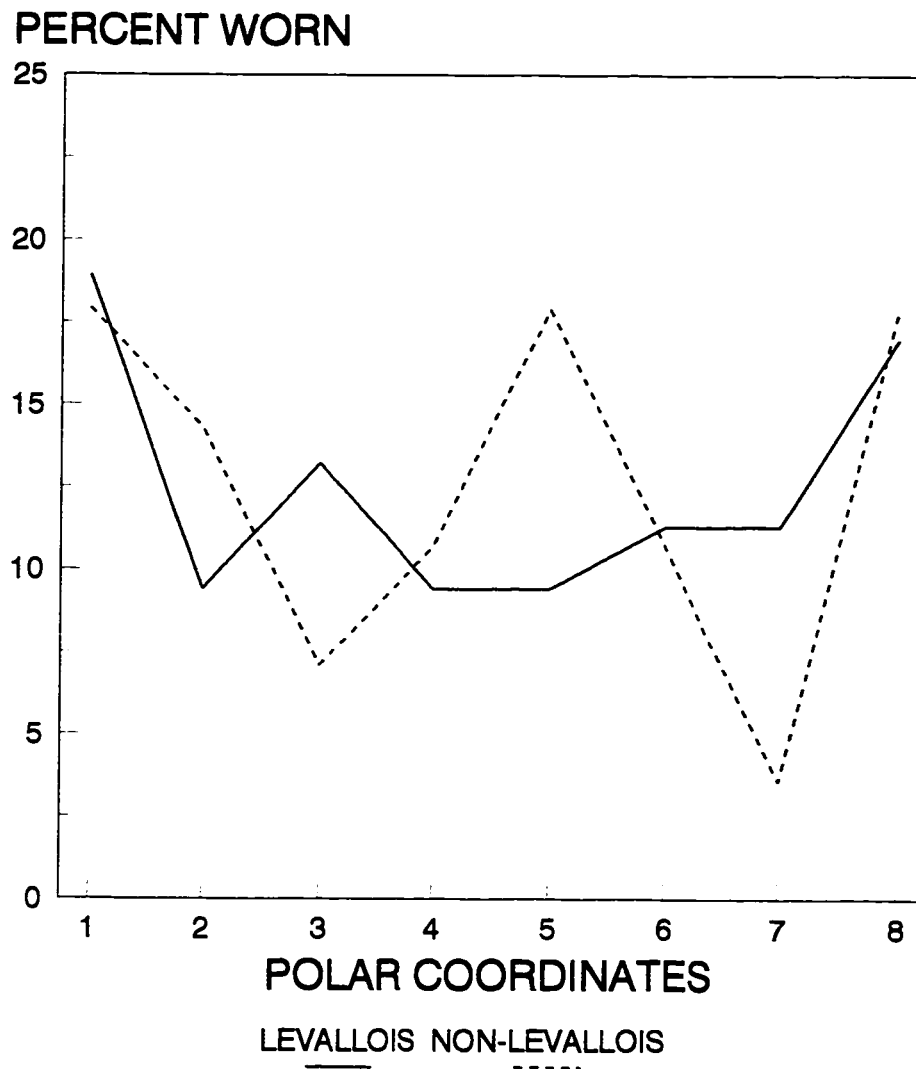


Figure 7.3. Frequency of wear on polar coordinates of convergent tools from Kebara IX. Data calculated from Shea (1991).

The LV/NLV of Kebara XD (Table 7.1) is moderate and the PO/B indicates a point dominated sample. Again, the pattern of wear distribution for Levallois artifacts is symmetrical (Figure 7.4) with peaks associated with greater use of the distal area of tools and hafting (PC 3 and 5). The non-Levallois pattern is laterally asymmetrical with a drop in the proportion of wear on PC 4 and 5. This difference of proportions associated with hafting is probably related to the greater number of points in the sample rather than a specific preference to haft Levallois artifacts (this is supported statistically below). Kebara XI samples have produced similar patterns for both Levallois and non-Levallois groups (Figure 7.5). The LV/NLV and PO/B are lower than Kebara XD (Table 7.1). There is also a high degree of concordance between patterns associated with Kebara XII (Figure 7.6). The LV/NLV ratio is high (4.6) and there is a moderate PO/B ratio (8.3). The observed peak between PC 4 and 5 may be a reflection of elongation of point blanks. Shea (1991:124) noted that Kebara IX-XIII have high proportions of both blades and points and a recurrent unidirectional mode of flake preparation. Blank elongation could transfer the location of hafting from PC 3 and 6 (correlated with broad flake blanks) to PC 4 and 5 (correlated with blades or narrow flake blanks).

The patterns produced for the Central and North Galleries of Nahr Ibrahim are similar in trend but differ in the proportions of wear for each PC (Figures 7.7 and 7.8). The Central Gallery is characterized by a low LV/NLV ratio (1.7) and a moderate PO/B (5.6). Polar coordinates 3 and 6 have a greater proportion of wear than 4 and 5 which corresponds to a greater proportion of points and oval flakes in the sample and fewer blades. Distal PC 8 and 1 also have greater proportions of wear. Both Levallois and non-Levallois patterns are symmetrical for the Central Gallery. North Gallery LV/NLV and PO/B ratios are both low (Table 7.1). There are a greater number of Levallois and non-Levallois blades in the North Gallery sample than are present in the Central Gallery. The proportions of wear for Levallois and non-Levallois samples are similar and symmetrical (Figure 7.8). Each

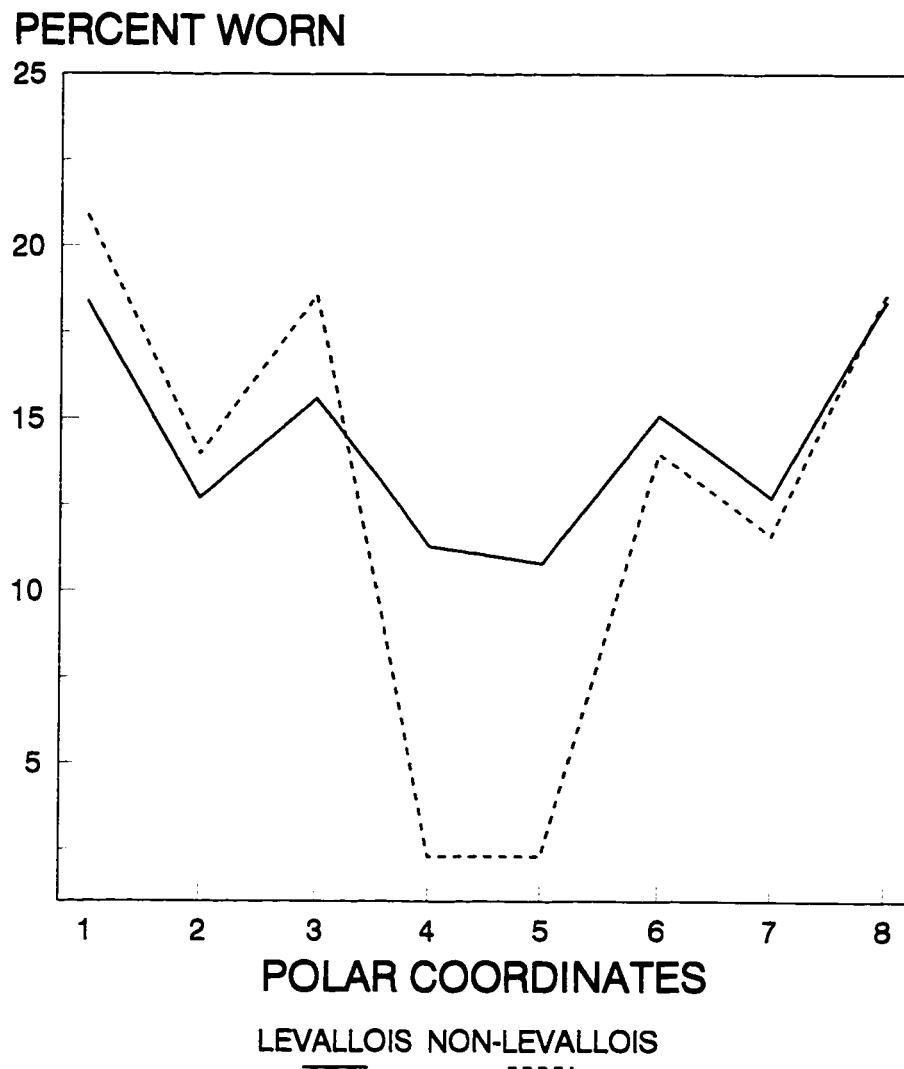


Figure 7.4. Frequency of wear on polar coordinates of convergent tools from Kebara XD. Data calculated from Shea (1991).

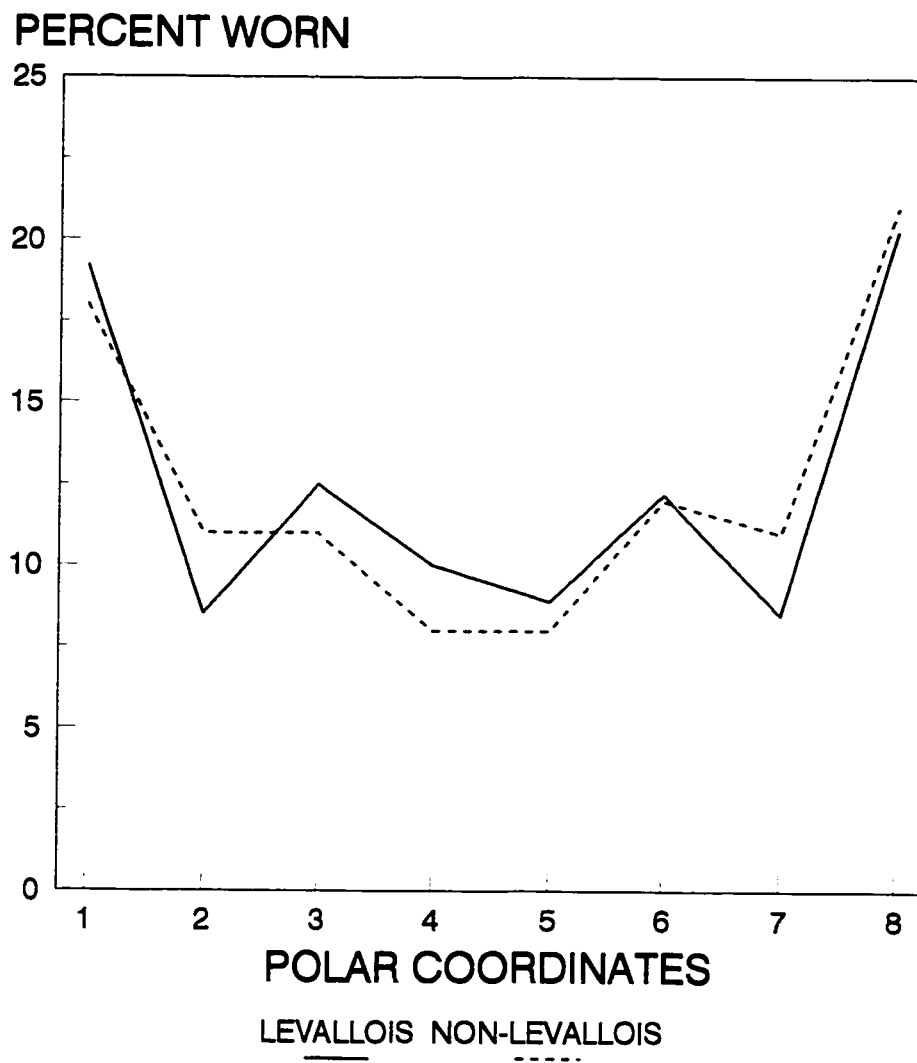


Figure 7.5. Frequency of wear on polar coordinates of convergent tools from Kebara XI. Data calculated from Shea (1991).

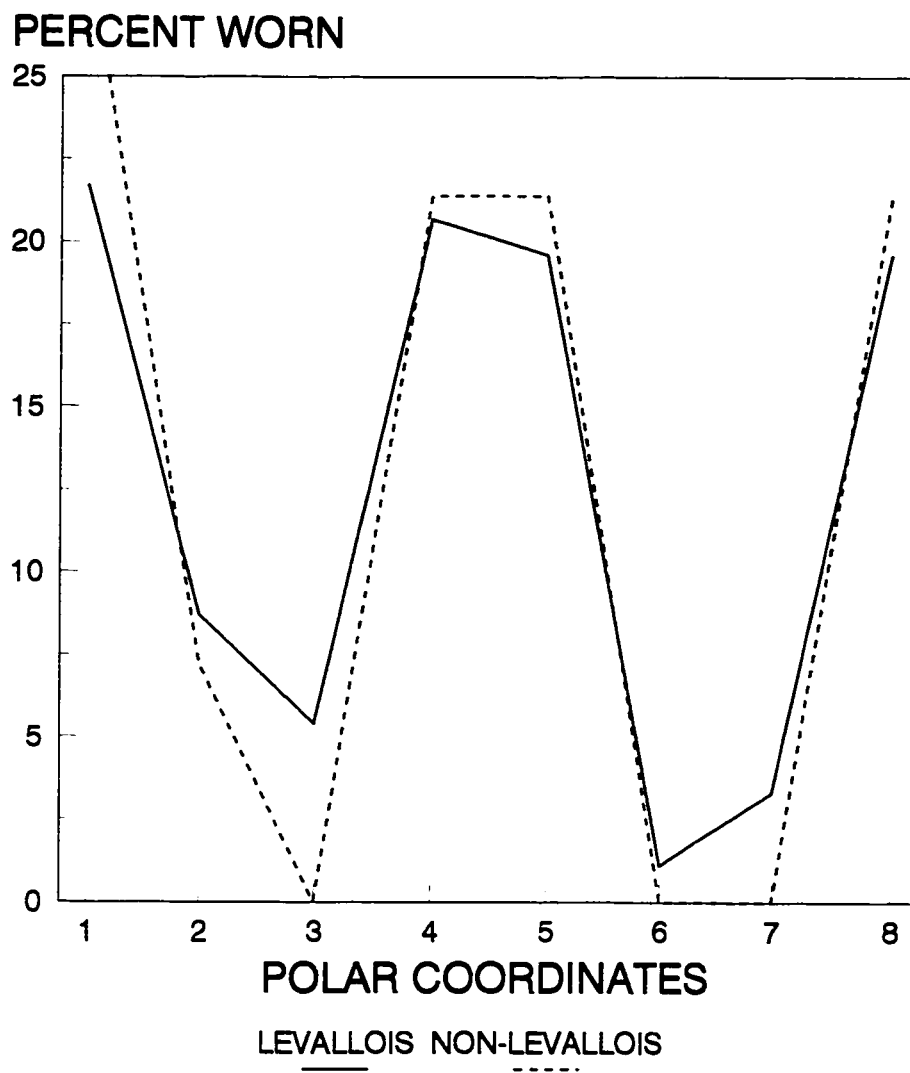


Figure 7.6. Frequency of wear on polar coordinates of convergent tools from Kebara XII. Data calculated from Shea (1991).

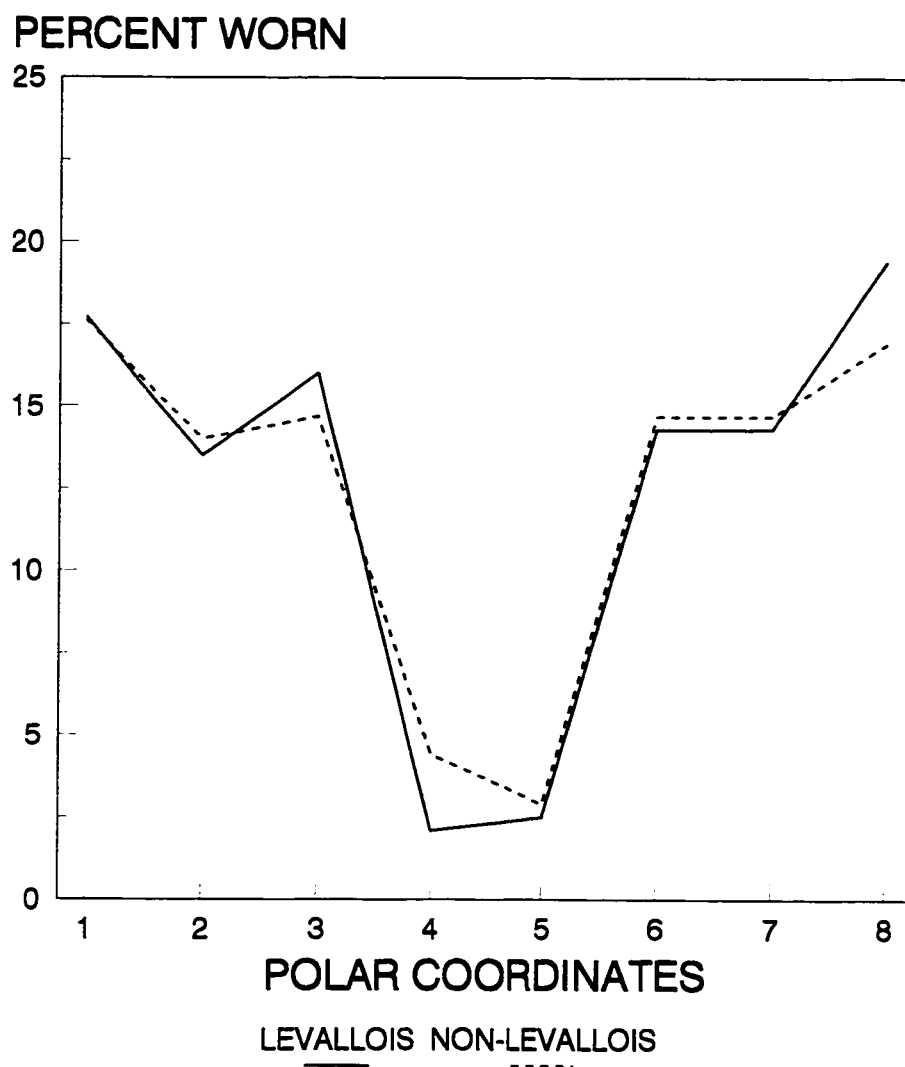


Figure 7.7. Frequency of wear on polar coordinates of convergent tools from Nahr Ibrahim Central Gallery.

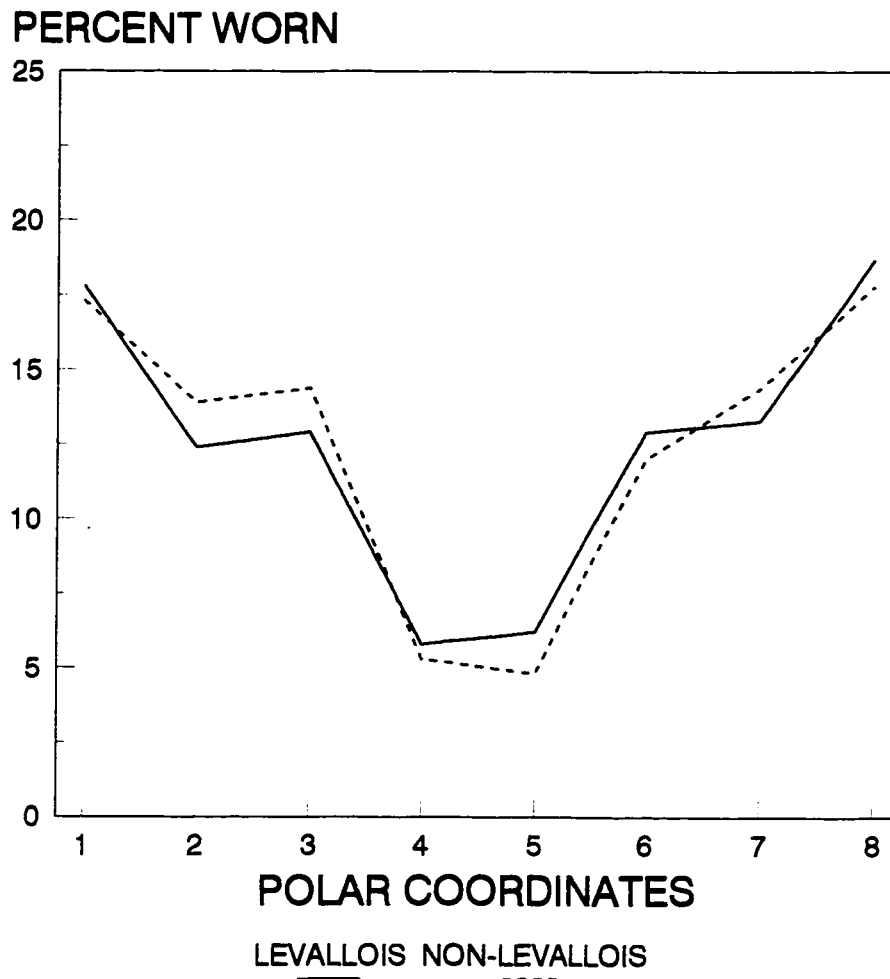


Figure 7.8. Frequency of wear on polar coordinates of convergent tools from Nahr Ibrahim North Gallery.

pattern exhibits the characteristic peaks at PC 3 and 6 but there is a slight increase of wear in PC 4 and 5 not observed in the Central Gallery. This corresponds to a low PO/B ratio (1.6).

The only sample robust enough to examine for patterns from Qafzeh is Qafzeh XV (Figure 7.9). The LV/NLV ratio (4.7) is high and the PO/B ratio (6.3) is moderate (Table 7.1). Proportions of PC wear are high for the distal area of Levallois and non-Levallois tools. The Levallois pattern shows the characteristic peaks at PC 3 and 6 but there is also a slight increase of wear in PC 4 and 5 which could be equated with more elongated points in this assemblage or variability in hafting patterns.

The wear patterns for Shanidar (Figure 7.10) are very similar to patterns for Levantine Mousterian assemblages. The only real difference being that Mousterian points from Shanidar are more heavily worn than Mousterian points from the galleries of Nahr Ibrahim. The points from Shanidar are also more heavily retouched at the distal end than those from Nahr Ibrahim. This suggests that various portions of convergent tools from Zagros Mousterian assemblages were employed in generally similar frequencies when compared to the Levantine Mousterian. A greater proportion of wear on the distal region compared to other areas of the tool indicate that the distal area was the focus of tool use; despite the fact that the sample is dominated by Mousterian points. The LV/NLV ratio (Table 7.1) is expectedly very low (.2) but the PO/B ratio is quite high (16.0). Despite the low proportion of Levallois tools in the sample, the PC wear rates for Levallois and non-Levallois convergent tools are quite concordant and symmetrical suggesting modes of use comparable to the Levantine Mousterian.

Tabun IX (Table 7.1 and Figure 7.11) has a low-moderate LV/NLV (1.9) and a moderate PO/B of 6.0. Both Levallois and non-Levallois patterns exhibit peaks in the distal region. The non-Levallois sample has roughly similar proportions of wear for PC 2 through 7. Certainly a proportion of the non-Levallois pattern can be

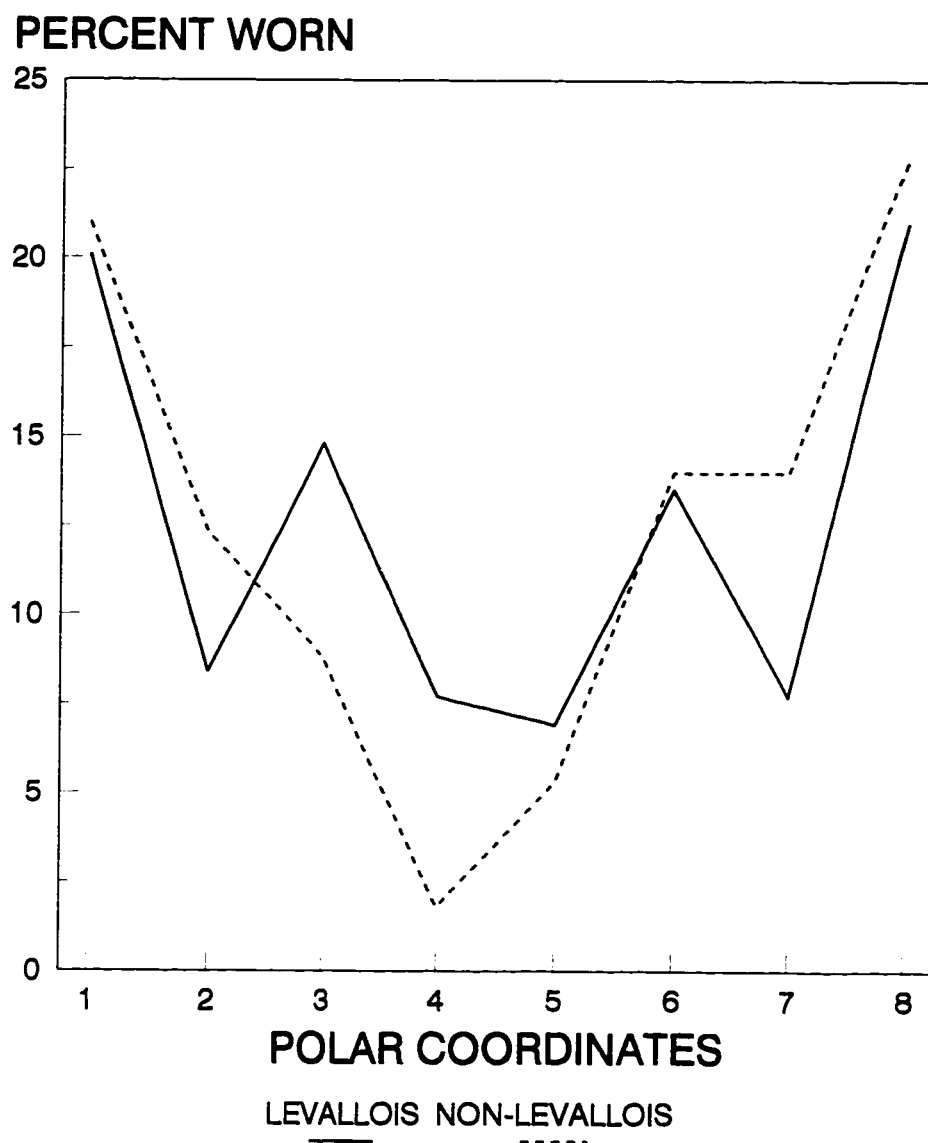


Figure 7.9. Frequency of wear on polar coordinates of convergent tools from Qafzeh XV. Data calculated from Shea (1991).

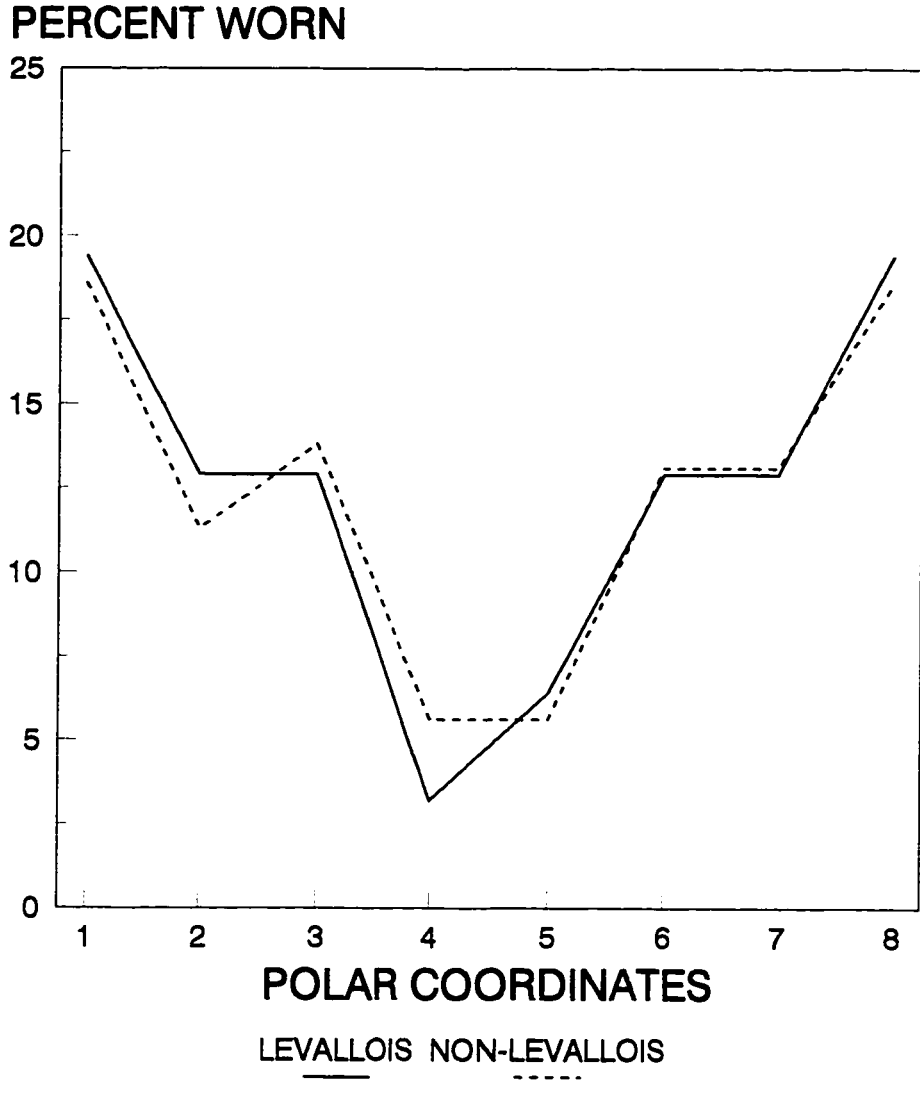


Figure 7.10. Frequency of wear on polar coordinates of convergent tools from Shanidar.

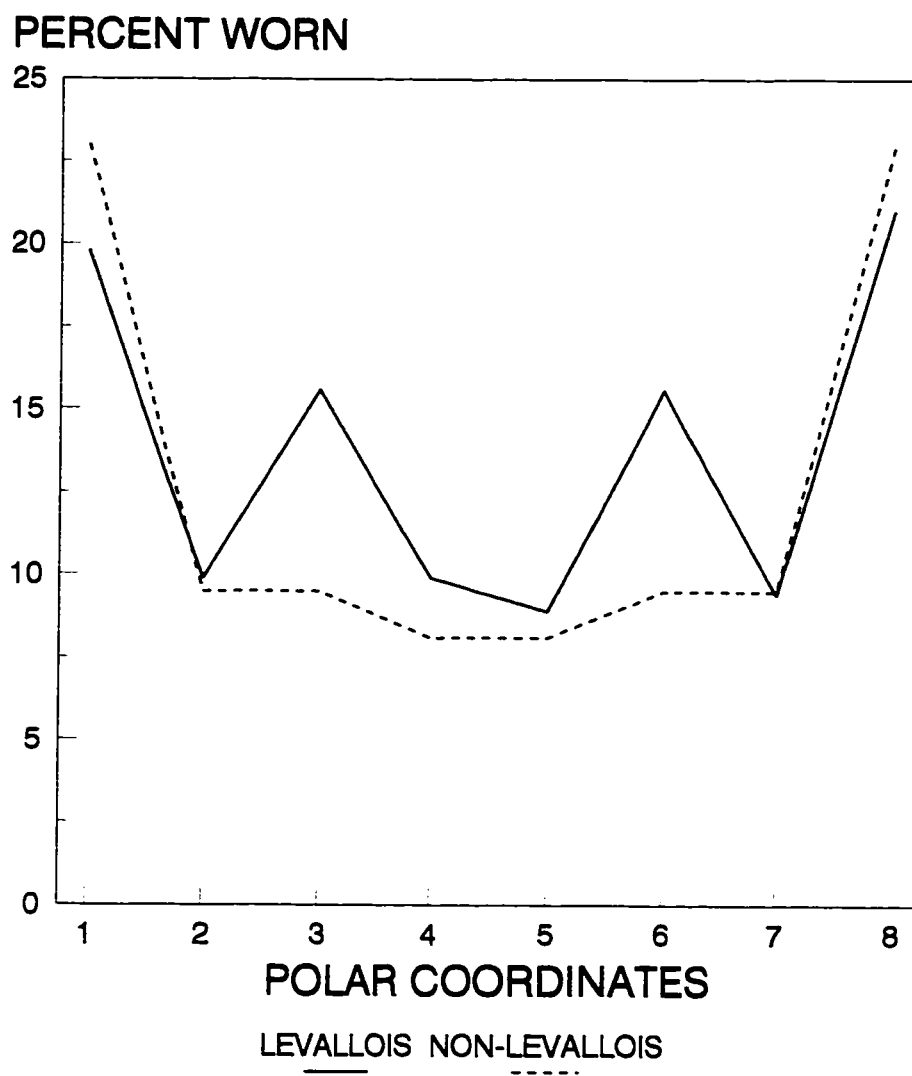


Figure 7.11. Frequency of wear on polar coordinates of convergent tools from Tabun IX. Data calculated from Shea (1991).

accounted for by the moderate PO/B ratio. The patterns of both groups are symmetrical.

Ratios of LV/NLV (2.9) and PO/B (12.0) at Tor Faraj C are moderate and high, respectively (Table 7.1). Levallois and non-Levallois (Figure 7.12) show greater wear associated with the distal area of tools. The Levallois pattern is quite stable between PC 2 through 7. Non-Levallois tools exhibit lower proportions of wear on PC 4 and 5 when compared to Levallois which is correlated with a higher incidence of hafting on Levallois specimens and ultimately the greater number of Levallois specimens in the sample. Greater frequencies of distal wear on non-Levallois specimens are influenced by a decrease in wear of PC 4 and 5.

Issues of Functional Variability of Convergent Tools

During the use-wear analysis for this study and the compilation of data from Shea's extensive study (1991) for comparative purposes, it became readily apparent that there were potentially significant differences in selection of Levallois and non-Levallois flakes for tool use. My initial impression, based on metric data from the North and Central Galleries of Nahr Ibrahim, was that there seemed to be little difference in selection pressures between Levallois and non-Levallois convergent blanks for tool use. This is still a valid conclusion that I have drawn from Chapter 6. There were certainly selective pressures in operation that favored Levallois convergent points, flakes, and blades for a narrow range of tool functions. An exception is Shanidar Cave due to the nature of raw material and the fact that it is Zagros Mousterian and not Levantine Mousterian.

Reconstruction of Tool Motions

There are three major tool motions that are typically associated with convergent tools in Levantine Mousterian assemblages. These include cutting, projectile impact, and hafting. Hafting is included as a tool motion because of the

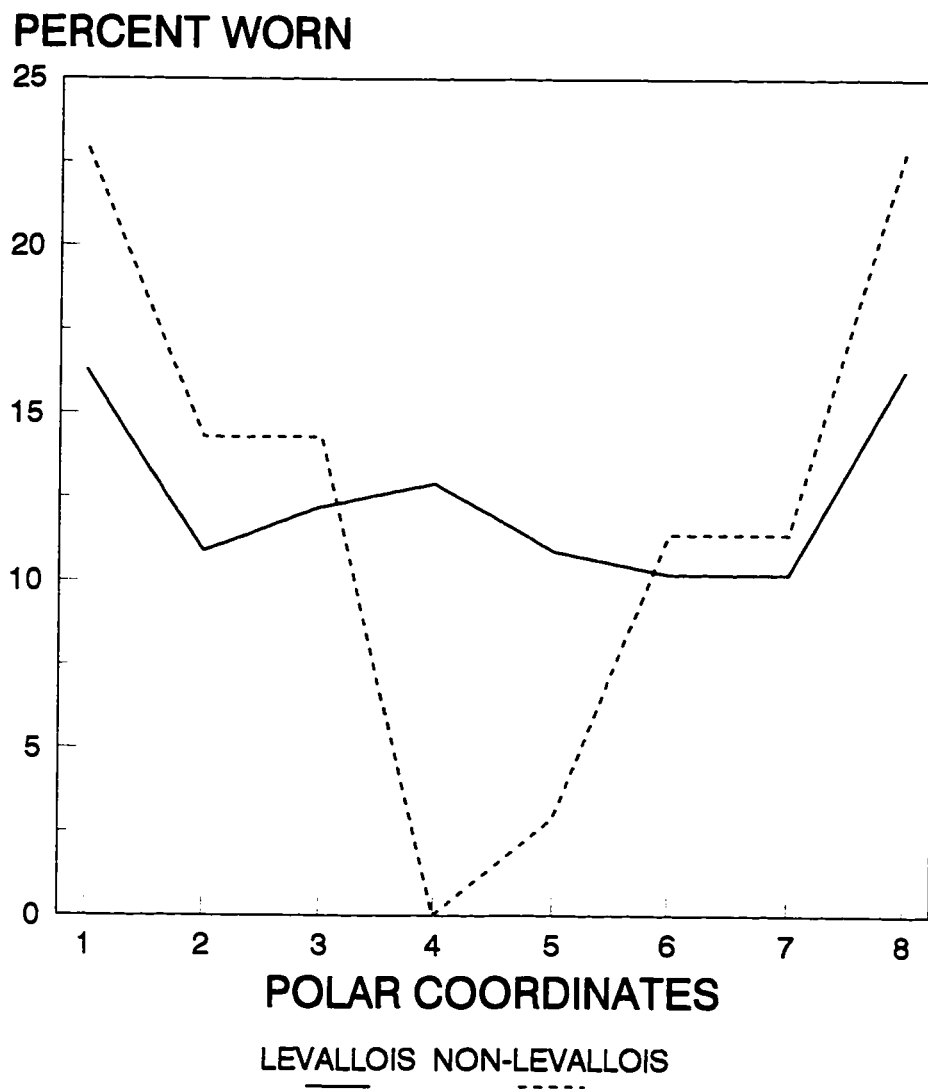


Figure 7.12. Frequency of wear on polar coordinates from Tor Faraj C. Data calculated from Shea (1991).

distinctive nature of the wear pattern. It is also typically associated with cutting and projectile impact tool motions. Awling and scraping are represented among a greater number of sites or assemblages than other tool motions. A second set of tool motions were also represented. These include chopping, drilling, graving, shaving, wedging, planing, adzing, and unknown. More discussion will be devoted to the most abundant tool motions, associated wear types and reconstructed tool uses but the remainder will be briefly discussed. The range of tool motions that were identified by Shea (1991) and myself during this study indicate that convergent implements were employed in a range of tasks typically associated with extractive and maintenance tasks. Tool motions associated with extractive tasks include projectile impact, cutting, and associated hafting wear traces. Generally, extractive tasks are linked to food procurement and processing of food items. Maintenance tool motions include those that were performed typically at the residential area and would include various piercing and perforating motions, graving, chopping, adzing, scraping, and planing. These motions are linked to tasks indicative of tool manufacture and repair but may also include manufacture of other artifacts.

Important Tool Motions Associated with Levantine Mousterian Convergent Tools Scraping

Although the pattern is not strong there is a tendency for more non-Levallois convergent tools to be associated with this tool motion (Table 7.2). This is not too surprising given the greater suitability of other flake shapes for scraper implements. The ratios for this tool motion are typically in favor of a slightly greater number of non-Levallois or roughly equal proportions of Levallois and non-Levallois blanks. The greater number of convergent tools with scraper wear from the Central Gallery of Nahr Ibrahim may coincide with the increase in Levallois points throughout the deposits (Panagopolou 1985). Qafzeh XV also stands out in the number of Levallois convergent tools employed as scrapers.

Table 7.2. Number of employable units (EU) of convergent tools utilized in scraping tasks. All data calculated from Shea (1991) except for Nahr Ibrahim and Shanidar.

Site or Assemblage	Levallois EU	Non-Levallois EU	Total	Ratio
Hayonim E	6	6	12	1.00
Kebara IX	2	1	3	2.00
Kebara XD	1	2	3	.50
Kebara XI	1	2	3	.50
Kebara XII	1	---	1	---
Nahr Ibrahim Central Gallery	13	15	28	.86
Nahr Ibrahim North Gallery	2	16	18	.12
Qafzeh XV	11	6	17	1.8
Qafzeh XVII	2	---	2	---
Qafzeh XVIII	1	2	3	.50
Shanidar	6	28	34	.21
Tabun IC	1	1	2	1.00
Tabun II	1	---	1	---
Tabun IX	5	4	9	1.25
Tor Faraj C	1	1	2	1.00

Cutting

The ratios for this tool motion (Table 7.3) are strongly in favor of selection of Levallois convergent blanks. Shanidar Cave stands out as an obvious exception. The greater frequency of Levallois flake selection correlates with a greater proportion of these flakes with haft wear and projectile impact damage. This specific selective pattern is a strong argument for production of convergent Levallois flakes primarily as parts of composite (hafted) tools. The data from Nahr Ibrahim is well within the range of variability for other assemblages examined by Shea (1991). Hayonim, Kebara, Nahr Ibrahim, Qafzeh XV, and Tor Faraj C all have significant numbers of convergent tools associated with cutting. Qafzeh XVII and XVIII and Tabun IC and II have low frequencies.

Distal Impact

High ratios of this tool motion (Table 7.4) can theoretically be linked to a higher incidence of use of convergent tools in hunting. All ratios indicate a higher use of Levallois convergent tools in this capacity. Kebara IX and XIII and Qafzeh XIX and XVIII and Tabun IB and IC have low EU totals for this tool motion. There are two possibilities to explain low EU totals in Levantine Mousterian assemblages (Shea 1991:142-143). These include a larger hunting territory so that points were broken and replaced away from the main residence more often than being returned to the site for retooling and rehafting. Also, it is possible that a different hunting technology rather than stone projectile points may have been employed: poison or perishable all wooden or bone tipped implements. Additional research by Shea and others (Lieberman 1993; Lieberman and Shea 1994; Shea 1995a 1995b) strongly argues for not only behavioral differences between anatomically modern and archaic

Table 7.3. Number of employable units (EU) of convergent tools utilized in cutting tasks. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Site or Assemblage	Levallois EU	Non-Levallois EU	Totals	Ratio
Hayonim E	47	17	64	2.76
Kebara IX	13	3	16	4.33
Kebara X	32	13	45	2.46
Kebara XD	52	8	60	6.5
Kebara XI	48	20	68	2.40
Kebara XII	11	—	11	—
Kebara XIII	2	—	2	—
Nahr Ibrahim Central Gallery	54	21	75	2.57
Nahr Ibrahim North Gallery	54	46	100	1.17
Qafzeh XV	60	10	70	6.00
Qafzeh XVII	2	2	4	1.00
Qafzeh XVIII	2	—	2	—
Shanidar	4	13	17	.30
Tabun IC	8	3	11	2.66
Tabun II	6	2	8	3.00
Tabun IX	27	12	39	2.25
Tor Faraj C	32	8	40	4.00

Table 7.4. Number of employable units (EU) of convergent tools with evidence of distal impact traces. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Site or Assemblage	Levallois EU	Non-Levallois EU	Totals	Ratio
Hayonim E	22	7	29	3.14
Kebara IX	4	4	8	1.00
Kebara X	19	14	33	1.36
Kebara XD	25	4	29	6.25
Kebara XI	51	13	64	3.92
Kebara XII	13	4	17	3.25
Kebara XIII	2	1	3	2.00
Nahr Ibrahim Central Gallery	9	4	13	2.25
Nahr Ibrahim North Gallery	8	5	13	1.60
Qafzeh XIX	1	—	1	—
Qafzeh XV	60	2	62	30.00
Qafzeh XVIII	3	—	3	—
Shanidar	—	6	6	.00
Tabun IB	4	—	4	—
Tabun IC	3	1	4	3.00
Tabun II	12	—	12	—
Tabun IX	21	2	23	10.7
Tor Faraj C	20	7	27	2.85

Homo sapiens but also greater intensification of hunting in marginal areas of the interior and southern Levant. There is a correlation between sites with multi-seasonal habitation and greater numbers of Levallois points and convergent tools with impact damage. The position of Nahr Ibrahim within Shea's (1995b) Northern Levantine Coastal Group and the lower EU totals with impact damage correlates well with his lower abundance of both Levallois points and points with impact damage from other sites in the same region.

Hafting

Ratios of hafting indicate a positive association with Levallois convergent tools and less so with non-Levallois specimens (Table 7.5). The abundance of hafting with Levallois tools is correlated with equally high ratios of Levallois flakes employed as cutting implements and projectile points. A greater presence of hafting suggests that they were an integral portion of the subsistence technology during the Levantine Mousterian; at least in the Northern Levantine Interior and Southern Levantine groups (see Shea 1995b). The North Gallery of Nahr Ibrahim is anomalous in the greater abundance of hafting on non-Levallois flakes; Kebara IX is similar in this trend. In his study Shea (1991:156) documented that 61.7 percent of all pointed artifacts had haft wear. A total of 74.2 percent of EU on pointed tools and 50 percent of EU on Levallois implements were of hafting.

Awling

This motion is not abundant among either Levallois or non-Levallois convergent tools. Ratios (Table 7.6) indicate a tendency for awling to be associated with non-Levallois implements. One notable exception is Qafzeh XV. The similarity of ratios of scraping and awling is used to infer that Levantine Mousterian convergent tools, especially Levallois flakes, were not typically employed in these tasks. Morphologically, convergent flakes are more suited to cutting and piercing

Table 7.5. Number of employable units (EU) of convergent tools with evidence of proximal hafting traces. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Site or Assemblage	Levallois EU	Non-Levallois EU	Totals	Ratio
Hayonim E	35	7	42	5.00
Kebara IX	5	6	11	.83
Kebara X	22	16	38	1.37
Kebara XD	30	3	33	10.00
Kebara XI	64	14	78	4.57
Kebara XII	22	4	26	5.50
Kebara XIII	2	1	3	2.00
Nahr Ibrahim Central Gallery	26	6	32	4.33
Nahr Ibrahim North Gallery	10	17	37	.58
Qafzeh XIX	1	—	1	—
Qafzeh XV	70	2	72	35.00
Qafzeh XVII	4	—	4	—
Qafzeh XVIII	1	1	2	1.00
Shanidar	1	9	10	.11
Tabun IB	5	—	5	—
Tabun IC	4	2	6	2.00
Tabun II	10	—	10	—
Tabun IX	30	3	33	10.00
Tor Faraj C	19	1	20	19.00

Table 7.6. Number of employable units (EU) of convergent tools with evidence of awling wear. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Site or Assemblage	Levallois EU	Non-Levallois EU	Totals	Ratio
Hayonim E	7	2	9	3.50
Kebara IX	1	1	2	—
Kebara X	8	10	18	.80
Kebara XD	5	1	6	5.00
Kebara XI	2	5	7	.40
Kebara XII	—	1	1	—
Nahr Ibrahim Central Gallery	3	—	3	—
Nahr Ibrahim North Gallery	1	1	2	1.00
Qafzeh XV	18	7	25	2.57
Qafzeh XVII	—	1	1	—
Qafzeh XVIII	—	1	1	—
Shanidar	—	4	4	—
Tabun IB	—	1	1	—
Tabun IC	2	—	2	—
Tabun II	1	1	2	1.00
Tabun IX	4	9	13	.44

tasks rather than scraping or awling. Their use in these latter tasks may represent a response to situational needs rather than planned activities employing specific tools.

Although the various ratios for the previously discussed tool motions seem to indicate a preference for Levallois convergent flakes as tool blanks care should be taken not to attribute too much behavioral significance to them. Results of chi-squared tests (Tables 7.7 and 7.8) reveal that there are no significant differences

Table 7.7. Results of chi-squared tests of the presence of cutting, distal impact, and haft traces on Levallois and non-Levallois convergent tools. Results evaluated at a .01 and a .05 confidence interval.

Site or Assemblage	Chi-Squared Value	Probability
Hayonim E	1.43	.489
Kebara X	.24	.887
Kebara XD	.43	.805
Kebara XI	2.97	.226
Kebara XII	2.94	.230
Nahr Ibrahim Central Gallery	1.19	.552
Nahr Ibrahim North Gallery	3.04	.219
Qafzeh XV	9.20*	.010
Shanidar	2.21	.332
Tabun IX	7.47*	.024
Tor Faraj C	3.48	.176

* Both Qafzeh XV and Tabun IX are significant at a .05 confidence interval. Qafzeh XV is almost accepted at a .01 confidence interval.

Table 7.8. Results of chi-squared tests of the presence of scraping, cutting, distal impact, and haft traces on Levallois and non-Levallois convergent tools. Results evaluated at a .01 and a .05 confidence interval.

Site or Assemblage	Chi-Squared Value	Probability
Hayonim E	5.62	.131
Nahr Ibrahim Central Gallery	9.22*	.027
Nahr Ibrahim North Gallery	13.46*	.004
Qafzeh XV	22.55*	.000
Shanidar	2.14	.543

* Nahr Ibrahim North Gallery and Qafzeh XV are significant at a .01 confidence interval. Nahr Ibrahim Central Gallery is significant at a .05 confidence interval.

between the proportion of Levallois convergent and non-Levallois convergent flakes and the presence of different tool motions. The chi-squared tests were designed to examine the presence of various tool motions on Levallois and non-Levallois convergent flake tools and the resulting values were evaluated at .05 and .01 confidence intervals.

There is no significant difference between Levallois and non-Levallois for any site or assemblage in Table 7.7 at the .01 confidence interval. Qafzeh XV is on the borderline of acceptance at this level. Both Qafzeh XV and Tabun IX are significant at a .05 interval. The very low representation of scraping among a number of the assemblages meant that only five groups could be examined when scraping was added as a fourth variable to the chi-squared analysis (Table 7.8). Nahr Ibrahim North Gallery and Qafzeh XV are significant at the .01 confidence interval while Nahr Ibrahim Central Gallery is significant at the .05 confidence interval. Previously, Shea (1991:168-170) noted that points, flakes, and blades displayed a similar proportion of EU with cutting wear, with points having a predominance of total EU worn from piercing and hafting. Blades and oval flakes had higher proportions of EU exhibiting scraping wear. The abundance of Levallois points in the various

Levantine Mousterian assemblages provide much of the statistically significant functional variability between Levallois and non-Levallois in Shea's study (1991:175, 1995b). When he eliminated all EU on points from the Levallois group there was a dramatic decrease in the number of significant differences at the functional level between non-Levallois and Levallois artifacts. Shea suggested that there were significant differences between points and oval flakes/blades as far as the range of tasks in which these flakes were employed. This study indicates that there is not a significant functional difference among pointed artifacts in Levantine Mousterian sites or assemblages and also supports the contention that variability that is observed may be related to the abundance of Levallois convergent tools (including points) versus similar non-Levallois tools in an assemblage (see Shea 1991, 1995b). The abundance of Levallois points from sites along the coastal margin and northern Levantine area are significantly lower than along the environmentally marginal interior areas (Shea 1991, 1995b). There is as yet no solid comparative data from the North and Central Galleries that could be used to place Nahr Ibrahim within the scenario of less Levallois point production along the coastal and northern regions. However, during my selection of material for this study I made a complete examination of the entire collection from both galleries. My impression at the end of sample selection was that there were fewer than expected Levallois points from each gallery (North Gallery: 16; Central Gallery 20). When these counts are compared to those provided by Shea (1995:280), especially for sites within the marginal interior zones, the totals from Nahr Ibrahim fall within the range for the Northern Levantine Interior Group (Shea 1995b:287).

Minor Tool Motions of Convergent Tools from Levantine Mousterian Sites

A number of individual EU from various sites were utilized in tasks requiring such tool motions as shaving, chopping, graving, drilling, planing, and adzing. The scarcity of EU attributed to these tool motions is used to infer that they are not

representative of the common range of tasks associated with Levallois or non-Levallois convergent tools. In such cases these tool motions, where present, may represent the expedient use of tools at hand to accomplish a particular task. Basic counts of EU associated with each of these tool motions are provided in Table 7.9. This data also supports inferences for convergent tools serving a very narrowly defined range of functions and Shea's initial interpretations that blank shape is related to types of tool use (1991:168). More edges were employed in tasks requiring shaving (n=34) than any other minor motion. Graving tool motions were next in abundance (n=11) followed by chopping (n=3), drilling and adzing (n=2 each) and planing (n=1).

Relationship of Tool Motion to Worked Material

In order to develop behavioral inferences based upon use-wear it is necessary to extract information pertaining to the material worked by individuals using stone tools. The identification of worked material in this study is not based upon strictly constructed experiments but upon a broad theoretical knowledge of use-wear formation and the properties of different materials manipulated by individuals using stone tools. This knowledge is drawn from an extensive body of experimental and archaeological studies of use-wear formation associated with a variety of tool motions and worked materials (Hayden 1981; Keeley 1980; Odell 1977; Panagopolou 1985; Semenov 1964; Shafer 1983; Shea 1991; Vaughan 1985). The specifics for worked material identification follow those employed by Shea (1991, 1995a) in his analysis of stone tools from several Levantine Mousterian sites. The purpose of following his methodology is to provide a structural framework for this comparative study.

The use of low-power magnification in this analysis precluded the specific identification of worked materials as was done by Keeley (1980) and Vaughan (1985). Rather, following Shea (1991, 1995a) an approach based upon recognition of the general resistance and silica content of the worked material was employed.

Table 7.9. Minor tool motions associated with convergent tools from Levantine Mousterian sites. All data calculated from Shea (1991) except for Nahr Ibrahim and Shanidar.

Site	Shave	Chop	Grave	Drill	Plane	Adze
Hayonim E	2					
Kebara IX	1					
Kebara X	1	1	3			
Kebara XD	2					
Kebara XI	4	2	2			
Kebara XII	3					
Nahr Ibrahim Central Gallery	2		2			
Nahr Ibrahim North Gallery	1			1	1	
Qafzeh XV	6					
Qafzeh XVII			1			
Shanidar				1		1
Tabun IB						1
Tabun IC						
Tabun II	1		1			
Tabun IX	5	1				

Table 7.10 provides information pertaining to the inferred hardness or resistance of worked material based upon use-wear criteria and silica content. Inferences of worked material are also based upon the character or brightness of the polish along the tool used edge.

Table 7.10. Categories of worked material utilized in this study. These materials are based on results of numerous experiments conducted by Shea (1991:Table 3.2).

Material Resistance	Low Silica	Medium Silica	High Silica
Yielding	Soft	Soft	Soft
	Animal	Vegetal	Inorganic
Semi-rigid	Medium	Medium	Medium
	Animal	Vegetal	Inorganic
Rigid	Hard	Hard	Hard
	Animal	Vegetal	Inorganic

Material resistance and silica content vary with worked material (Table 7.11) and influence the general use-wear characteristics associated with a worn tool edge. Materials with low or no silica content are characterized by matte polishes while moderate and high silica content produce bright and vitreous polishes, respectively. Fracture characteristics of worn edges also vary with resistance properties: *yielding* materials produce more abrasive wear than microfracturing and microfractures are typically small (< 1mm) with feather terminations; *semi-rigid* materials have roughly equal proportions of abrasion and microfracturing and microfractures are medium (1-2mm) with a mix of feather, step, and hinge terminations; *rigid* materials produce a greater incidence of microfracturing than abrasion with large (2-5mm) hinge and step-terminated microfractures.

Table 7.12 provides data on the number of EU of all samples combined that are associated with various worked materials processed by an array of tool motions. There are a total of 1647 EU represented. The following tool motion and worked

material combinations represent 72.5 percent of all tool use: cut and medium animal (26.4 percent), projectile impact and unknown material (19.9 percent) and haft contact (26.1 percent). With the exception of other minor tool motions and worked materials, Table 7.12 indicates that convergent implements were primarily employed as hafted and unhafted butchering tools and hafting hunting weapons. The patterns of association between tool motion and worked material are discussed below.

The most common worked materials represented by use traces on convergent tools are medium animal, medium vegetal, hard vegetal, and soft animal (Table 7.13). Medium animal represents 31.5 percent of all EU from all sites combined. Medium vegetal represents 6.9 percent; hard vegetal 3.5 percent; and soft animal only 2.7 percent. These data can be used to argue for a high degree of not only functional but also task specificity for Levantine Mousterian convergent tools.

Table 7.11. Specific examples of worked materials according to silica content and material resistance properties (adapted from Shea 1995a:Table 6.3).

Resistance/Silica	Low Silica	Medium Silica	High Silica
Yielding	Skin (fresh)	Roots and tubers	Grasses
	Meat, fat	Reeds	Bamboo (fresh)
	Hair		Sand
Semi-rigid	Skin (dried)	Soft woods	Sand
	Dried meat	Oak	Clay
	Soaked or boiled antler, bone.	Birch	Silt
		Maple	
Rigid	Bone (fresh)	Dried and seasoned	
	Antler	woods	Stones
	Horn	Tropical hardwood	
	Ivory		

Table 7.12. Summaries of tool motion (TM) and worked material (WM) for all sites.

TM	SA	SV	IS	MA	MV	IM	HA	HV	IH	HC	UK	Total
Cut	35	3		435	45	5	57	27			5	612
Shave	2			6	12	2		2				24
Scrape	8	4	2	43	28	1	34	17	3		5	145
Plane					1							1
Chop							1				2	3
Adze					1				1			2
Wedge					2							2
Projectile											327	327
Haft										430		430
Awl	2			42	18	2	1	9			1	75
Engrave					4	1	5	1				11
Drill					1						1	2
Unknown				4					2		7	13

Worked material categories include the following: SA = soft animal, SV = soft vegetal, IS = indeterminate soft, MA = medium animal, MV = medium vegetal, IM = indeterminate medium, HA = hard animal, HV = hard vegetal, IH = indeterminate hard, HC = hafting, UK = unknown

Table 7.13. Summary of worked materials from each site in the study sample.

Assemblage	SA	SV	IS	MA	MV	IM	HA	HV	HI	IH	HC	UK	TOTALS
Hayonim E	2	1	2	52	8	1	9	14	---	---	42	30	162
Kebara IX	---	---	---	10	2	1	5	3	---	---	11	8	40
Kebara X	---	3	---	36	17	---	8	2	1	---	38	33	138
Kebara XD	---	---	---	53	8	3	5	2	---	---	33	29	133
Kebara XI	5	---	---	42	9	---	8	3	---	2	52	51	172
Kebara XII	---	2	---	8	3	---	---	1	---	---	23	14	51
Kebara XIII	---	---	---	2	---	---	---	---	---	---	3	3	8
Central Gallery	8	---	---	67	14	---	14	3	1	2	32	18	159
North Gallery	11	---	---	84	5	---	21	3	1	---	37	16	179
Qafzeh XIX	---	---	---	---	---	---	---	---	---	---	1	1	2
Qafzeh XV	11	---	---	63	20	---	9	9	---	---	72	62	246
Qafzeh XVII	1	---	---	5	---	1	---	1	1	---	4	2	15
Qafzeh XVIII	---	---	---	5	---	---	1	---	---	---	2	---	8
Shanidar	---	2	2	19	1	4	12	11	---	1	10	14	76
Tabun IB	---	---	---	1	1	---	---	---	---	---	1	5	11
Tabun IC	3	---	---	6	4	---	1	1	---	1	6	4	26
Tabun II	2	---	1	5	2	---	2	1	---	---	10	12	35
Tabun IX	1	---	---	37	18	2	6	5	---	---	33	23	125
Tor Faraj C	2	---	---	33	3	2	2	---	---	---	20	28	90

The proportions of various worked materials vary between sites (Table 7.13). Hayonim E has 32 percent of all EU associated with medium animal materials. The total proportion of vegetal material (hard, medium, soft) at Hayonim E is 14.2 percent.

The range of values for medium animal materials at Kebara vary from 15.7 percent (Kebara XII) to 39.8 percent (Kebara XI). Kebara XII (24.4 percent), IX (25 percent), and X (26 percent) are quite similar in their proportions of this worked material group. Kebara XD and XI have 7.5 and 7 percent of all EU associated with vegetal material. Kebara IX, X, and XII percentages for vegetal material range from 11.8 to 15.9 percent.

The Central and North Galleries at Nahr Ibrahim have higher proportions of EU worn from medium animal materials (42.1 percent and 46.9 percent, respectively). The Central Gallery is higher in vegetal materials (10.7 percent) than the North Gallery (4.5 percent) but the difference is not statistically significant. Both galleries also have 20 percent of EU with haft contact.

The proportion of medium animal materials at Qafzeh XV is 25.6 percent (similar to percentages from Kebara X, XI, and IX). Total vegetal materials are 11.7 percent of all EU. Shea (1991:131) noted that Qafzeh XV resembled Tabun B/Phase 3 assemblages. Kebara A, XI, and IX are also Tabun B suggesting a possible technological/functional relationship.

Shanidar Cave does not differ significantly from the Levantine Mousterian assemblages. Medium animal represents 25 percent of all EU. The combined value of all vegetal materials is 17.1 percent. At least in terms of these major worked materials there does not appear to be any great difference between Shanidar and other assemblages. Proportions of other worked materials are also comparable.

Tabun IC (Tabun C/Phase 2) yielded 23 percent of all EU attributable to medium animal materials. Tabun IX (Tabun D/Phase 1) had 29.6 percent medium animal type wear. The percentage of vegetal materials for Tabun IX is 18.4 percent.

Tor Faraj C (Tabun D/Phase 1) is almost entirely dominated by medium animal worn EU (36.6 percent) with almost no EU worn from vegetal materials. Only 7.2 percent of EU were employed in processing materials other than medium animal. This value does not include haft wear or unknown materials.

Briefly, from Table 7.13 it can be seen that the majority of EU from all sites were employed against materials of the low to medium silica range and the semi-rigid to rigid resistance range. It is apparent that Levantine Mousterian convergent tools were employed in a variety of tasks involving the procurement and processing of animal and vegetal materials. The range of tasks would include those incorporated under the rubric of extractive and maintenance tasks (see below).

Using Tool Motion and Worked Material to Infer Activities

Shea (1991:140) used a series of twelve activity or task groups to examine behavioral differences associated with different Levantine Mousterian tool types. These activity groups are based upon inferences from worked material and tool motions. Only ten of his original twelve groupings are applicable to the present study (Table 7.14). EU associated with unknown tool motions or inferred activities are not included in Table 7.14.

The results of Table 7.14 clearly indicate that convergent tools are associated with particular activities. The inferred activities are grouped into extractive and maintenance task sets (following Shea 1991). Extractive tasks are those directly associated with food procurement and food processing while maintenance tasks include various tool production and repair situations (Shea 1991:158).

Extractive Activities

Projectile Impact

Shea (1991:141-145) initially confirmed the use of convergent tools as hafted hunting weapons for the Levantine Mousterian. Shea's research has demonstrated

Table 7.14. Number of EU associated with different activities from selected sites/assemblages. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Site/assemblage	Extractive Task Set					Maintenance Task Set				
	PI	BC	BT	HF	SP	HW	LW	SC	SK	HD
Hayonim E	30	8	45	42	---	---	24	---	---	10
Kebara IX	8	5	8	11	---	---	5	---	---	2
Kebara XD	33	8	29	38	3	1	18	---	---	9
Kebara XI	29	5	46	33	---	---	10	---	---	7
Kebara XII	17	---	10	26	2	---	4	---	---	---
Nahr Ibrahim Central Gallery	12	15	57	32	---	---	17	---	1	15
Nahr Ibrahim North Gallery	12	21	80	37	---	---	9	---	1	13
Qafzeh XV	62	11	48	72	---	1	29	---	---	30
Shanidar	6	2	21	10	2	1	11	---	---	8
Tabun IC	4	1	8	24	---	---	5	---	---	1
Tabun II	12	2	4	10	---	---	3	---	---	3
Tabun IX	23	4	24	33	---	---	24	---	---	13
Tor Faraj C	27	2	35	20	---	---	3	---	---	---

that it may be a misnomer to apply the term "projectile" in reference to these artifacts because the same damage pattern can accrue on hafted points used as daggers and thrusting spears in addition to hand thrown spears.

Other evidence for technologically assisted hunting during the Lower and Middle Paleolithic comes from Clacton, England and Lehringen, Germany (Movius 1954; Oakley et al. 1977). The preserved wooden spear from Clacton dates to roughly 350,000 B.P. (Mellars 1996:227) and was manufactured of yew. The wood species for the Lehringen specimen has not been identified but dates to the last interglacial (Mellars 1996:227). Callow (1986) identified unique distal fractures on pointed tools from La Cotte de St. Brelade, Channel Islands. Pointed flakes-blades from Middle Stone Age deposits at Klasies River Mouth in South Africa have been interpreted as projectile points by Singer and Wymer (1982:60-64). The sites of Nahr Ibrahim, Lebanon and Shanidar, Iraq can now be added to this growing body of evidence.

Impact damage is associated with 8.1 percent of all EU on convergent tools in the Central Gallery and 6.9 percent of all similar EU from the North Gallery at Nahr Ibrahim. Shanidar Cave yielded impact damage on 9.8 percent of all observed EU in that sample. Impact wear can be recognized by a distinctive variety of fractures (Dockall 1997, in press) which were observed on specimens from Nahr Ibrahim and Shanidar. Characteristic damage traces include distal macrofracture and/or crushing (Figures 7.13A-B and 7.14A). Macrofractures are usually greater than 5 mm in length and may propagate along a lateral edge or longitudinally down the dorsal or ventral face of the point. Occasional accessory wear traces include spin-off fractures (Figure 7.14B) and linear polishes (Figure 7.15) identified by experimental and archaeological studies (Fischer et al. 1984). Proximal damage was identified on some specimens from Nahr Ibrahim with associated distal impact traces. Proximal damage results upon impact as the shaft of the spear is forcibly seated against the point base or as the point moves within the haft element. Identical wear traces have

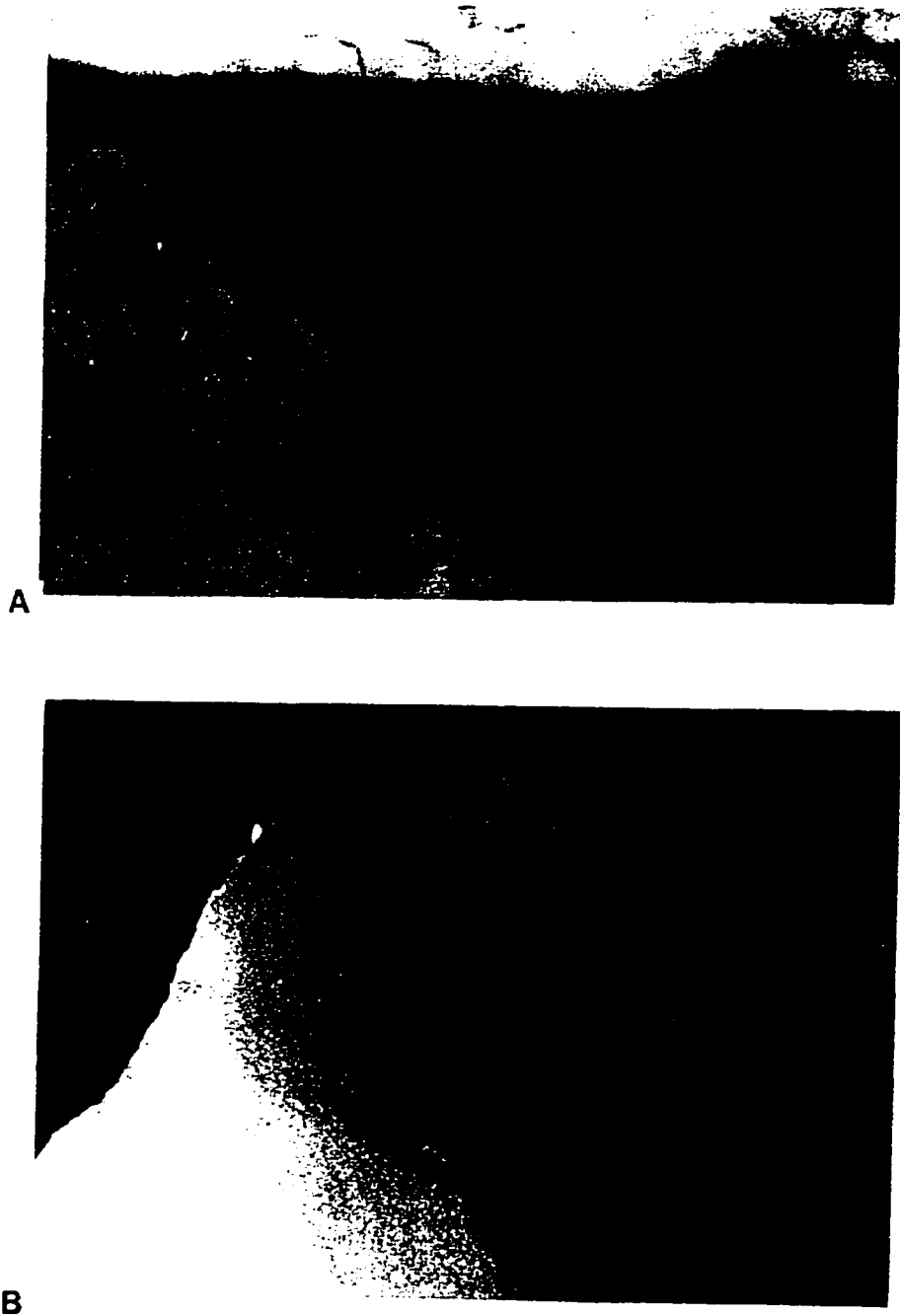


Figure 7.13. Microphotographs of projectile impact damage. (A) Longitudinal macrofracture on a transverse break on NI 426-61 (width of field 35 mm). (B) Lateral macrofracture on NI 612-66 (width of field 35 mm).

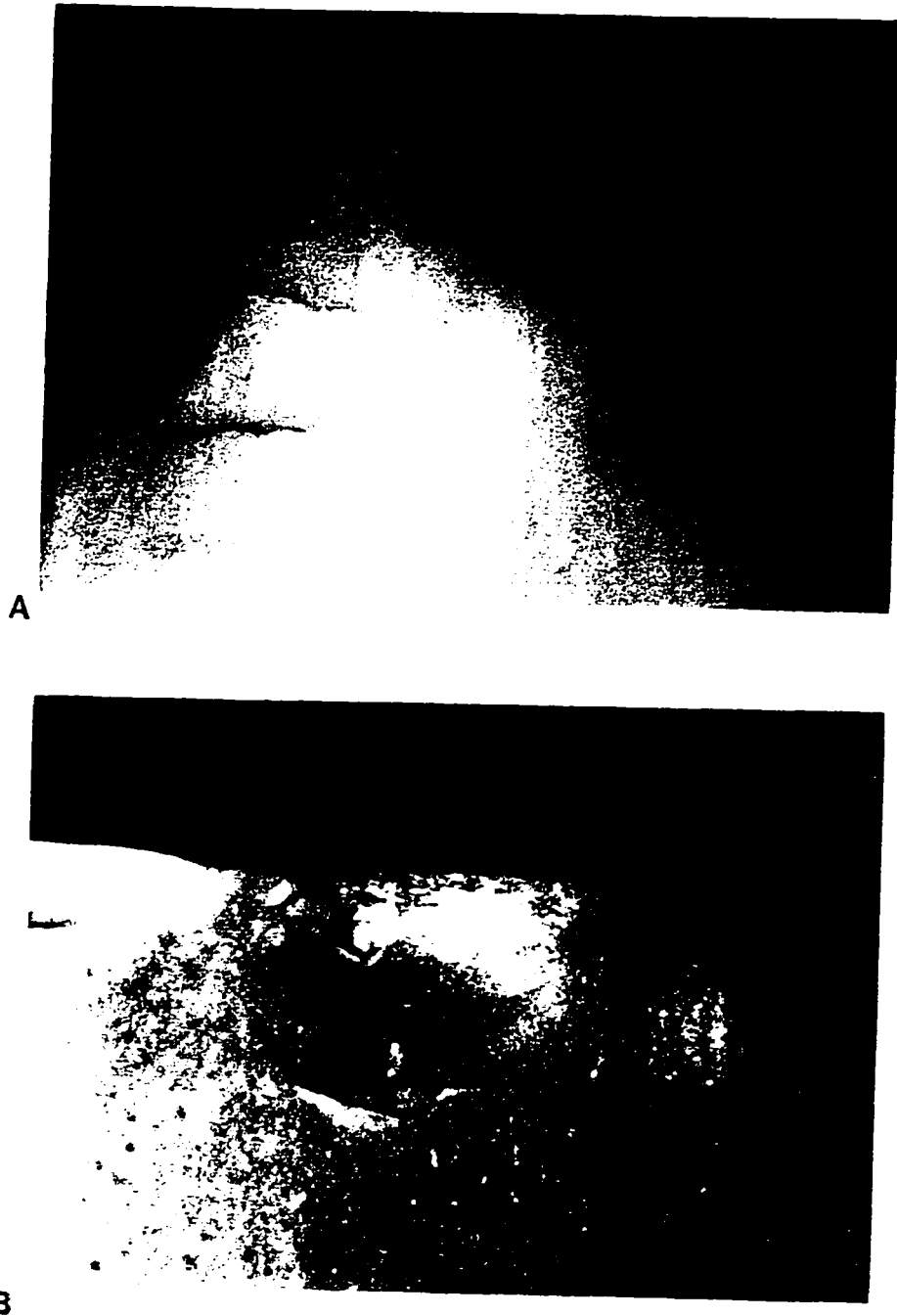


Figure 7.14. Microphotographs of additional types of projectile impact damage. (A) Distal crushing and step fractures on NI 426-63 (width of field 35 mm). (B) Spin-off fractures originating from a transverse fracture on NI 426-61 (width of field 35 mm).



Figure 7.15. Microphotograph of linear impact polish on polar coordinates 810 of NI 475-29. A lateral macrofracture runs along the left edge (width of field 35 mm).

been identified both archaeologically and experimentally on unmodified flakes and bifaces used as projectile points (Odell and Cowan 1986). Hafting wear was consistently associated with impact traces at Nahr Ibrahim and Shanidar. Shea (1991) also demonstrated a positive correlation between the presence of hafting and impact damage at other Levantine Mousterian sites in the Levant.

The design and hafting of these weapons is critical to interpretations of use. The proximal dimensions of Levantine Mousterian convergent tools generally preclude the possible use of a foreshaft/mainshaft composite weapon design. Henry (1995a:121) recently hypothesized that benefits of a foreshaft (decreased mainshaft breakage) could have been achieved by loosely mounting points to a single mainshaft. In so doing, damaged tips of thrusting and throwing spears could have been replaced quickly in the field with some type of mastic. This hypothesis is offered by Henry as an explanation for low breakage rates of points from Tor Sabiha and Tor Faraj, Jordan. If points had been securely mounted then it would be expected that more broken points would have been returned to camps. Based on this interpretation Henry (1995a:121) suggested that foreshafts and secure mounting were not associated with the use of Levallois points as hunting weapons.

There are several lines of inquiry that can be used to bring Henry's interpretation of weapons design into question based on use-wear and weapons design parameters:

- (1) Loose mounting and bindings would impose a greater chance of failure in prey acquisition through a misdirected hit. The point may not be secure enough for a felling or lethal wound, especially if used in the role of a thrusting weapon where force is extremely critical to puncture thick hides. Failure at close range during hunting is not an option especially if the game animal is large-sized and the design of hunting weapons is constrained by the ever-present chance of failure (Bleed 1986).

(2) The use of a mastic and no wrapping will not allow a quick re-arming if the hunter must quickly pursue or flee a wounded animal. Mastics must usually be heated and then allowed to harden to secure the point sufficiently for use. Mastic alone is often not sufficient for close-in or encounter hunting.

(3) Henry ignores the hafting evidence of bindings on points from elsewhere in the Levant.

(4) Thus far, there has been no mention in the literature of adhering mastic residues on points or point fragments from Middle Paleolithic sites. This is not to say that mastic was not used in conjunction with bindings.

Briefly, the technological parameters discussed in Chapter 6 can be used to develop a model of suitability of convergent tools as hafted hunting weapons:

(1) Symmetry of shape produces a sharp point at the distal end of converging lateral edges.

(2) The central dorsal ridge from the tip toward the diverging ridges may yield more strength and resistance to breakage across the tip and medial portion of the point.

(3) The prepared butt is designed to produce a wide proximal end and yet maintain a certain standard of width/thickness.

Point size does not seem to have been as critical as width/thickness and symmetry. The importance of symmetry is suggested by some tools which have only minimal distal modification on one or both edges. Usually this modification is just enough to bring the tip in line with the long axis of the point.

The manufacture technique to produce a wide butt and convergence at the tip means that a significant portion of the point would have been in the haft. The result would be that the retouch of damaged specimens was not as feasible as replacement--even if only minimally damaged. This would account for some points only minimally damaged and then discarded and is applicable to both Zagros and Levantine Mousterian convergent tools.

The convergence of Levallois points and other pointed tools and flakes is not well-suited for most scraping tasks (Shea 1995b:282). Consequently, the piercing property of pointed tools was probably the desired aspect of their morphology. The hafting of the proximal end and thick bulb of percussion would have been a significant design variable to overcome. According to Shea (1995b:285-286) one of the more feasible ways to haft convergent tools is to employ a shaft with a shelf (Figure 7.16 upper row) rather than a split socket. The use of mastic and/or bindings would then be used to hold the point in place. Occasionally, the dorsal or ventral surface of the proximal end could be retouched to make hafting easier. An alternative method of hafting that would produce the same pattern of haft wear (Figure 7.16 lower row) is to bind the convergent tool sideways in a split handle.

Experiments have demonstrated that Levallois points serve as efficient hafted hunting weapons (Shea 1991, 1995b) but had short use-lives. He further suggested that these types of weapons would have been well-suited for groups that did not rely heavily on spear points or manufacture and transport them frequently. Shea (1995b:286) has attributed the design of these weapons as akin to reliable systems following Bleed (1986) and not to maintainable technological systems.

However, I would argue that aspects of both maintainability and reliability can be inferred for weapon design in this case. Certainly these implements were not overdesigned and were easily transported and repaired. Depending on the situation they could be easily field repaired. Due to the difficulty of operationalizing a number of Bleed's (1986) criteria this is difficult to evaluate. Following Hayden et al (1996), certain aspects of tool design and use constraints can be proposed for this task.

Stone Weapon Tip Task Constraints

Even at their most basic, these types of hunting weapons are designed to procure needed animal resources and serve on occasion as instruments of defense and

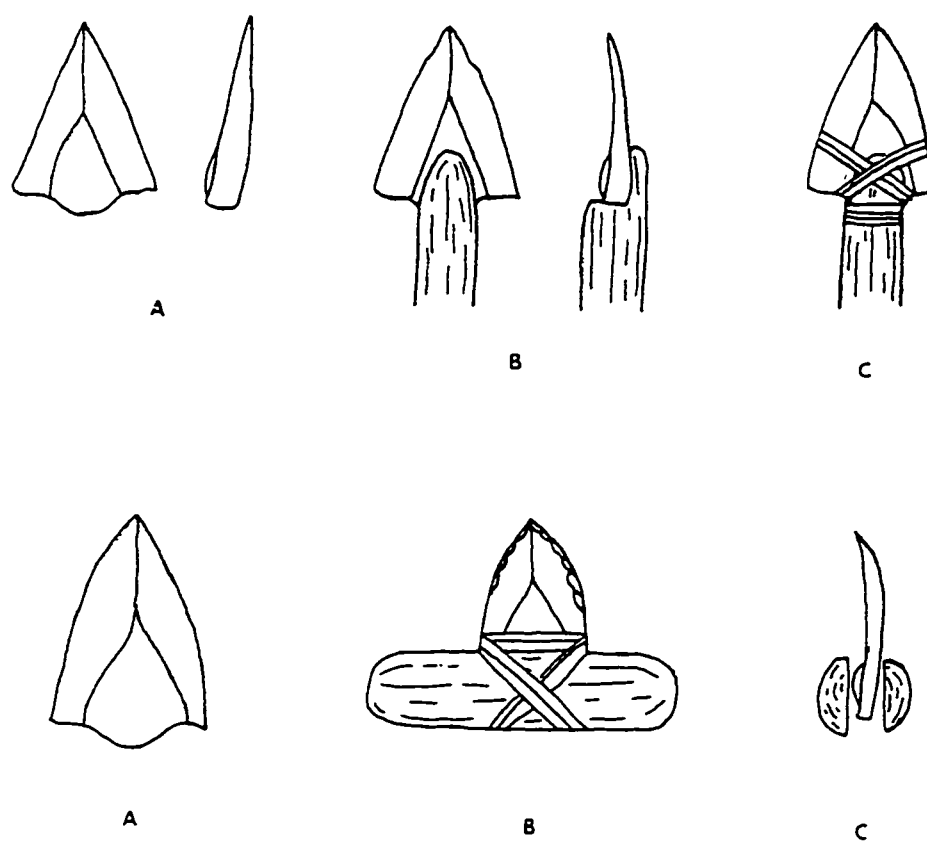


Figure 7.16. Schematic of probable method of mounting and hafting convergent tools as hunting weapons or cutting tools. Upper row: (A) unhafted convergent tool; (B) convergent tool in place on shelf at end of mainshaft; (C) mode of wrapping bindings. Lower row: (A) unhafted convergent tool; (B) method of hafting in split handle with bindings in place; (C) cross-section view of convergent tools in split-stick haft (bindings removed).

offense. Mellars (1996:227-244) provides a summary of ample evidence from Europe for a range of hunting strategies and sophistication in procuring large game during the Middle Paleolithic. Studies by Lieberman and Shea (1994) suggest a similar record for the Levantine Mousterian. Even if employed on a sporadic basis, the hunting weapon must be designed to be dependable.

Stone Weapon Tip Material Constraints

Raw material of suitable size and quality to produce points of sufficient size for hafting and efficiency in taking prey are the only constraints in this regard.

Stone Weapon Tip Technological Constraints

The manufacture of suitable flakes involved the production of Levallois points and suitable non-Levallois flakes. This suggests that although manufacture could involve considerable preparation of Levallois cores the likelihood also existed that other suitable flakes were selected from Levallois and non-Levallois debitage. Size, shape, and distal convergent were important. Lateral edges are usually acute to provide for penetration and cutting. It is assumed that there is a considerable skill level associated with the manufacture of Levallois points. Skill-level of non-Levallois convergent flakes is considered lower but a number of them may be by-products of the Levallois strategy. Suitable blanks could also have been procured from midden context.

Distal convergence and broad proximal dimensions mean that there is little room for repair of broken implements. Shea (1991:141) identified retouch on only 9.4 percent of all projectile impact EU. This study had documented retouch on 18.7 percent of all EU with projectile impact in Levantine Mousterian samples. Shanidar is not included in this figure but all impact-damaged specimens from there were retouched. Ease of weapon replacement must be considered important when employing flakes that have a potentially short use-life such as projectile points.

Width and thickness were also critical variables in blank production that guided overall size and shape. Tool morphology also placed limitations on hafting possibilities.

Stone Weapon Tip Transport and Mobility Constraints

Hafting patterns and the archaeological record do not support the presence of foreshaft technology in the Levantine Mousterian. Holdaway (1989:80) argued that if a particular tool category also included items used as hafted projectile points then there should be a greater number of proximal than dorsal fragments in habitation sites. Citing examples from bifacial hunting technology in North America, Holdaway further argued that Levantine and Zagros Mousterian data do not fit the expected discard pattern for hafted projectile points. Specimens from Nahr Ibrahim and Shanidar that exhibit projectile impact damage have that damage confined mainly to the distal area with little proximal breakage. Projectile impact damaged specimens illustrated by Shea (1991) also have wear confined mainly to the distal region with no failures closer to the hafted end.

Holdaway's (1989) discard model is based on discard patterns of bifacial hunting technology employing the use of both foreshaft and spearthrower. The postponement of in-field repair of damaged weapons could only have been possible if the Mousterian tool users either carried a mainshaft and foreshaft or several spears with the point mounted directly to the end of a single mainshaft (Solecki 1992:210). Minor damage can be repaired with the point still hafted but major damage necessitates unhafting for repair or replacement.

Evidence thus far for the Middle Paleolithic argues for some form of close-in or encounter hunting in addition to scavenging strategies. Spear throwers and foreshafts seem to be a later development of the Upper Paleolithic (Mellars 1996:228). Given the difficulty for one individual to handle several spears, Middle Paleolithic hominids must have employed some method of repair. Also, thrusting or

short distance throwing spears would not make effective weapons against animals such as gazelle. The most likely targets of Levantine Mousterian hunters were ibex, auroch, red deer, fallow deer and other animals of similar size (Shea 1991:144). Shea has suggested that poisons of various types may have been employed as an additional hunting tactic. Cooperative group hunts would have allowed hunters to carry less weaponry during the hunt if the replaceable foreshaft was not present.

Butchery

The tool motions of cutting, scraping, and shaving of soft and medium animal materials (Figure 7.17A-B) are included in all butchery EU (see Shea 1991:145). Shea distinguished between EU of butchery and hide-working on the basis of intensity of striations and edge-rounding. I also attempted to employ this general criterion in my analysis and some degree of interanalyst error is inevitable.

All assemblages except Qafzeh XXIV had EU attributed to butchery (Shea 1991). The proportion of these EU among the various assemblages ranged from 10 to 25 percent. Butchery EU among convergent tools ranges from 11.8 to 46.2 percent for the assemblages compared to 27.5 percent for all pooled assemblages.

Shea (1991:146) identified a slight positive correlation between the abundance of EU with projectile impact and those with cutting that suggested a possible behavioral link between these activities at sites. Acknowledging the problems inherent with sample size and recovery techniques, this correlation can be investigated for convergent tools (Figure 7.18). Figure 7.18 indicates a rather negative correlation between the Log percentage of butchery EU and Log percentage of impact EU for assemblages in this study. The R-square value (.40) indicates that roughly 40 percent of the variability can be explained by the EU data. The general pattern mimics what is described in the literature regarding differences between butchery and hunting tasks among ethnographically studied groups (Shea 1991:146). This pattern (Figure 7.18) cannot be entirely attributed to different locales of game

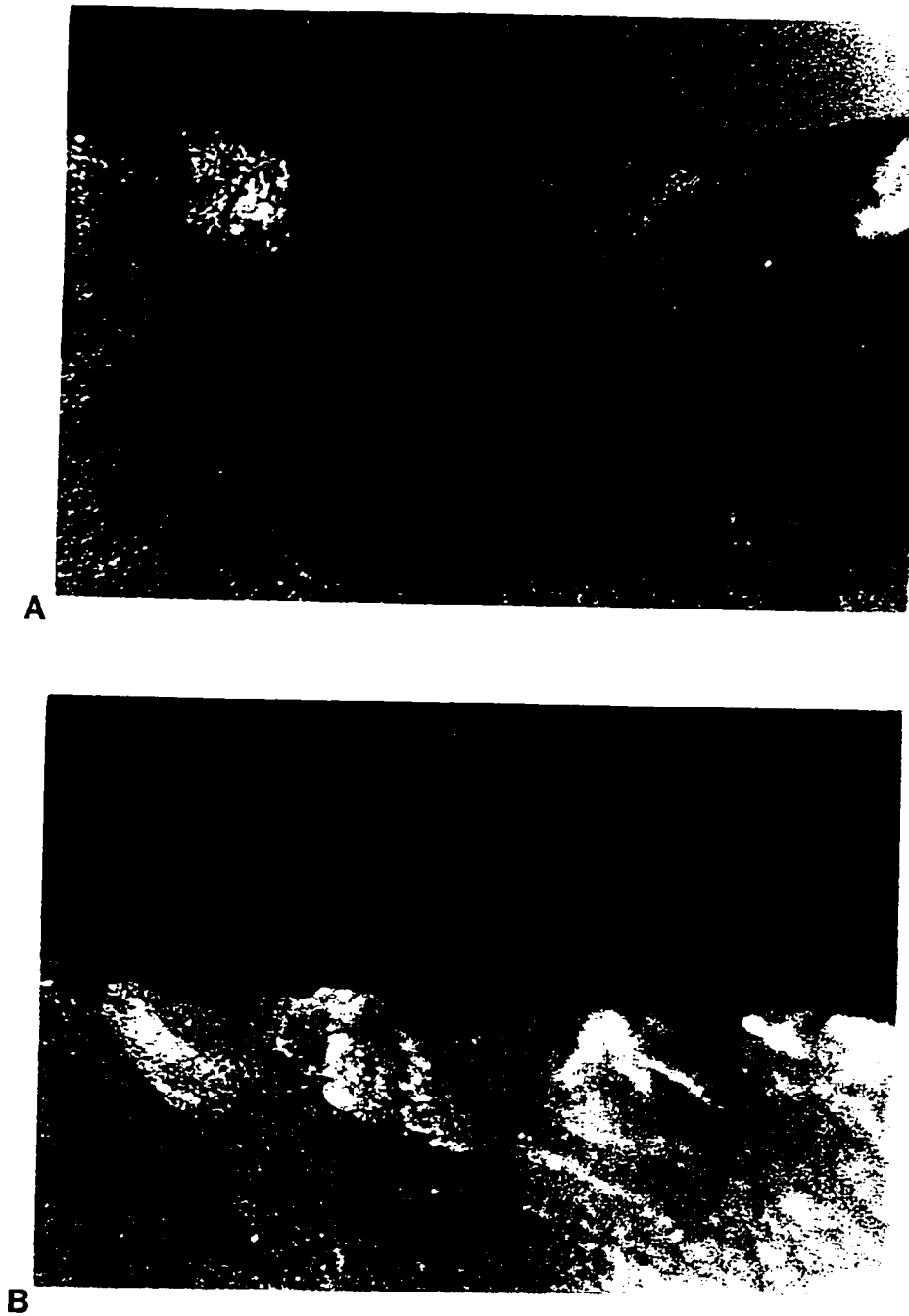


Figure 7.17. Microphotographs of cutting wear associated with a medium-animal material. Both photographs illustrate bifacial, obliquely-oriented microscars with mixed hinge/step terminations, matte polish, and edge-blunting. Specimen NI 64-49. (A) width of field 8.7 mm; (B) width of field 17.5 mm.

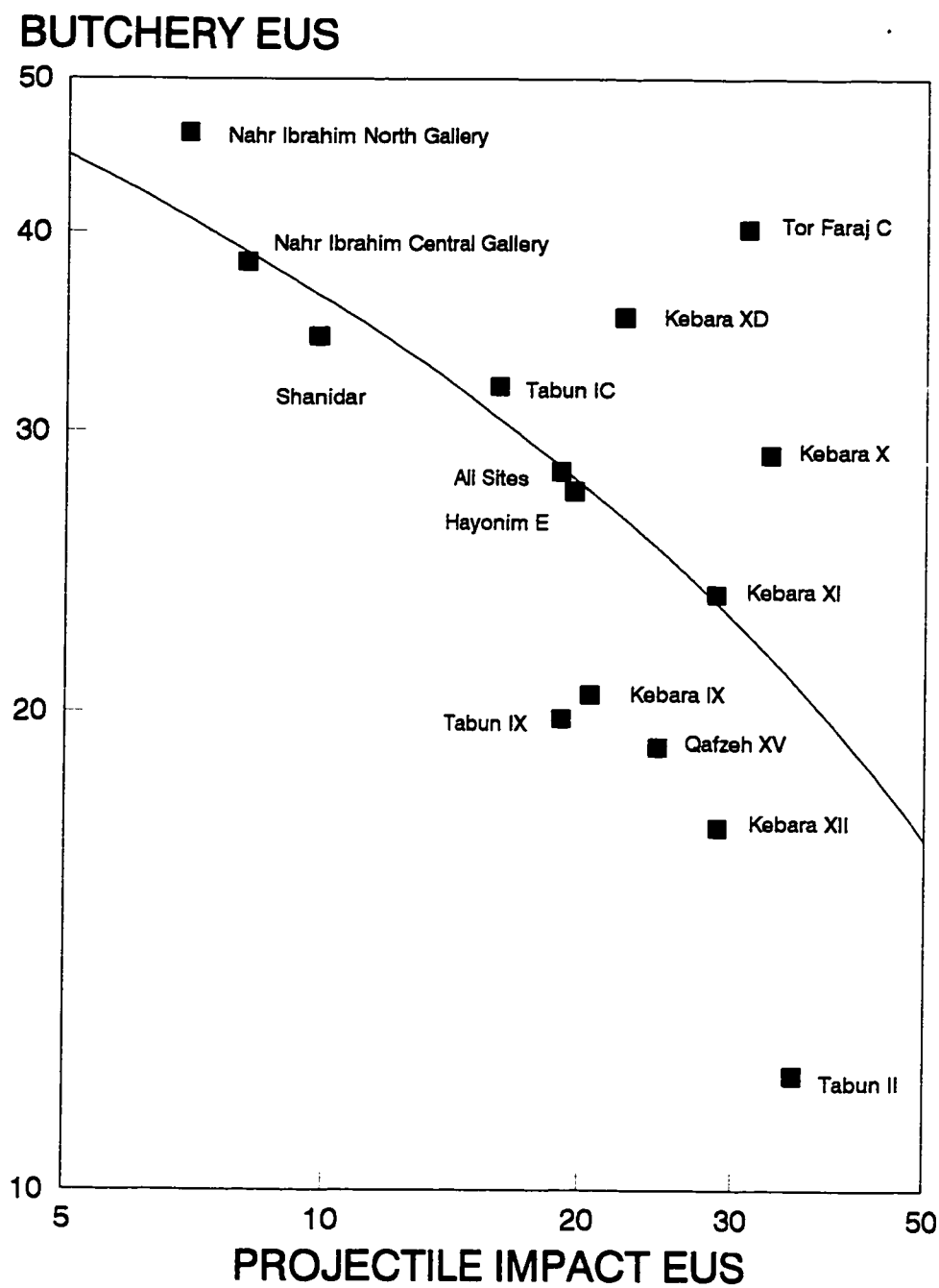


Figure 7.18. Log plot of the abundance of projectile impact and butchery EU from all sites. All data calculated from Shea (1991) except for Nahr Ibrahim and Shanidar.

processing and game procurement or discard rates and discard location. To reiterate Shea (1991), some of the observed functional variability of pointed tools is due to differences in production rates of convergent flakes to other flake types. It can also be a reflection of the selection of certain flakes for tasks and the rate at which those tasks were performed. Differences in the volume of material processed at a particular site would also influence these patterns (see Hayden et al. 1996).

Other studies have also identified use-worn implements as butchering tools although it is not regarded as one of the more common inferred activities (Anderson-Gerfaud 1990:398; Beyries 1987, 1988; Grimaldi and Lemorini 1995:152). These same studies have not documented the presence of impact damaged specimens.

Butchery tools can be either hafted or unhafted. Hafted butchering tools may be related to the array of tools associated with hunting toolkits and may represent a part of the extractive toolkit that is frequently discarded away from the habitation site. A measure of the relationship between hafting and EU worn in butchering tasks is to examine the proportion of each in the assemblage (Figure 7.19) factoring in the influence of hafting on impact damaged implements. All EU from hafting of projectile points are removed from Figure 7.19. There is no specific pattern revealed and the R-square value (0.00) does nothing to explain the distribution of points about the regression line. This indicates that there is virtually no relationship between the number of butchery EU and hafting EU. Nearly all hafting is associated with projectile impact damage.

The absence of any association between hafting and butchery tools does not mean that there were no hafted butchering tools because there were a few observed in the North and Central Galleries of Nahr Ibrahim. The presence of hafting wear is a very conservative measure of the abundance of hafted tools in an assemblage. If the tool is bound in a secure haft then there may be no identifiable haft wear to accrue along the edges or surfaces.

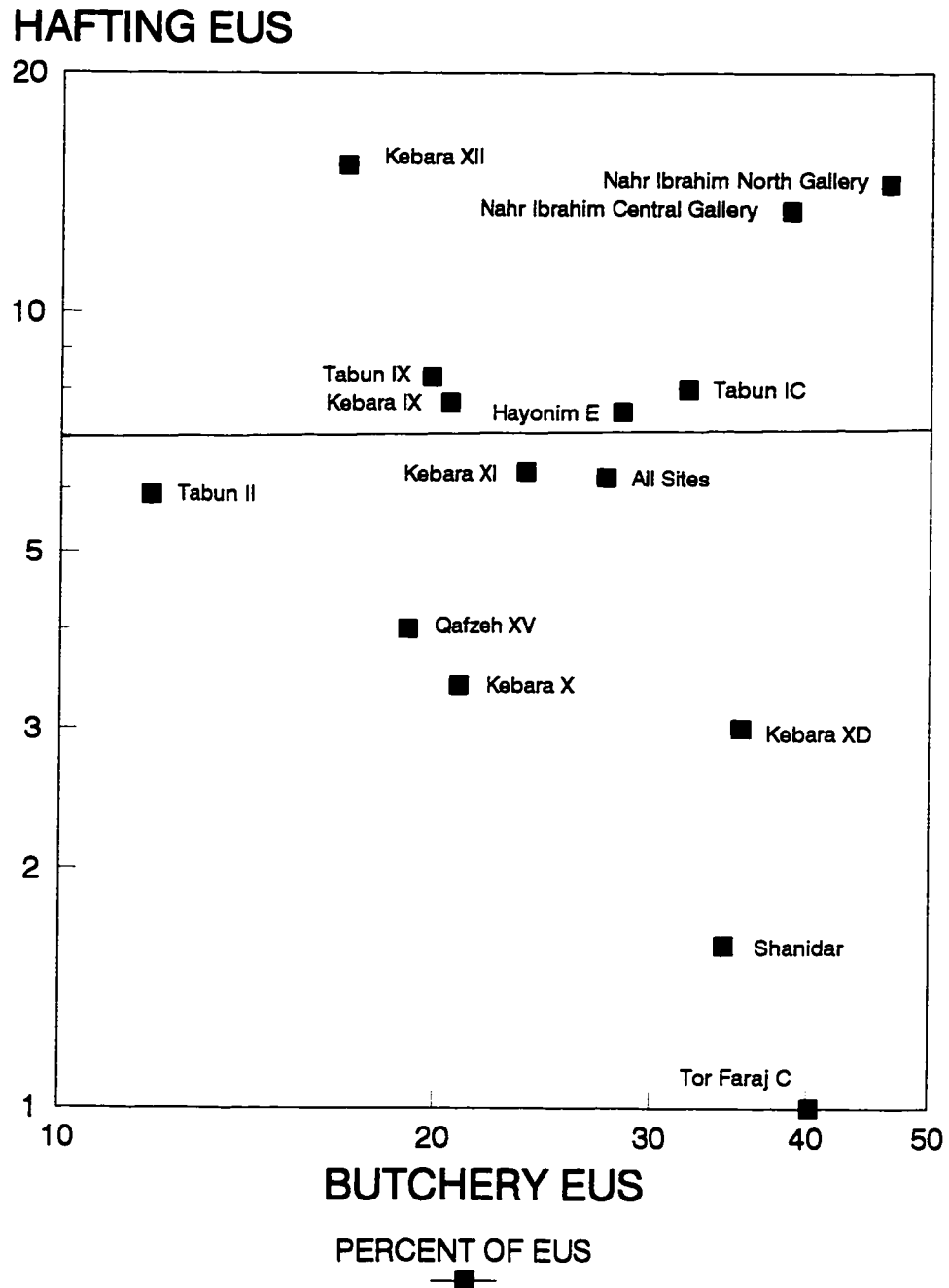


Figure 7.19. Log plot of the abundance of hafting and butchery EU from all sites. All data calculated from Shea (1991) except for Nahr Ibrahim and Shanidar.

Butchering implements are typically considered to be expediently manufactured tools prepared for the task at hand. Experiments (Frison 1979) have shown that the manufacture of a haft for butchering implements takes more time than the manufacture of the stone counterpart. Butchering an animal of medium to large size places considerable stress and wear on tools requiring these tools to be replaced or resharpened frequently. Therefore, the data suggests that unhafted flakes were both more efficient and easier to replace given their short use-lives (Frison 1968, 1974, 1979; Frison and Bradley 1980).

Butchering Implement Task Constraints

The most common butchering tool (among convergent flakes) was the unhafted Levallois or non-Levallois convergent flake. These implements were occasionally employed in butchering (cutting meat, tendon, hide, ligament, and bone) but were undoubtedly used to process resources such as hide and sinew. If all Levantine Mousterian samples are combined, a rather high proportion of all butchery EU of convergent tools exhibited some form of retouch ($n=148$ or 33.7 percent). If Shanidar is included the proportion of modified EU goes up only to 35.8 percent. The pattern of modified butchery EU is explored at the site/assemblage level below but this proportion suggests at least a low level of time investment in butchering tool maintenance; probably associated with the tool use episode and should not be interpreted as curation (also see Shea 1991:194).

Butchering Implement Material Constraints

The use of suitable raw material is the only material constraint in this use category. Additional material constraints would include similar raw materials for construction of a haft element as in projectile points.

Butchering Implement Technological Constraints

Typically these implements require little investment in manufacture time or skill except perhaps for those of Levallois technology. There is no basis to argue for a preference of either Levallois or non-Levallois flakes for use as butchering tools. A total of 73 percent (n=336) of all butchery EU are associated with Levallois artifacts but, as argued earlier, the ratio of Levallois to non-Levallois seems to be related to the abundance of such artifacts as Levallois points in an assemblage.

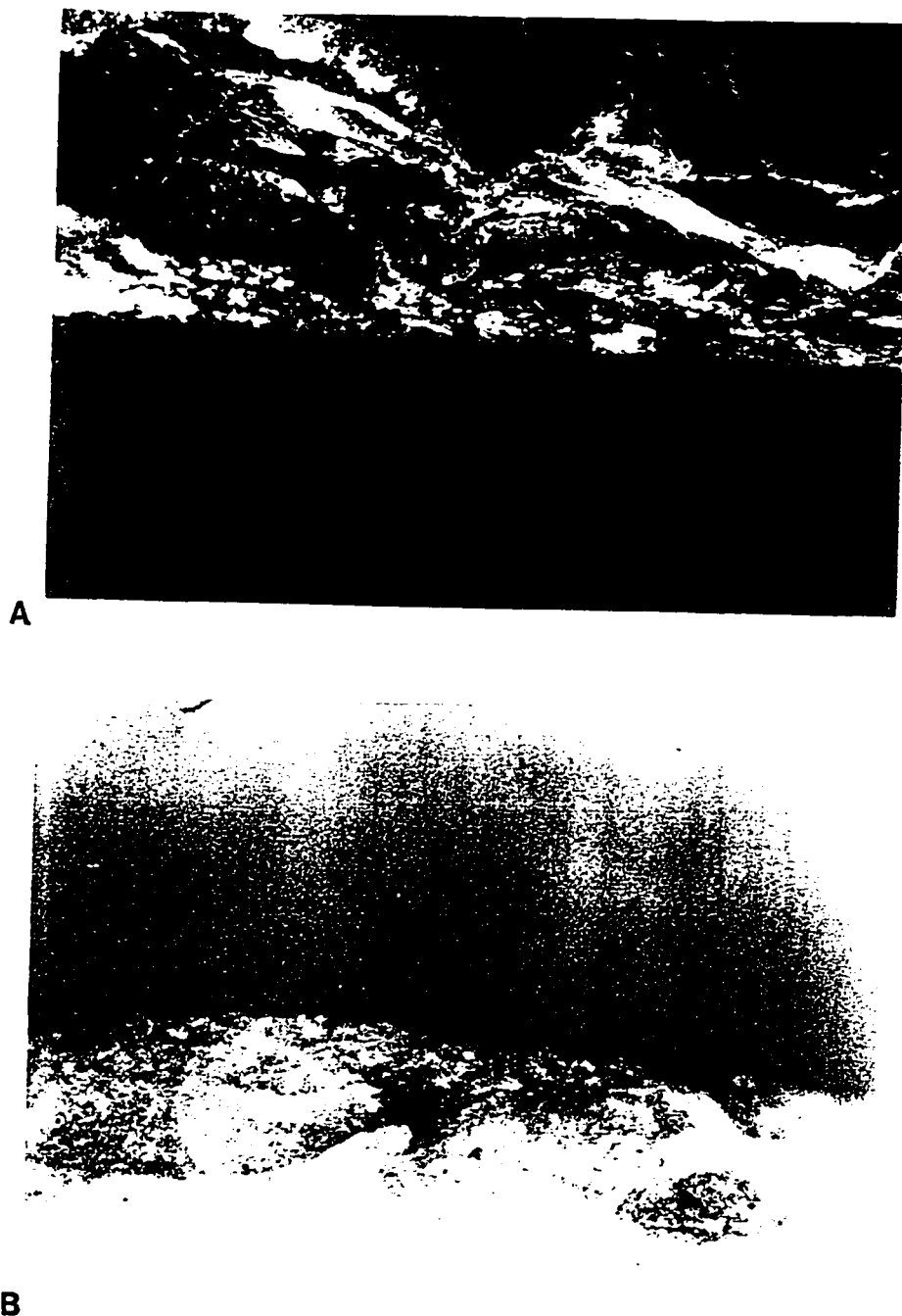
There also appears to have been an advantage of pointed flakes over blades and oval flakes for use in butchering. Shea (1991:258) identified butchery wear on 25.8 percent of all point EU compared to 15 to 20 percent for blades and oval flakes. Tool design involved the selection of appropriate convergent flakes with relatively straight lateral edges with acute angles. Maintenance was emphasized over reliability (Bleed 1986; Hayden et al. 1996).

Butchering Implement Transport Constraints

Butchery implements that are discarded at the habitation site have no transport constraints (Hayden et al. 1996:20). Consequently there were probably no constraints to consider in the design of these implements. The toolkit would have included either cores or selected flakes to employ in butchering-related activities. Such implements were also multifunctional and were occasionally used in a variety of other maintenance related tasks: plant processing, woodworking, scraping. Costs of these implements in terms of individual carrying capacity would have been low.

Bone Contact

This category includes all EU worn from use against hard animal material inclusive of bone, antler, horn, and possibly frozen meat. Bone contact (Figure 7.20 and 7.21) resulted from butchery, bone carving, manufacture of bone implements, or processing frozen or dried animal carcasses (Shea 1991:148). Evidence for bone



B

Figure 7.20. Microphotographs of bone contact wear. (A) Unifacial perpendicular microscars with hing/step terminations on lateral edge of NI 555-51. A matte polish is present on areas of topographic relief (width of field 8.5 mm). (B) Oblique bifacial step-terminated microscars and pronounced edge-rounding on edge of NI 426-75 (width of field 8.5 mm).

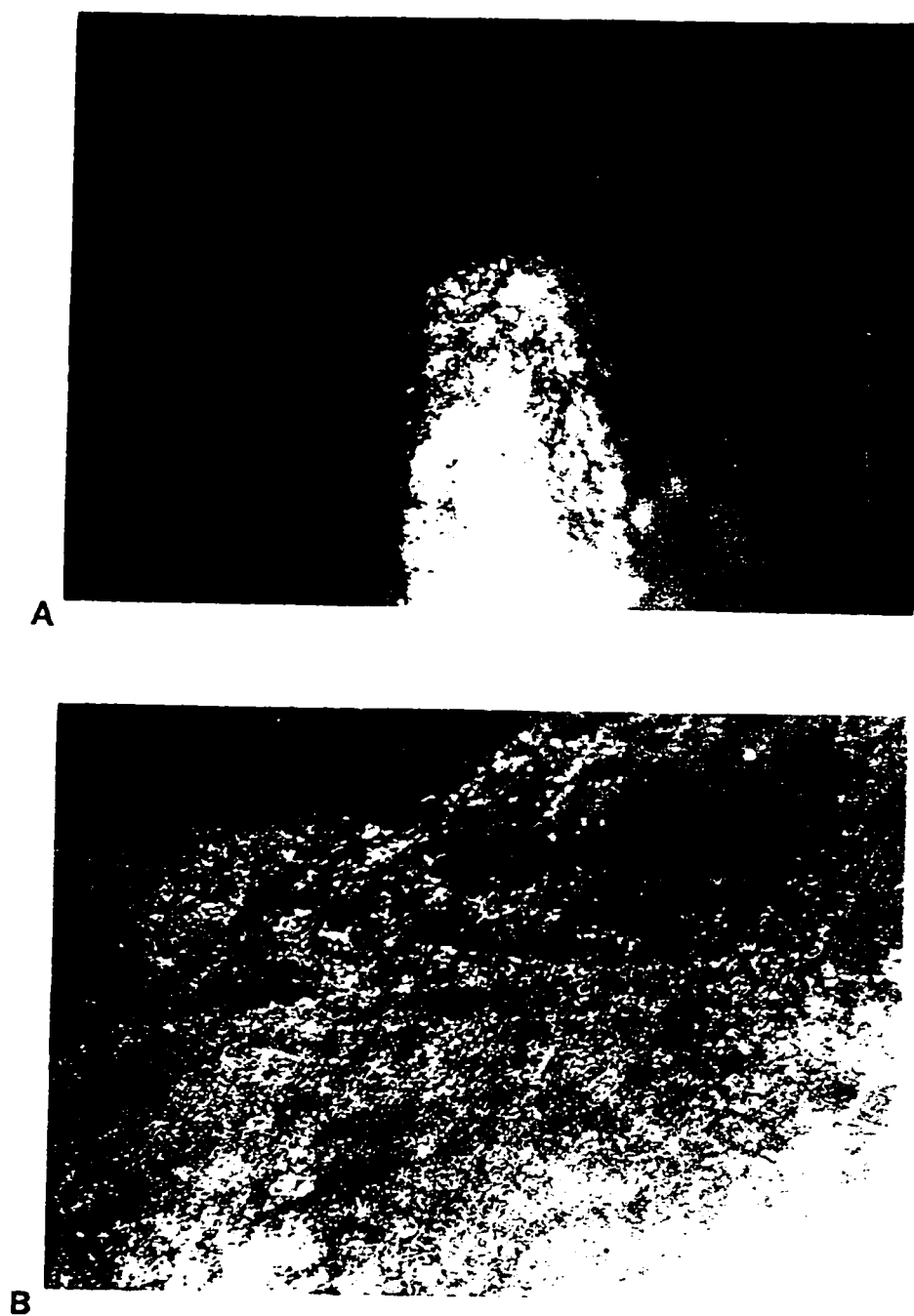


Figure 7.21. Microphotographs of additional types of bone contact wear. (A) Rounding and bright matte polish on distal tip of NI 144-116 used to drill bone (width of field 17.5 mm). (B) Bright matte surface of edge of NI 576-99 used to cut bone (width of field 35.0 mm).

work in the Middle Paleolithic of Europe and the Levant has taken on greater importance with the growth of research into archaic hominid cognition and symbolic behavior (Hayden 1993:117-128; Clark and Lindley 1990:237-238; Marshack 1988; Mellars 1996:371-375).

Shea (1991:148) identified wear characteristic of bone contact on only five to ten percent of EU in Levantine Mousterian assemblages. Other use-wear analysts have identified modest traces (Beyries 1988) or equivocal bone wear (Anderson-Gerfaud 1990; Shchelinskii in Plisson 1988) on Middle Paleolithic tools.

Evidence of bone contact on EU from convergent tools varied from 2.3 percent for Tor Faraj C to 12.8 percent for Kebara IX. The total for all sites combined is only 5.5 percent. The Central and North Gallery of Nahr Ibrahim each had 10.1 and 12.1 percent respectively. Approximately 20 percent of the analyzed sidescrapers from the Central Gallery of Nahr Ibrahim also had wear from bone-antler material (Panagopolou 1985:160-161). Panagopolou noted the presence of bone wear on all scraper sub-types, one burin, and two graver tips. This attests to a greater preference for scraper morphotypes than convergent tools in working bone, horn, and antler.

By far the majority of convergent tool EU worn from bone contact were employed in cutting (61.5 percent) followed by scraping (30.8 percent). Chopping, engraving, and awling make up 7.7 percent of all bone contact EU from all sites. Modification was present on 57.6 percent of all bone contact EU. The tool motions that could most likely be attributed to butchery include, cut, chop, and some unknown proportion of scraping. Engraving and awling are felt to have been associated with the manufacture and/or maintenance of bone, antler, or horn artifacts.

There are several specific tasks that could have involved varying amounts of scraping, cutting, engraving, or awling. These include scraping to remove periosteum or other adhering tissues away from bone surfaces, groove and snap,

groove and splinter, incising, and drilling of suspension holes. The material, task, and technological constraints are considered to be similar to those for butchering, woodworking, or hideworking tasks.

Hafting

Shea (1991:155-178) identified unique wear patterns on proximal lateral edges and surfaces that he identified as hafting. These wear traces on convergent tools (Figures 7.22 and 7.23) are characterized by clusters of microscars with feather, hinge, or step terminations. Occasionally, edge and surface abrasion accompany these wear traces. He noted that hafting was present in all Levantine Mousterian assemblages except Qafzeh XVII. Rates of hafting among EU varied from 10 to 25 percent. Shea (1991:156) also traced a negative correlation of hafting EU and hideworking EU. Points or convergent tools had a higher proportion of haft wear than other flake types. An abundance of hafting was present on tools worn from projectile impact and butchering. Oval flakes, blades, and cortex tools have very low amounts of hafting.

Hafting traces have also been documented for the European Middle Paleolithic. Anderson-Gerfaud (1981) recognized haft wear on virtually all convergent scrapers from the French Mousterian of Acheulian Tradition at Corbiac. Several tools (hafted sidescrapers) from Biache St. Vaast exhibited haft wear suggestive of a skin and wood haft element (Beyries 1988).

Varying proportions of activities are represented by hafted convergent tools. A full 61.7 percent of all butchery EU from Levantine Mousterian sites are associated with hafting EU. Other activities include light-duty woodworking (14.5 percent), hideworking (22.5 percent), and bone contact (57.1 percent). At Shanidar only 10.5 percent of all non-projectile impact EU are associated with hafting. Although there was not a statistically significant pattern associated with butchery and



Figure 7.22. Microphotographs of hafting wear. (A) Clustered perpendicular unifacial feather and step-terminated microscars along edge of NI 426-60 (width of field 35 mm). (B) Clustered perpendicular and overlapping feather-terminated microscars with matte polish along edge of NI 475-29 (width of field 35 mm).

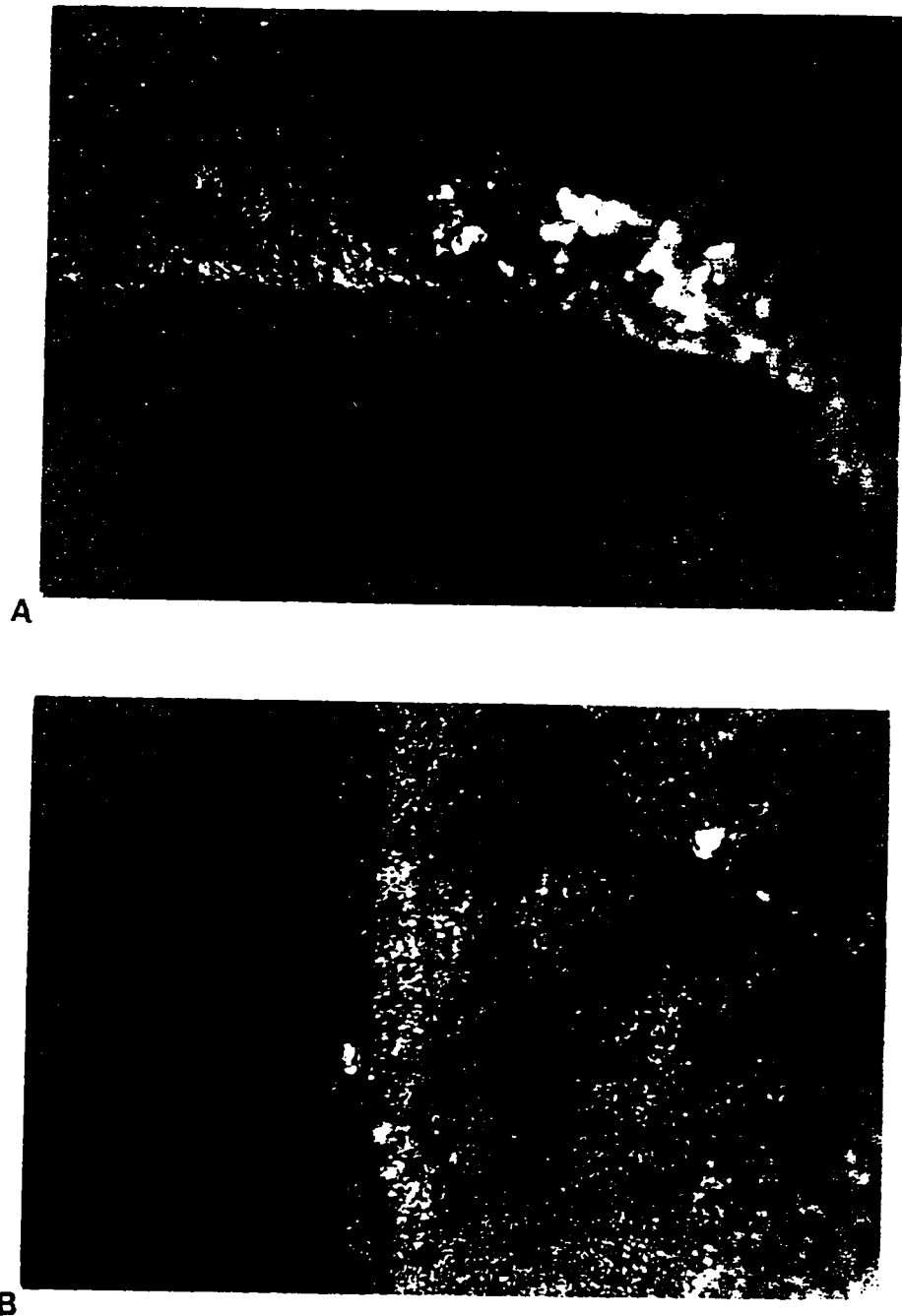


Figure 7.23. Microphotographs of accessory types of hafting wear. (A) Bright dorsal ridge polish from contact with wooden portion of haft on NI 475-29 (width of field 35 mm). (B) Bright spots of dorsal ridge polish on NI 8-106 from abrasive contact with wooden portion of haft (width of field 17.5 mm).

Haft traces from the Levantine Mousterian are quite similar for implements with projectile impact or other forms of wear. This indicates that broadly similar patterns of hafting may have been employed. The handle portion of the tool could have been either bone or wood and bindings could have been sinew or fiber with or without mastic.

Although we may not be able to reconstruct the exact nature of hafting, the presence of hafting is an important technological and behavioral indicator. Hafting is often associated with curation of stone tools and is effort expended beyond the manufacture of the stone tool that is used to enhance tool performance. Certain tasks are facilitated and tools made more efficient by affixing a haft element.

The manufacture of the components of a haft element (handle, bindings, mastic) can take more time than the manufacture of the tool part (Keeley 1982:800). It is not unreasonable to consider the haft element or handle of a tool as more valuable and more curated than the stone tool itself. Hafts are designed to have longer use-lives generally than the stone portion of the tool.

The behavioral significance of hafting is complicated by several factors (Keeley 1982). Attempts to identify hafting are confounded often by the presence of hafted and unhafted versions of the same tool types. Unhafted versions of tools are often larger than their hafted counterparts. There are also different methods of hafting similar tools through the use of wedge, wrapped, or mastic haft elements. Whereas unhafted tools are more likely to be discarded at the locus of use, hafted tools are often used in one spot and discarded via retooling in another place (Keeley 1982:202). It is often difficult to determine whether the discard location represents an activity area or retooling area.

An abundance of local suitable raw material may result in a decreased use of hafted tools in favor of more expedient hand-held versions. The lithic assemblage can reflect this technological choice in a high proportion of debitage, cortical debris, and minimally retouched or used tools. Small-size or limited raw material could

result in an assemblage with more retouched tools and increased evidence for hafting. Discarded hafted tools at locations of abundant raw material could be expected if there is some degree of retooling of personal hunting kits used away from the camp site (Keeley 1982:804). Keeley (1982:804) proposed that use-wear associated with unhafted tools should reflect more accurately the activities conducted on site.

Hafting Task Constraints

Odell (1994:54) conceived of hafting as a technological response to risks. Attached haft elements place certain limits on the used portion of the tool. Haft elements limit the available edge and area of a tool that can be used in a task. Such hafted tools are more apt to be transported from one location to another (which Odell considers as a form of curational behavior, but see Keeley {1982} for an opposing view).

Hafting Material Constraints

The material constraints of hafting are limited by the availability of certain raw materials: material for the handle, bindings, and mastic.

Hafting Technological Constraints

Hafted tools are constrained in the manner in which they can be manipulated during use. Manual prehension enables the tool user to move the tool around, hold it differently, and more edge is available to employ during tool use (Odell 1994:66). Increased hafting (or hafting in general) should decrease the number of available EU on a tool. There should be a relationship between the number of tool motions, activities, or worked materials associated with particular tool types but this may only be identified at the assemblage level.

Maintenance Activities

Soft Plant Processing

Shea (1991:149-150) identified soft plant processing on only 1.7 percent of his combined Levantine Mousterian sample. These EU only amounted to .6 percent of all hafted tools and 6.9 percent of all soft plant processing EU were associated with hafting. EU associated with this material are not represented by more than 10 percent of all EU in any sample.

The common wear pattern recorded by Shea (1991:49) consisted of bright polishes, very light edge abrasion and small microfractures. Occasionally, this wear is accompanied by fine striations. The polish is diffuse but bright and not the typical vitreous appearance. The wear pattern is characteristic of cutting reeds, cane, or other pithy or woody plants (Shea 1991:149).

Only 12 EU from convergent tools exhibited soft plant processing wear. These assemblages include Kebara X (3 EU), KebaraXD (3 EU), Kebara XI (2 EU), Kebara XII (2 EU), and Shanidar (2 EU). This suggests that convergent or pointed tools were not often employed in this activity. Due to the scarcity of EU associated with soft plant processing there is little that can be inferred regarding technology, behaviors, or the specific design of these tools (if different from convergent tools employed in other tasks).

Heavy-duty Woodworking

Employed units inferred to have been used in heavy-duty woodworking are associated with the tool motions of wedge, adze, and chop and medium or hard vegetal materials (see Shea 1991:150). Only three EU of convergent tools were associated with heavy-duty woodworking. These include one EU each from Kebara X, Qafzeh XV, and Shanidar. The specimen from Shanidar was employed in a wedging motion and is associated with opposed-end battering (Dockall 1993).

Heavy woodworking activities have been identified in low numbers (between 1 and 5 percent) in all samples from the Levantine Mousterian (Shea 1991:150). The relative absence of such activities at Levantine Mousterian or Zagros Mousterian cave sites may be a reflection of task location and tool design. Convergent tools are not designed to be employed in heavy chopping or adzing activities. The use of convergent tools in these tasks is probably some of the best evidence for the use of expedient tools in ad-hoc scenarios in which a suitable flake is selected from those at hand: this compares most favorably to Binford's (1979) situational gear.

Shea (1991:151) suggested that most heavy-duty woodworking activities were conducted away from habitation sites employing implements with more mass: modified and un-modified angular chunks and fragments. This inference is based upon the ethnographic observations of Hayden (1981) of Australian Aborigines woodworking tasks. In this instance the finer aspects of woodworking were conducted at the campsite employing smaller flaked stone tools (modified and unmodified) and are more aptly included within light-duty woodworking.

Because wear associated with heavy-duty woodworking was associated with the expedient use of convergent tools in impromptu task settings there is nothing that can be inferred regarding tool design. Raw material and technological constraints are limited by the size of the piece selected for the task.

Tool motions such as adzing, chopping, and wedging are typically associated with the procurement of resources for manufacture into perishable artifacts. This would account for their minority at most Levantine and Mousterian of Acheulian Tradition habitation sites (Anderson-Gerfaud 1990:401; Shea 1991:151). It would be interesting if suitable assemblages from open-air sites were examined for use wear pertaining to these activities.

Light-duty Woodworking

As part of the maintenance task set, light-duty woodworking EU comprise 14.5 percent of all EU associated with hafting but only 1.4 percent of all Levantine Mousterian convergent tool EU. Worked materials are medium to hard vegetal and tool motions include cut, shave, scrape, awl, plane, or engrave (Figures 7.24-7.26).

The proportion of light-duty woodworking EU for convergent tools ranges from 3.4 percent at Tor Faraj C to 20 percent at Tabun IC. When all tool and flake types are considered, EU referable to light-duty woodworking range between 25 to 40 percent for Levantine Mousterian sites (Shea 1991:152). There is a negative correlation between the abundance of light-duty woodworking EU and EU associated with various prey capture and processing tasks. This pattern or trend is also reflected among convergent tools in this study (Figure 7.27). Assemblages with more than about 80 percent extractive EU generally have less than 10 percent light duty woodworking EU (R-square value = .79).

Shea suggested that this negative correlation may be related to the location of task performance. Sites at which large amounts of light-duty woodworking occurred had less extractive EU (1991:152). A similar correlation was found between the proportion of butchery EU and projectile impact EU for convergent tools.

Light-duty woodworking tasks were identified from a variety of European Mousterian sites (Anderson-Gerfaud 1990; Beyries 1988). These researchers and Shea (1991:371) indicate that a significant proportion of light duty EU were modified. A total of 43.6 percent (n=76) of all light-duty woodworking EU on convergent tools were modified by retouch. Edge-retouch on woodworking tools is probably related to the hardness of medium-hard vegetal materials and the need for edge stability during tool use.



Figure 7.24. Microphotograph of wood shaving wear. Wear characterised by unifacial oblique microscars with step terminations and matte polish on NI 377-003. Interpreted as light-duty woodworking implement (width of field 17.5 mm).

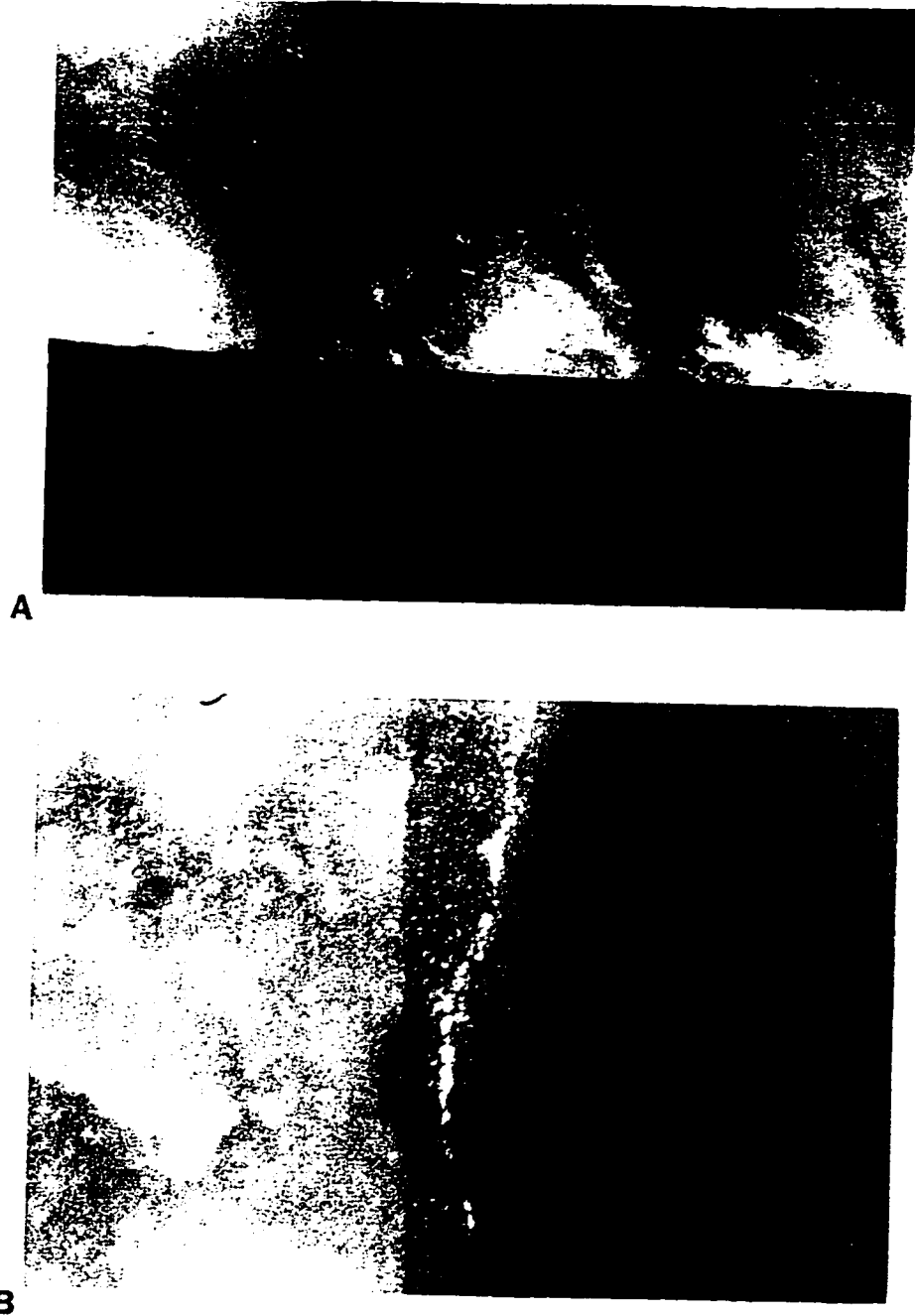


Figure 7.25. Microphotographs of wood cutting wear. (A) Unifacial perpendicular microscars with step and feather terminations and matte polish on retouched edge of NI 426-81 used to scrap wood (width of field 17.5 mm). (B) Bright polish and edge-rounding on edge of NI 377-004 used to cut a medium-hard vegetal material such as wood (width of field 4.0 mm).

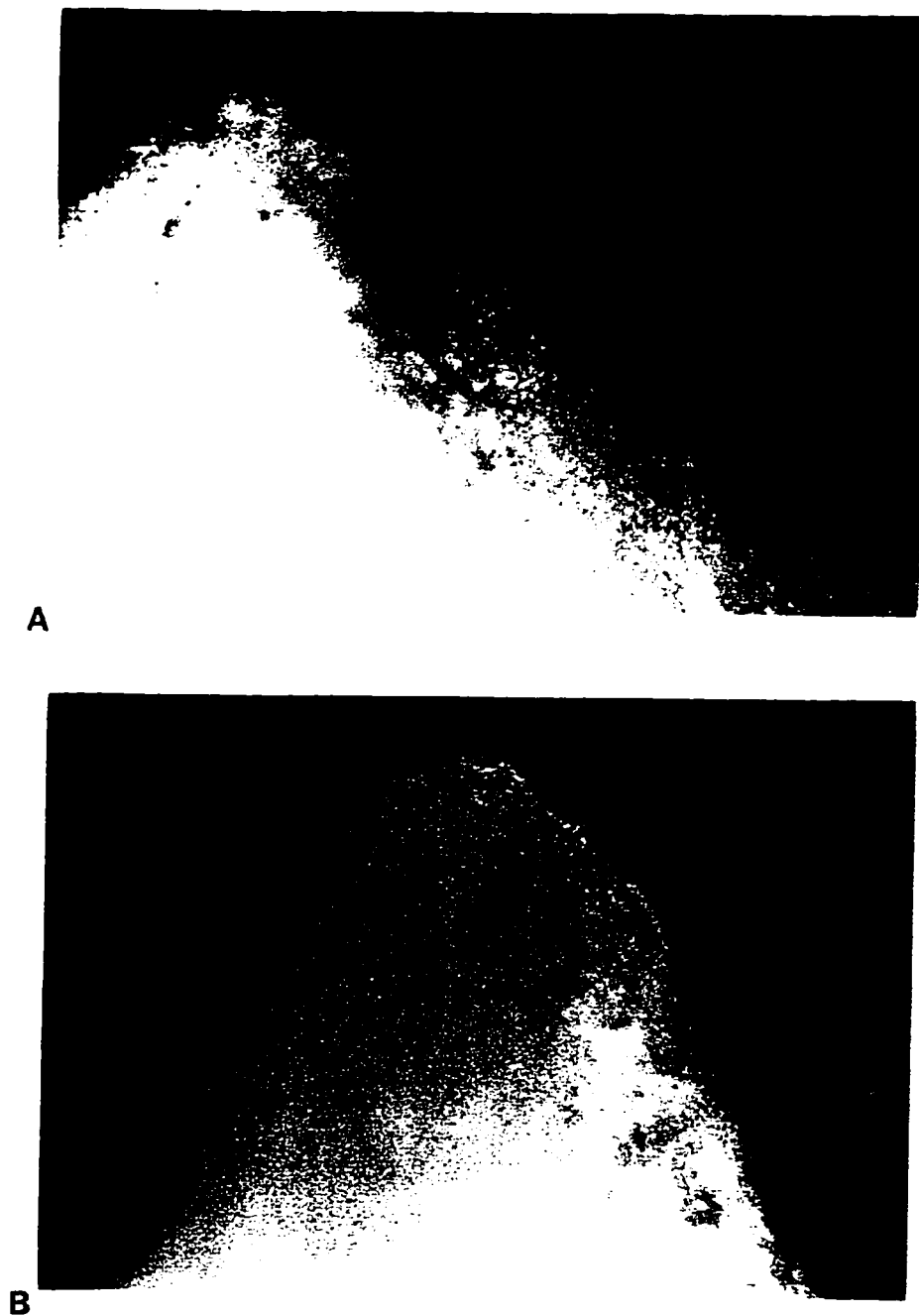


Figure 7.26. Microphotographs of use-wear associated with light-duty woodworking. (A) Distal tip crushing, matte polish, and development of flat wear facets on NI 424-144 from drilling a medium-hard vegetal material such as wood (width of field 8.5 mm). (B) Distal edge and tip rounding and light polish on NI 426-57 employed to drill/bore a medium-hard vegetal material such as wood (width of field 17.5 mm).

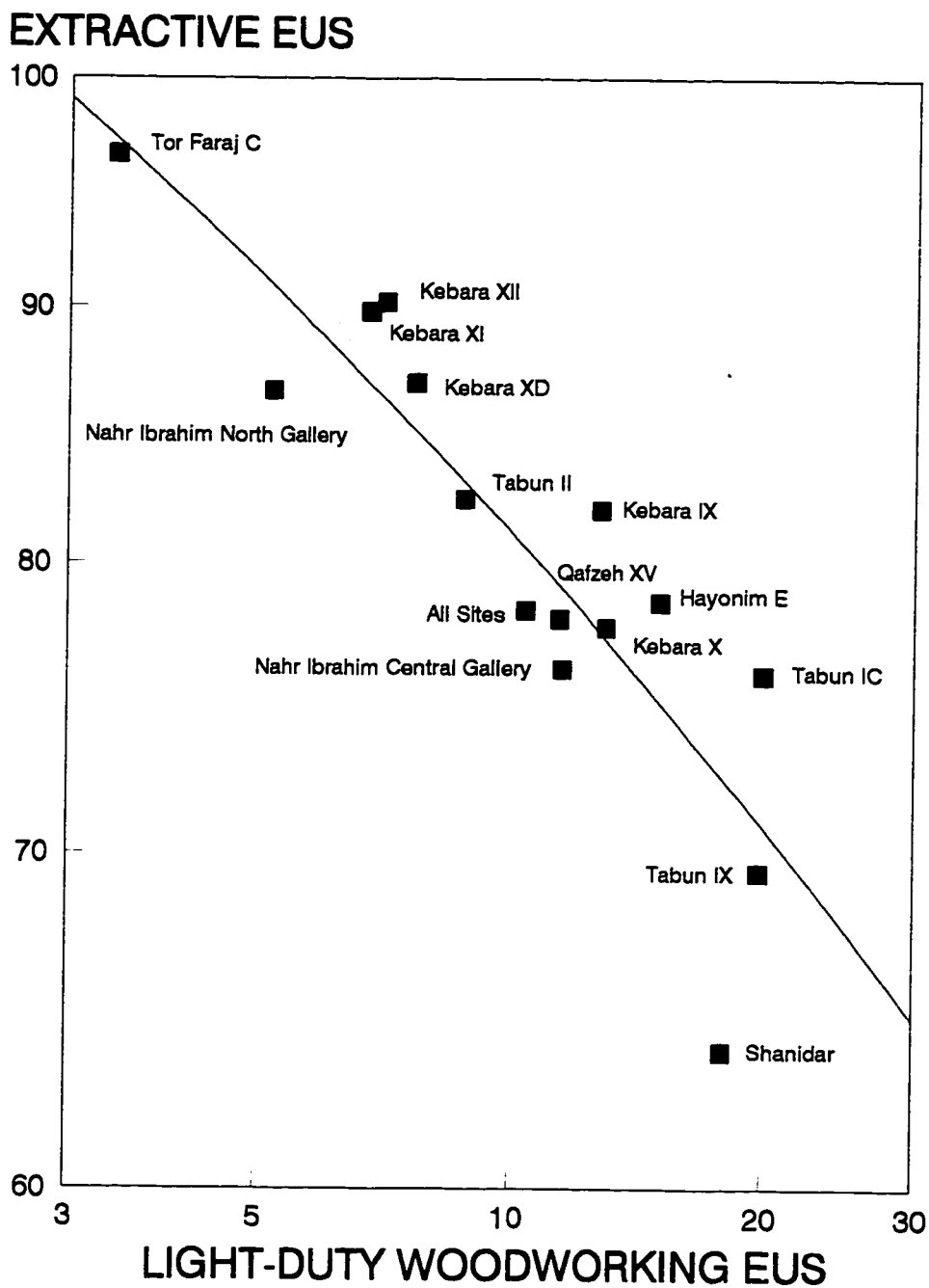


Figure 7.27. Log plot of the proportion of extractive and light-duty woodworking EU from all sites. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Light-duty Woodworking Task Constraints

Tool motions such as cut, scrape, shave, plane, awl, or engrave require tools possessing a convergent tip and lateral edges of sufficient length to provide adequate cutting ability. Convergent flakes provide both attributes in one package that can sustain edge retouch or hafting to facilitate task performance.

Light-duty Woodworking Material Constraints

The only material constraints are suitable stone to produce tool blanks and appropriate resources for haft and handle construction if necessary.

Light-duty Woodworking Technological Constraints

The exact technological constraints of light-duty woodworking implements probably varied with the tool motion and the size of the flake being used. There was apparently little or no technological difference between hafted or unhafted convergent tools used in butchery, woodworking, or hideworking. Differences may be found possibly in hafting orientation and amount or mode of retouch.

Stone Contact and Stone Knapping

There were no EU of convergent tools employed in either stone contact or stone knapping. There is one EU each from the North and Central Gallery at Nahr Ibrahim that exhibits battering and isolated cone fractures (Figure 7.28). This wear reflects the results of percussion retouch along a dorsal ridge of the tool to provide backing. The tool was placed upon an anvil of some type during retouch. These implements were not employed as flint-knapping tools.

Hideworking

All EU that are attributed to hideworking are associated with scraping, awling, and a soft-medium animal material (Figures 7.29 and 7.30). When all



Figure 7.28. Microphotograph of anvil contact wear on NI 576-99. Use-wear consists of conchoidal microscars and step fractures on the dorsal ridge. The wear was produced from anvil contact during percussion retouch to produce backing (width of field 35 mm).

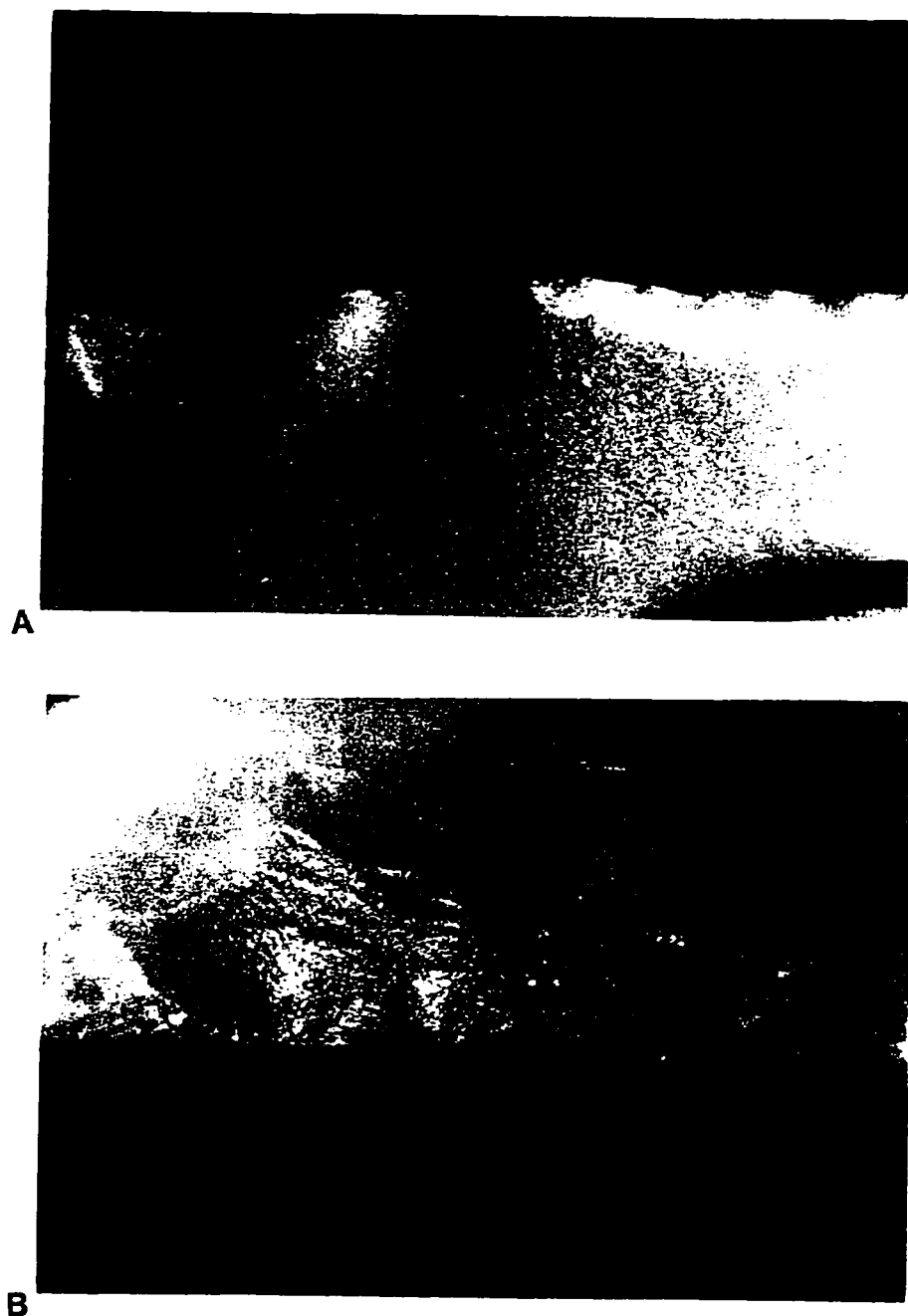


Figure 7.29. Microphotographs of use-wear associated with hide-working. (A) Oblique bifacial feather and step-terminated microscars on NI 426-59 from cutting a soft-medium animal material (width of field 35 mm). (B) Unifacial perpendicular/oblique feather and step-terminated microscars, rounding, and overall matte polish on distal tip edge of NI 475-44 used to awl medium-animal material (width of field 17.5 mm).

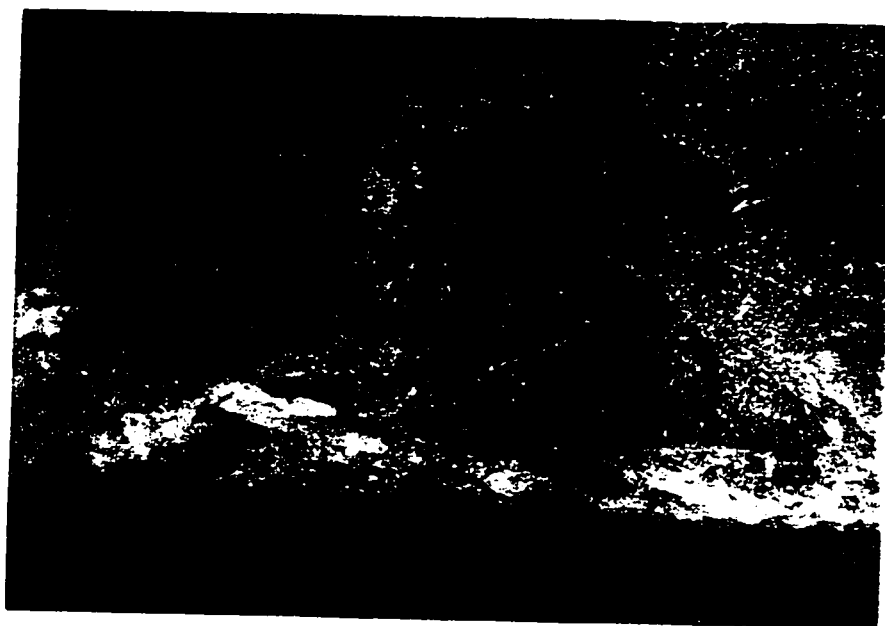


Figure 7.30. Microphotograph of retouched edge of NI 158-28. Use-wear shows step-terminated microscars and edge-rounding. Edge used to scrape a medium animal material during hideworking (width of field 17.5 mm).

convergent tool samples are combined only 7.1 percent of all EU are referable to hideworking. Shea (1991:147) noted that hideworking EU varied from 5 to 15 percent of all EU in Levantine Mousterian assemblages.

There is a slight negative correlation between the abundance of hideworking EU and EU associated with butchery and projectile impact (Shea 1991:147). Shea inferred that this meant a certain degree of areal distance between the procurement and processing of animal resources during the Levantine Mousterian.

Convergent tool hideworking EU range from 0 percent (Tor Faraj C and Kebara XIII) to 11.9 percent (Qafzeh XV). Shanidar exhibits 13.1 percent hideworking EU. When Shea's negative correlation between the proportion of hideworking and extractive tasks is examined there is not a clearcut trend for convergent tools.

Hafting in the Levantine Mousterian was present on 15.6 percent of all hideworking tools and represented only 6.4 percent of all hafted tools (Shea 1991:353). Retouch was present on 44.8 percent of all hideworking EU and represented 14.1 percent of all retouched EU in the Levantine Mousterian (Shea 1991:363). This data indicates that hideworking tools were commonly retouched and occasionally hafted. Central Gallery sidescrapers from Nahr Ibrahim exhibited an increased association with fresh hide or meat in Layer 3 (35.3 percent).

Approximately 65 percent of all worked material in Layer 3 was attributed to hideworking (Panagopolou 1985:155) according to sidescraper use-wear data. A total of 22.5 percent of all convergent tools employed in hideworking were hafted and 55.9 percent were modified by retouch. The convergent tool utilized in hideworking was typically modified by some form of percussion retouch and was periodically hafted. Panagopolou (1985) noted that sidescrapers were typically hand-held rather than hafted during use. Tool motions that were associated with convergent tools in hideworking include cut, scrape, awl, and shave. The most

abundant tool motion is awling (n=47 or 39.8 percent), followed by scraping (n=40 or 33.9 percent), cutting (n=30 or 25.4 percent) and shaving (n=1 or .8 percent).

Other studies have also identified skin and hideworking on Middle Paleolithic tools. Roughly 10 percent of all retouched tool types in the French MAT were associated with hideworking (Anderson-Gerfaud 1990:405). Shchelinskii (cited in Plisson 1988) found that Middle Paleolithic tools were frequently employed in hide piercing and scraping. Beyries (1988:214) reported that only 5 percent of analyzed tools from a series of French Middle Paleolithic sites were used on skin or hides.

Hideworking Task Constraints

Hideworking is associated with a variety of tool motions. Middle Paleolithic use-wear and techno-typological studies have solidly demonstrated that specific implements were manufactured for scraping hides that are not of the convergent form. However, convergent flakes do provide suitable employable areas for cutting, scraping, and piercing hides. More blades and oval flakes were employed in hideworking tasks than points in most Levantine Mousterian assemblages (Shea 1991:358) suggesting that points were not typically produced expressly for hideworking purposes. Scraping skins and hides requires a durable edge often reinforced by secondary retouch. Implements employed to pierce holes in hides or skins are frequently retouched to create a finer point and occasionally are hafted to provide added leverage.

Hideworking Material Constraints

The use of suitable fine-grained siliceous materials is the only raw material constraint. An exception would be the constraints of hafting materials for hafted versions. The occasional use of convergent tools in minor hideworking tasks is felt not to incur any material costs since these implements appear to have been employed in other tasks primarily.

Hideworking Technological Constraints

As stated earlier, hideworking tools in the Levantine Mousterian were more frequently manufactured from blades or oval flakes. The tool motions of cutting and piercing are frequently associated with any hafted or unhafted knife. Although probably designed for the procurement and processing of game these convergent tools were on occasion employed in various aspects of hideworking. Scraping, awling, and cutting of hide suggest the manufacture of leather items from previously prepared hides: perhaps bags, clothing, sinew strips for hafting, small shelters. Although the wear on convergent tools is identical to that which may be produced during hide preparation it should probably not be associated with that activity.

The manufacture of items from skins or hides is easily performed with hafted and unhafted knives and similar implements. The performance of these tasks usually occurs at the habitation site and may include the final stages of hide preparation. Convergent flakes and tools employed in these types of hideworking tasks were probably not specifically manufactured for that purpose but reflect the use of a suitable member of a portable toolkit employed in a variety of tasks.

Hideworking Transport and Mobility Constraints

Typically, hafted implements employed in heavy-duty hideworking (scraping, planing, dehairing, softening) are subjected to high rates of static loading and edge attrition necessitating frequent resharpening. This study and Shea (1991) indicate that pointed or convergent tools are only occasionally retouched and do not exhibit the degree of retouch or resharpening common to implements of the Zagros Mousterian or Quina assemblages. The use intensity of convergent tools is really quite low unlike heavy-duty hideworking implements.

Implements such as convergent tools which were occasionally employed in late stage hide processing and leather artifact manufacture were probably not cached at the site unlike special hideworking tools (see Hayden et al. 1996:31). Convergent

tools were an integral part of an individual toolkit or were expediently selected or produced flakes of short-term use. During short-term use a number of these implements could be resharpened as needed. As part of the individual toolkit the transport costs of these tools were negligible and there is no technological difference with similar tools used in woodworking, butchering, or plant processing.

Use-Intensity of Convergent Tools

Odell (1996a:195-200) examined use-intensity of stone tools in terms of the number of EU per tool. Below I examine the use-intensity of convergent tools by site and industry. There is only a slight correlation (R-square value=.16) between the abundance of hafting in Levantine Mousterian assemblages and the average number of EU per tool (Figure 7.31). Shanidar had an average of 1.7 EU per tool (n=40) with hafting present on 16.4 percent of all tools. Hafting rarely exceeded 30 percent in any assemblage except for Kebara XI, Kebara XII, and Kebara XIII (Kebara XI and XII had the lowest number of EU per tool). There is a loose clustering of data points about the upper end of the regression line suggesting a general similarity in convergent tool use-intensity and hafting among Levantine Mousterian assemblages.

When we consider just the number of EU (eliminating all hafting EU) there is a more visible distinction at the level of industry (Figure 7.32). Phase 1 (Tabun D) convergent tools have a generally higher number of EU per tool. This suggests a greater use-intensity of these implements in Phase 1 assemblages. Phase 3 (Tabun B) convergent implements have fewer EU per tool than Tabun D. Rates of hafting between all industrial variants are essentially the same with only Phase 3 having higher rates of hafting. Phase 2 (Tabun C) pointed tools are similar in pattern to Tabun B. Values for Hayonim E and Shanidar are provided for comparison. It is apparent that there is not a direct relationship between the proportion of hafting and the number of EU per tool among the assemblages. There is considerable

NUMBER OF EUS PER TOOL

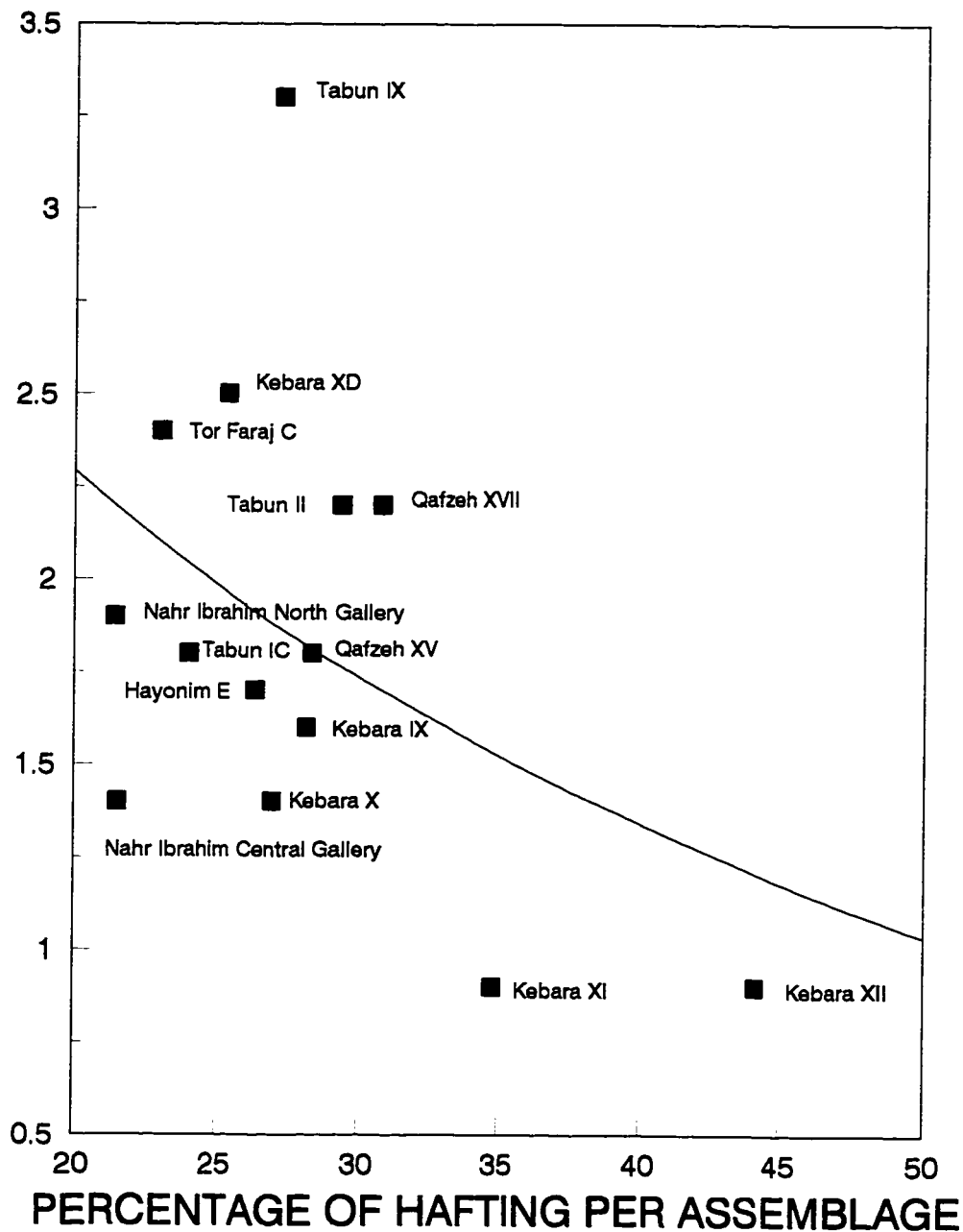


Figure 7.31. Plot of proportion of hafting EU and average number of EU per tool among all assemblages. All data calculated from Shea (1991) except for Nahr Ibrahim and Shanidar

AVERAGE NUMBER OF EUS PER TOOL

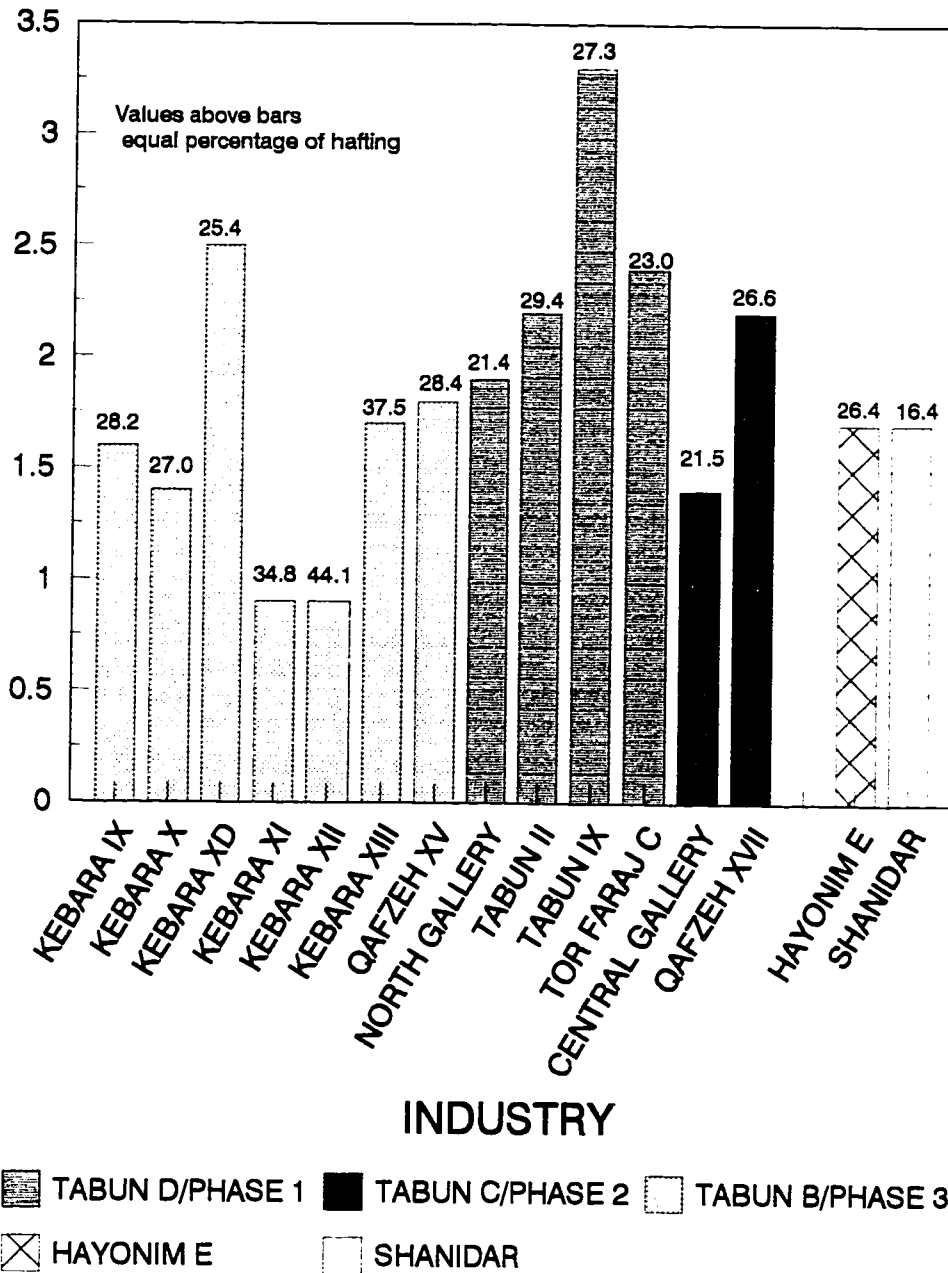


Figure 7.32. Bar graph of average number of EU per tool by assemblage and industry. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

overlap in hafting rates between each industry but Tabun D assemblages exhibit a trend to have higher numbers of EU per tool than other industry variants. Higher numbers of EU per tool in some assemblages may be related to the proportion of extractive and maintenance tasks represented among tool types in each assemblage (this issue is explored in detail below).

Associated with use-intensity is the concept of multifunctionality. Use-wear data for convergent tools in the Levantine Mousterian has suggested they were designed to be primarily employed in extractive tasks. Their use in various maintenance tasks is associated with their potential to serve a variety of functions. This potential is restricted or enhanced by the presence or absence of a haft element. Levallois and non-Levallois convergent flakes performed these tasks equally well but Levallois flakes were more often selected for extractive tasks.

Hafting, as part of tool design, was probably added to convergent tools to enhance the reliability of these tools in single or small-group trips or single-hunter scenarios (see Odell 1996b:67). The functional range of hafted tools is restricted by the haft. Tools designed for multiple uses are generalized and their design reflects ease of maintenance and expected use on different resources. By extrapolation we could expect lower proportions of these tools to be hafted. Hafted tools are associated with production of tools in advance of use (Keeley 1982; Odell 1994, 1996a, 1996b). Manually prehended tools are considered to be generalized and more readily employable in a variety of functions.

Relationship Between Extractive and Maintenance Task Sets

The organization of stone tool technology is influenced to a great degree by the variety of tasks that must be performed. Whether the technology reflects animal food procurement/processing, artifact manufacture/maintenance, plant food procurement/processing or some mixture of these behaviors is reflected in the technology, tool types, and ultimately in the use-wear record.

Levantine Mousterian assemblages seem to differ in the proportion of extractive and maintenance EU according to industrial variant (Shea 1991:159). Extractive/Maintenance EU ratios (E/M) for Phase 2 (Tabun C) assemblages are usually less than 1.00 indicative of a maintenance oriented assemblage. Phase 1 (Tabun D) ratios overlap with Phase 3 (Tabun B) E/M values (Shea 1991:159). These results are suggested by Shea to indicate behaviorally important differences associated with technological distinctions of Levantine Mousterian variants.

The distinctions that are visible at the assemblage level seem to disappear when individual tool categories are considered (Figure 7.33). Although there is a significant correlation between the proportion of extractive to maintenance EU (R-square value = .99) for convergent tools, the distribution does not correspond to industry type. The pattern observed here suggests that the use of convergent tools in extractive or maintenance tasks is independent of techno-typological affiliation. There may be other logistical factors that influence this pattern. Table 7.15 provides the number, percentage, and E/M ratio for convergent tools by industry. There is no significant difference in ratios between industry variants and there is considerable overlap between groups. Logistical factors that could influence the proportion of extractive and maintenance tasks include retooling and repair of personal gear, settlement/subsistence patterns, mobility, and tool discard patterns.

Technological Attributes Bearing Functional Significance

A series of morphological and technological attributes were selected that have been shown to have functional significance by various researchers. These variables include fracture patterns, methods of tool blank modification (retouch), and spine-plane angles (retouch angle in cases of modified tool edges). Each of these attributes will be considered in terms of the functional variability of convergent tools from each site in the study as well as the comparative database (from Shea 1991).

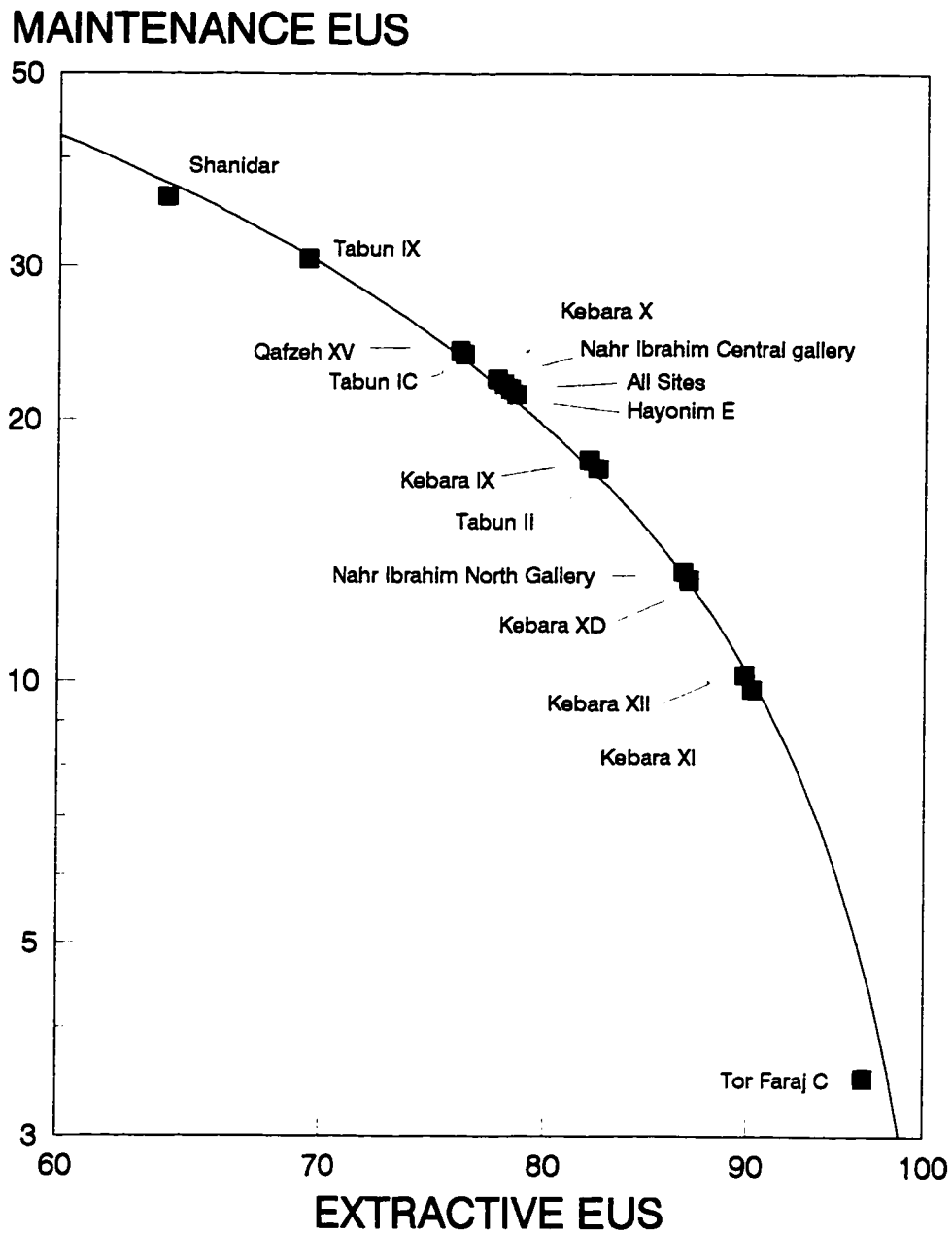


Figure 7.33. Log plot of proportion of extractive and maintenance EU for all sites. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Table 7.15. Number, percentage, and ratio of extractive/maintenance EU (E/M) according to type of Levantine Mousterian industry. All data except Nahr Ibrahim and Shanidar calculated from Shea (1991). Letter in parentheses by site name refers to industry variant.

Site/Assemblage	Extractive EU		Maintenance EU		E/M
	No.	Percent	No.	Percent	
All Sites	1309	78.3	363	21.7	3.6
Kebara IX (B)	32	82	7	18	4.6
Kebara X (B)	108	77.7	31	22.3	3.5
Kebara XD (B)	113	86.9	17	13.1	6.6
Kebara XI (B)	202	90.2	22	9.8	9.2
Kebara XII (B)	53	89.8	6	10.2	8.8
Nahr Ibrahim Central Gallery (C)	116	78	33	22	3.5
Tabun IC (C)	19	76	6	24	3.2
Tabun II (D)	28	82.4	6	17.6	4.7
Tabun IX (D)	84	69.4	37	30.6	2.3
Tor Faraj C (D)	84	96.5	3	3.5	27.6
Shanidar (Zagros)	39	63.9	22	36.1	1.8
Hayonim E (?)	125	78.6	34	21.4	3.7
Qafzeh XV (?)	193	76.2	60	23.8	3.2

Fracture Patterns

The importance of fracture patterns and their relevance to the study of Levantine Mousterian variability was explored in Chapters I and V. During sample selection every attempt was made to include identifiable fragments of convergent tools. Difficulties were encountered in attempting to identify fragments of these implements. It was not always possible to positively assign very small (< 2 cm) proximal or distal fragments. In only one case was a medial fragment identified.

The most common fragments included proximo-medial and medio-distal and these were not abundant in number.

The number and percentage of convergent tools from Nahr Ibrahim representing different fragment and fracture types is provided in Table 7.16. Complete specimens dominate both samples but the Central Gallery has a slightly higher percentage of broken specimens. Breakage patterns differ slightly between galleries. The Central Gallery has a higher proportion of proximal fragments (combined proximal and proximo-medial-16 percent). The low percentages of medio-distal and absence of distal fragments reflect the difficulty of identifying these

Table 7.16. Number and percentage of fragment and fracture types from the North and Central Galleries at Nahr Ibrahim. The counts and percents also include specimens in the technological analysis without use-wear. Differences in totals and percents of whole specimens according to fragment or fracture type are result of metric distinctions between specimens considered complete with a portion of the tip gone and those considered fragments whose complete length could not be determined.

	Central Gallery		North Gallery	
	No.	Percent	No.	Percent
Whole	59	78.7	99	89.2
Broken	16	21.3	12	10.8
	Fragment Type			
Proximal	4	5.3	—	—
Medial	1	1.3	—	—
Proximo-medial	8	10.7	10	9.0
Medio-distal	3	4	1	.9
Lateral-Basal	—	—	1	.9
Whole	59	78.7	99	89.2
	Fracture Type			
Transverse	53	71.6	86	77.5
Impact	11	14.9	15	13.5
Thermal	2	2.7	—	—
Whole	53	71.6	86	77.5

fragments of convergent tools. The presence of proximo-medial and medio-distal fragments among Central Gallery specimens indicate that this may be the most common breakage pattern. Breakage resulting in two parts can be attributed to a number of factors: knapping errors, tool use, trampling, material or tool recycling. The presence of proximo-medial fragments to the virtual exclusion of distal fragments from the North Gallery is unexplained.

None of the fragments from the North Gallery had use-wear. There were five proximal/proximo-medial fragments that had haft wear from the Central Gallery, two of which also had impact damage. The remaining three specimens had transverse breaks across the blade which suggests haft breakage during use. Cutting and piercing tasks can place significant stresses across the blade of hafted tools, especially during butchering or processing of scavenged carcasses. The most significant aspect of this evidence is that it indicates the on-site discard of broken hafted implements and the return of damaged hunting gear to a base camp for repair. Evidence for these behaviors are present in both the North and Central Gallery of Nahr Ibrahim and other Levantine Mousterian sites. There are no fracture types such as perverse or silet that would suggest manufacture breaks. Transverse breaks can occur during use or manufacture.

It is suggested that hafted cutting or butchering tasks are more susceptible to breakage during use than unhafted versions. The handle acts as a lever which places stress across the blade during use (Shea 1991). The abundance of hafted implements may be a partial explanation for the scarcity of broken specimens.

The data collected by Shea (1991) is sufficient for some preliminary interpretations of fracture patterns for other Levantine Mousterian sites. Shea's data indicates not only the replacement of broken tools but the possible use of tool and flake fragments as new tools (Table 7.17).

Specimens were selected from Shea's data if they had been identified as a pointed blank: the blank type would be a point but the blank technology placed it as a

Table 7.17. Counts of different fragment categories of broken tools calculated from Shea (1991).

Assemblage	Haft wear	Impact/impact and haft wear	Haft/other	Other
Hayonim E	—	2	—	4
Kebara IX	—	2	—	1
Kebara X	—	—	1	1
Kebara XD	—	1	—	2
Kebara XI	—	2	—	1
Qafzeh XV	5	9	2	10
Tabun IC	—	1	—	1
Tabun II	—	—	—	1
Tabun IX	1	—	—	1
Tor Faraj C	—	5	—	—

flake fragment. Other fragments were also selected if microwear indicated the use of a point in various piercing motions. The data was grouped into four categories for summary purposes: fragments with only haft wear, those with impact or impact/haft wear, specimens with haft/other wear, and fragments with wear other than impact and no haft wear.

Fragments with impact or impact/haft wear and those with other wear traces and no haft wear are the most common fragment categories (41.5 percent each). Behaviorally this can be interpreted to include the discard and replacement of broken convergent tools. Fragments with no haft wear but other classes of wear could represent broken tool discard or the secondary use of flake and tool fragments. Fragments with haft wear or haft/other wear also represent the discard of broken composite tools; perhaps the repair of personal gear. Qafzeh XV is interesting because of the number of fragments compared to other sites.

Spine-Plane Angle and Tool Motion

Experimental and archaeological studies have indicated a relationship between spine-plane or edge angle and tool motion (Hayden 1981; Odell 1979; Wilmsen 1967, 1968). Data from these studies demonstrates that tool motions associated with the use of lateral edges can be used to define an angle range for certain tasks.

Spine-plane angles for Central and North Gallery tools were taken following Odell (1979). Tables 7.18-7.22 provide the range and summary statistics for five major tool motions of convergent tools. The data is presented by site and Levantine Mousterian industry for comparison. All Kebara assemblages have been pooled because they represent Tabun B and were associated with Neanderthal hominid skeletal remains. Tabun II and IX were pooled as Tabun D. The data are further subdivided into unmodified and modified edges in order to examine the influence of retouch on tool-use angles. Angles for unmodified edges measure both the natural edge of the tool or flake as removed from the core and the angle of an edge used as a tool.

The major tool motions include cutting, scraping, hafting, impact, and awling. There are several patterns to be observed in the data allowing for differences in sample size. There are similarities in standard deviation (STD) and variance (VAR.). Unmodified edges generally have lower STD and VAR than modified edges. Retouch can impose a greater degree of variability among spine-plane/edge angles. Shanidar has consistently higher average angles for all tools due to the difficulty of creating and maintaining acute edges on smaller-size flakes.

The ranges for cutting and scraping on unmodified edges exhibit an overlap that is due to selection of flakes with acute-spine plane angles. It also attests to the utility of convergent tools in an array of tasks. The maximum SPA of modified scraping edges and the average of these edges are higher than modified edges employed in cutting tasks.

Table 7.18. Spine -plane angle variability associated with cutting wear. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Unmodified Tool Edges					
Site	Range	Avg.	STD	Var.	No.
Kebara pooled (B)	10-58	33.36	9.16	83.99	177
Tabun IC (C)	28-55	37.71	8.53	72.78	7
Qafzeh XVII (C)	19-36	31	5.72	32.67	4
Nahr Ibrahim Central Gallery	24-56	37.68	7.59	57.64	49
Tabun II, IX pooled (D)	20-55	35.81	8.63	74.54	21
Nahr Ibrahim North Gallery (D)	27-60	38.46	6.86	47	47
Tor Faraj C (D)	15-55	33.33	9.86	97.22	36
Qafzeh XV (?)	16-65	41.45	10.64	13.26	65
Hayonim E (?)	14-50	36.31	7.72	59.53	35
Shanidar (Zagros)	33-61	47.33	9.41	88.56	6
Modified Tool Edges					
Kebara pooled (B)	20-78	40.67	15.32	234.56	12
Tabun IC (C)	15-42	30	10.70	114.50	4
Qafzeh XVII (C)	43	43	0	0	1
Nahr Ibrahim Central Gallery	31-71	48.94	11.32	128.13	25
Tabun II, IX pooled (D)	25-60	42.35	9.43	88.84	26
Nahr Ibrahim North Gallery (D)	27-67	46.61	9.16	83.98	50
Tor Faraj C (D)	30-70	42.50	16.39	268.75	4
Qafzeh XV (?)	16-50	35.80	9.96	99.16	10
Hayonim E (?)	19-65	42.83	11.92	142.00	29
Shanidar (Zagros)	44-76	55.27	10.59	112.20	11

Table 7.19. Spine-plane angle variability associated with scraping wear. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Unmodified Tool Edges					
Site	Range	Avg.	STD	Var.	No.
Kebara pooled (B)	20-64	39.57	10.32	106.53	21
Nahr Ibrahim Central Gallery	24-57	40.01	12.24	149.85	7
Nahr Ibrahim North Gallery (D)	25-51	39.75	11.18	124.93	4
Tor Faraj C (D)	50	50	0	0	1
Qafzeh XV (?)	27-45	37.08	5.47	29.92	13
Hayonim E	23-55	44	10.44	109	6
Modified Tool Edges					
Kebara pooled (B)	52-56	54	2	4	2
Tabun IC (C)	50-58	54	4	16	2
Qafzeh XVII (C)	42-62	52	10	100	2
Nahr Ibrahim Central Gallery	38-73	53.76	8.72	75.97	21
Tabun II, IX pooled (D)	30-81	48.10	14.38	206.89	10
Nahr Ibrahim North Gallery (D)	43-78	57.93	10.90	118.72	14
Tor Faraj C (D)	50	50	0	0	1
Qafzeh XV (?)	42-70	61	11.45	131	4
Hayonim E (?)	48-85	60.15	11.96	143.14	6
Shanidar (Zagros)	35-80	67	9.52	90.71	34

Table 7.20. Spine-plane angle variability associated with haft wear. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Unmodified Tool Edges					
Site	Range	Avg.	STD	Var.	No.
Kebara pooled (B)	14-88	44.27	11.77	138.61	143
Tabun IC (C)	47-50	48.50	1.50	2.25	2
Qafzeh XVII (C)	35-39	37	2	4	2
Nahr Ibrahim Central Gallery	28-65	44.93	9.71	94.25	27
Tabun II, IX pooled (D)	30-70	50.38	9.17	84.18	34
Nahr Ibrahim North Gallery (D)	34-74	47.62	10.15	103.04	27
Tor Faraj C (D)	20-70	52.06	15.15	229.58	17
Qafzeh XV (?)	16-65	41.45	10.64	113.26	65
Hayonim E (?)	35-69	48.80	8.07	65.13	35
Shanidar (Zagros)	32-73	54.2	13.14	172.56	5
Modified Tool Edges					
Kebara pooled (B)	20-78	40.67	15.32	234.56	12
Tabun IC (C)	15-42	30	10.70	114.50	4
Qafzeh XVII (C)	78-80	79	1	1	2
Nahr Ibrahim Central Gallery	35-69	54.52	11.19	125.27	5
Tabun II, IX pooled (D)	27-71	57.56	12.28	150.69	9
Nahr Ibrahim North Gallery (D)	38-73	52	10.55	111.35	10
Tor Faraj C (D)	29-45	36.33	6.60	43.56	3
Qafzeh XV (?)	25-80	55.71	21.61	467.06	7
Hayonim E (?)	30-65	45.29	11.09	123.06	7
Shanidar (Zagros)	52-63	57.2	4.8	23.36	5

Table 7.21. Spine-plane angle variability associated with awling wear. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Unmodified Tool Edges					
Site	Range	Avg.	STD	Var.	No.
Kebara pooled (B)	14-73	32.38	15.31	234.36	16
Nahr Ibrahim Central Gallery	43-47	44.75	2.25	5.06	2
Tabun II, IX pooled (D)	22-65	45	15.48	239.5	4
Qafzeh XV (?)	14-43	26.25	9.12	83.19	16
Hayonim E (?)	15-38	26.60	9.89	97.84	5
Modified Tool Edges					
Kebara pooled (B)	26-76	54.67	21.06	443.56	3
Tabun IC (C)	37-40	53.5	16.5	272.25	2
Qafzeh XVII (C)	22	22	0	0	1
Nahr Ibrahim Central Gallery	57	57	0	0	1
Tabun II, IX pooled (D)	12-55	32.73	14.12	199.29	11
Nahr Ibrahim North Gallery (D)	57-69	63	6	36	2
Qafzeh XV (?)	13-60	33.89	17.69	312.77	9
Hayonim E (?)	14-46	31.60	14.15	200.24	5
Shanidar (Zagros)	58-74	68.25	6.1	37.19	4

Table 7.22. Spine-plane angle variability associated with impact wear. All data calculated from Shea (1991) except Nahr Ibrahim and Shanidar.

Unmodified Tool Edges					
Site	Range	Avg.	STD	Var.	No.
Kebara pooled (B)	10-70	22.77	9.81	96.20	126
Tabun IC (C)	15-26	21.25	4.21	17.69	4
Qafzeh XVII (C)	20	20	0	0	1
Nahr Ibrahim Central Gallery	32-42	36.75	5.25	27.56	2
Tabun II, IX pooled (D)	11-53	22.54	9.41	88.61	28
Nahr Ibrahim North Gallery (D)	39-40	39.5	.50	.25	2
Tor Faraj C (D)	10-50	22.42	9.6	92.24	24
Qafzeh XV (?)	10-40	18.80	6.29	39.59	56
Hayonim E (?)	12-35	16.77	4.85	23.56	26
Modified Tool Edges					
Kebara pooled (B)	14-86	38.13	25.55	652.61	8
Qafzeh XVII (C)	15-32	23.50	8.50	72.25	2
Nahr Ibrahim Central Gallery	53-65	60.15	4.45	20.15	4
Tabun II, IX pooled (D)	12-35	20.29	7.79	59.92	7
Nahr Ibrahim North Gallery (D)	36-58	44.48	7.59	57.55	6
Tor Faraj C (D)	20-40	31.67	8.50	72.22	3
Qafzeh XV (?)	15-32	21.33	7.18	51.56	6
Hayonim E (?)	14-18	16	1.63	2.67	3
Shanidar (Zagros)	46-79	61.33	13.24	175.22	6

The data from this study certainly corresponds to the ethnographic data on tool angles. The range and average of cutting spine-plane angles compare well to Hayden's (1981:124-125) data on Western Desert Australian Aborigine flake saws (25-60 degrees). Wilmsen (1968:156-158) limited the range of cutting tool angles to 26-35 degrees.

The range and average for unmodified scraping edges generally overlap with those of cutting. Hayden (1981:124) identified two clusters of angles for scraping: 35-50 degrees and 60-95 degrees. The ranges for both unmodified and modified convergent tools in the Levantine Mousterian approach this range (20-64 degrees for unmodified and 30-85 degrees for modified). Average modified scraping edge angles are higher than unmodified edges. Wilmsen's (1968:156-158) category for general tools exhibited an angle range of 46-55 degrees and heavy duty tools a range of 66-75 degrees. The angle range for woodworking tools of the Xeta Indians of Brazil 65-85 degrees (Miller 1979:403). Scraping edges on retouched convergent tools include angles that fall within the ranges for scraping and general tools. Use-wear corroborates the use of convergent tools in an array of tasks which include scraping and cutting of dense materials that would require steeper and more durable edges than soft material processing.

Most haft areas of convergent tools were unmodified and the angle range (14-88 degrees) and average (45.59 degrees) reflect SPA trends in unmodified convergent flakes. The range for modified haft edges is 25-90 degrees (average=53.82 degrees). There is no functional argument that can be developed for haft angle variability since edge contour was probably a more critical factor in hafting convergent tools.

The SPA range for unmodified convergent tool tips employed as awls (14-73 degrees, average=30.76 degrees) and similarly used modified edges (12-76 degrees, average=40.13 degrees) are identical. The same observations can be made for hafted projectile point tips (unmodified range 10-70 degrees, average=21.33

degrees; modified range 12-86 degrees, average=33.12 degrees). Tip shape is more important in piercing tasks such as drilling, awling, and engraving. Projectile tips must both pierce and cut.

Summary data on SPA for convergent tools employed in other tasks is provided in Table 7.23. These angles are also comparable to those observed by Hayden (1981) and Miller (1979). The variability of SPA/EA among convergent tools in the Levantine Mousterian is comparable and within the range of variability observed in recent ethnographic studies and archaeological assemblages. The processes of selection of suitable tool edges and projections for completing various tasks seem to have yielded similar results for both archaic Levantine Mousterian hominids and anatomically modern humans. This study suggests that these selective processes were identical among both groups.

Table 7.23. Summary data for minor tool motions for all Levantine Mousterian samples combined. Data includes sites from Shea's (1991) study and Nahr Ibrahim.

Unmodified Edges					
Tool Motion	Range	Avg.	STD	Var.	No.
Shave	26-54	36.73	8.59	73.84	15
Plane	90	90	0	0	1
Adze	46	46	0	0	1
Chop	35-40	38.25	2.05	4.19	4
Wedge	29	29	0	0	1
Engrave	52-70	61	9	81	2
Modified Tool Edges					
Shave	26-55	40.30	8.52	72.61	10
Adze	10	10	0	0	1
Drill	59	59	0	0	1

Edge Modification and Edge Shape

The evidence from the Levantine Mousterian demonstrates that retouched artifacts are not abundant. The majority of retouch that is present is not invasive and was performed to shape an edge (Shea 1991:237-238). The purpose of much of the retouch was to provide for prehension (manual or hafting) to regularize an edge, or brief periods of resharpening.

Variability in retouch intensity was recorded for each EU in the Central and North Gallery sample from Nahr Ibrahim. Retouch intensity is a qualitative measure based on the number of episodes of retouch visible. It is assumed that greater amounts of retouch represent, in most cases, some degree of tool resharpening and repeated use. One drawback to this method is that previous episodes of retouch can often be removed by later periods of resharpening. Light retouch is characterized by a single row of retouch scars, moderate has two rows of scars, and heavy retouch has multiple and overlapping rows of retouch scars. Unmodified EU predominate in the Central Gallery (61 percent, n=100). The North Gallery exhibits roughly equal proportions of unmodified (46.2 percent, n=84) and light retouch EU (40.1 percent, n=73). Moderate retouch is present on 9.8 percent (n=16) of Central Gallery and 13.7 percent (n=25) of North Gallery EU. Only three EU (1.8 percent) from the Central Gallery had heavy retouch. The data suggest that convergent tools from the North Gallery were retouched more often which may correlate with the higher average number of EU per tool for this gallery. North Gallery convergent tools exhibit greater use and retouch intensity with equivalent percentages of hafting with the Central Gallery. The E/M ratio of 6.5 for the North Gallery provides additional support for greater convergent tool use intensity and resharpening. There appears to be a difference in the technological organization and possibly design of convergent tools between the North and Central Gallery. Convergent tools played a greater role in animal procurement and processing in the North Gallery. Comparable data from other Levantine Mousterian sites is currently unavailable.

There is a predominance of convex lateral edges, followed by straight, recurved, and concave (Table 7.24) among Levantine Mousterian convergent tools. Convex and straight edges are also common among pointed tools from Shanidar (Table 7.24). The abundance of trihedral implement tips in the Levantine Mousterian is due to convergent methods of dorsal surface preparation prior to removal from the core. All trihedral points from Shanidar were either maintained or created by retouch.

A range of tool motions and tasks emphasizing cutting and piercing resulted in the selection of flakes with straight and convex edges and convergent tips. Moderate numbers of lateral edges were also retouched to create or maintain these lateral edge shapes or to create functional tips. The range of edge shapes and proportions of modified to unmodified edges correlates well with tools employed in both extractive and maintenance tasks.

Summary

The technological parameters of convergent tool manufacture explored in Chapter VI were combined by Levantine Mousterian hominids to produce flakes that could easily be employed as hafted and un-hafted implements in a variety of extractive and maintenance tasks. The principle tasks included various cutting, scraping, and piercing motions. Convergent tools were primarily used as projectile points and butchering implements for procuring and processing a variety of animal resources. Secondarily, convergent flakes frequently served as scraping, drilling, and awling implements that were used to make and repair tools and other perishable artifacts.

Table 7.24. Relationship between edge shape and edge modification among EU from Levantine Mousterian and Zagros Mousterian convergent tool samples. Data for the Levantine Mousterian represents pooled samples from Shea (1991) and Nahr Ibrahim. Zagros data represented by Shanidar.

All Levantine Mousterian Samples Pooled						
Edge Shape Category	No.	Percent	Modified		Unmodified	
			No.	Percent	No.	Percent
Convex	467	29.3	162	34.7	305	65.3
Straight	279	17.5	82	29.4	197	70.6
Concave	182	11.4	27	14.8	155	85.2
Recurved	241	15.1	29	12.0	212	88.0
Point (3 sides)	397	24.9	73	18.4	324	81.6
Point (4 sides)	23	1.4	10	13.5	13	86.5
Other	13	.4	---	---	---	---
Zagros Mousterian (Shanidar Cave)						
Convex	28	36.8	25	89.3	3	10.7
Straight	27	35.5	23	85.2	4	14.8
Concave	1	1.3	1	100.0	---	---
Recurved	7	9.2	3	42.9	4	57.1
Point (3 sides)	11	14.5	11	100.0	---	---
Point (4 sides)	1	1.3	1	100.0	---	---

Although the design of convergent tools was quite simple, these implements were well-suited to the variety of tasks that they were used to perform. As such, the design can be interpreted as very maintainable and functional within a variety of environmental conditions common to the Levant during the early Upper Pleistocene. The manufacture of Levallois products from specially prepared cores is considered by some researchers (Hayden et al. 1996:37) to have been very wasteful of raw

material. Even so, the production of convergent tools from Levallois and non-Levallois methods provided a flake with an extremely sharp tip and lateral edges. The amount of functional edge per flake was probably higher than flaking methods associated with unprepared cores.

The functions, activities, and tasks inferred for convergent tools typically involve a heavy reliance upon pointed tools and tools with sufficient cutting edges; these tools were associated with the processing of significant amounts of material that may have varied seasonally or geographically, especially given the variety of habitats of different game animals that could have potentially been exploited (Table 2.1). It is postulated that the abundance of convergent tools and the proportion of these tools employed in extractive and maintenance tasks probably varied with the amount of animal processing anticipated and performed and the degree of group mobility.

The absence of any significant evidence of consistent and patterned retouch associated with repair or maintenance suggests that convergent tools were not typically curated for long periods. This inference is also supported by the use-wear data which indicates very light use on most EU and breakage patterns. The handles of hafted specimens probably represent the curated portion of such tools. Convergent tool morphology meant that most hafted tools were not amenable to significant amounts of maintenance in the form of retouch. This is primarily due to the necessity of including about one-third of the tool length within the haft bindings because of the broad proximal dimension. Any damage or wear to the tip and lateral edges that would normally result in retouch maintenance for narrower tools frequently required replacement of the convergent tool. There was less time-investment associated with tool maintenance compared to the amount of time invested in tool replacement.

CHAPTER VIII
CONCLUSIONS:
BEHAVIORAL IMPLICATIONS OF CONVERGENT TOOL VARIABILITY
IN THE LEVANTINE MOUSTERIAN

This dissertation has provided a detailed technological and functional analysis of convergent tools from Nahr Ibrahim, Lebanon. The study focused on samples selected from the Central and North Galleries and included specimens of Levallois and non-Levallois character. Technological and functional data were used to employ concepts of tool design as suggested by Hayden et al. (1996). Aspects of convergent tool technology, manufacture, and use can be combined with Kuhn's concept of tactical provisioning strategies to provide an understanding of convergent tool design and the logistical setting of convergent tool use.

Impressions of Middle Paleolithic technological and functional variability have typically included differing impressions of cognitive differences between anatomically modern humans and archaic/Neanderthal hominids (for examples see Binford 1989; Chase 1991; Chase and Dibble 1987; Gibson 1993; Gowlett 1984; Hayden 1993; Ingold 1993a; Karlin and Julien 1994; Lindley and Clark 1990; Montagu 1976; Rowley-Conwy 1994; Schlanger 1994; Wynn 1989, 1991). Unfortunately, all of the varying interpretations have the same drawback; they must, of recourse, use the same database. According to one of the most passionate researchers on the topic (Hayden 1993:113) the implications of more negative views of archaic and Neanderthal humanness are twofold. First, it was essentially genetically impossible for these early hominids to possess certain behavioral sets commonly associated with anatomically modern hominids. Second, it was only with the appearance of *Homo sapiens sapiens* that traits such as language, hunting, symboling, foresight and planning depth, curation, blade manufacture and tools of perishable materials became a reality. The evidence from functional and

technological studies of Middle Paleolithic stone tools certainly calls into question some of these issues.

Flaked Stone Technology and Cognition

The flaking of a core to produce a flake or the manufacture of a tool from a mass of raw material by chipping is a goal-oriented activity. All flaked stone technology is goal-oriented and numerous goals can be defined at various levels. Processual approaches to lithic technology have isolated several interrelated variables of lithic technological systems, including raw material procurement, tool manufacture, use, and discard/reuse, which are influenced by logistical factors such as territory, range, settlement/subsistence patterns, mobility, and group relationships (Collins 1975, Holmes 1919; Shafer 1973). Binford's (1989) contention that Lower and Middle Paleolithic technology was characterized by a very low level of organization and lack of planning are at odds with the body of data which suggests just the opposite. To further characterize such industries as expedient as Binford does is to perpetuate a common misunderstanding of generalized core technologies associated with both archaic and anatomically modern humans (see Baumler 1988; Isaac 1977, 1978; Kuhn 1990, 1991, 1995; Johnson 1986; Teltser 1991). Expedient or flake technologies are best evaluated in terms of the logistical factors previously mentioned rather than on appearances of complexity. The complexity and organization of lithic technology is often associated with non-technological aspects of human existence.

The manufacture of even the most simple stone tools require the abilities to manipulate an amorphous solid both mentally and physically, plan ahead, and mentally visualize the desired end-product. The repetition of patterns of stone tool manufacture require the mental ability to conceive and memorize methods of manufacture to consistently achieve the desired end-product, whether it be a flake or a bifacial artifact. This is certainly demonstrated in the complexity of methods

associated with Lower and Middle Paleolithic stone tool manufacture and use (Boëda 1982, 1993; Boutie 1981; Dibble 1981; Van Peer 1992; Wynn 1977). Complex reduction strategies associated with bifacial tool and prepared core technologies (for example Acheulian handaxe or Levantine Mousterian industries) require the application of a set of complex spatial and volumetric concepts (Van Peer 1992; Wynn 1977). The manufacture of formal flaked stone artifacts requires the flintknapper to employ the Euclidean concept of bilateral assymetry (Wynn 1989:50). Artifact symmetry is not due strictly to chance but to the ability of the knapper to interpret the raw material, successfully apply previously learned concepts or methods of knapping. According to Wynn (1989:63-64) the manufacture of symmetrical artifacts reflects the presence of the idea of the shape in the mind of the flintknapper prior to its manufacture.

Convergent Tool Technology and Size

Even though Wynn is referencing the manufacture of bifacial artifacts I feel that a similar basic argument can be developed for the manufacture of specific flake morphologies such as are associated with the Levantine Mousterian. Wynn perceived the manufacture of Levallois products as less sophisticated than the manufacture of an Acheulian handaxe (1989:94) but certainly the preparation of the Levallois core is comparable in complexity. If Van Peer (1992) and Boëda (1986, 1988, 1993, 1995) are correct in the volumetric concept of Levallois reduction then the manufacture of Levallois cores is perhaps more complex than Wynn would have us believe. The volumetric concept coupled with the lineal and recurrent methods of Levallois preparation and flake removal (Boëda 1982, 1988, 1993, 1995) provide a model of Levallois technology that is complex and dynamic. Complexity of the Levantine Mousterian and Levallois technology is also enhanced by the ease with which identical endproducts can be produced by a variety of techniques and the flexibility of the method (Boëda 1986, 1988, 1983; Marks and Friedel 1977; Marks and Volkman

1983; Van Peer 1992). The method of manufacture employed to produce particular flake morphologies or edge types was part of the technical knowledge of the group and these methods were related to the manner in which the tools were to be used (Meignen 1995:364; Ridington 1982).

Research (Gordon 1993; Henry 1995a, 1995b; Henry et al. 1996; Lieberman and Shea 1994; Marks 1988; Shea 1991, 1993, 1995a 1996) suggests that the manufacture, abundance, function, discard and curation of convergent tools (especially points) in the Levantine Mousterian are related to patterns of core reduction, group mobility, transhumance and settlement/subsistence. The relative importance of convergent tools in the Levantine Mousterian is readily depicted in the proportion of points to other flake types in various assemblages (Shea 1995a). The ratio of Levallois points to Levallois flakes varied within certain geographic zones of the Levant with interior northern and southern areas having greater numbers of points than Mediterranean coastal areas. Independent data from Levantine Mousterian sites in southern Jordan support these findings (Henry 1995a, 1995b). Use-wear indicates that the role of convergent flake implements varied with respect to these same geographic zones (Shea 1991) with coastal assemblages reflecting a greater use of these implements in various maintenance tasks suggestive of tool and perishable artifact manufacture and maintenance and processing of non-animal resources. Interior and marginal areas indicate a greater use of convergent flake tools in extractive tasks, in particular hunting and butchering. Nahr Ibrahim North and Central Gallery samples correspond to rates of extractive /maintenance tasks associated with the Mediterranean coastal strand.

The production of convergent flakes differed between the Central and North Galleries at Nahr Ibrahim. Convergent flakes from both galleries were prepared by both radial/centripetal and unidirectional convergent methods. The major difference between galleries is in the proportion of these methods. Unidirectional convergent scar patterns are present on 65.7 percent of non-Levallois triangular flakes and 78.8

percent of Levallois triangular flakes from the North Gallery. Levallois and non-Levallois blades in the North Gallery are also dominated by unidirectional convergent dorsal surface preparation. Convergent flakes and blades from the Central Gallery have higher proportions of the radial/centripetal pattern.

The North and Central Gallery display differences in the degree of distal and lateral edge surface preparation on convergent flakes. The most striking differences can be observed between Levallois and non-Levallois triangular flakes. The greater degree of radial/centripetal surface preparation in the Central Gallery is correlated with greater lateral edge and distal surface preparation. Lateral and distal surface preparation are present on North Gallery non-Levallois triangular flakes but not on Levallois triangular flakes due to use of the unidirectional convergent method.

Further evidence of standardized preparation and manufacture of convergent tools can be found in cortex data. Nine percent of all convergent tools from the Central Gallery and 9.6 percent of North Gallery specimens have only minor amounts of cortex. The proportion of convergent tools with cortex from other Levantine Mousterian sites ranges from only 3.7 to 12 percent and may be partly related to the use of varying sizes of chert nodules.

Standardization of endproducts in the Levantine Mousterian is represented by recurrent flake types: oval, point, blade. Patterns of platform technology and methods of platform preparation of convergent flakes were essential to maintaining shape and consistency in attributes of length, width, and thickness. Differences in platform technology between the Central and North Gallery are linked to the method of dorsal surface preparation of convergent flakes in each gallery. The importance of multi-facet platforms and platform morphology can be observed in the virtual absence of cortical and partial-cortical platforms. Convergent flake tools from the Central Gallery exhibit multi-facet and triangular multi-facet platforms on 26 percent of all Levallois specimens and on 26.7 percent of all convergent tools from this gallery. The use of this type of platform technology is even higher for the North

Gallery (56.8 percent for all Levallois tools and 44.1 percent for all convergent tools). The chapeau de gendarme platform type is limited exclusively to Levallois products from both galleries (56 percent in the Central Gallery and 31 percent in the North Gallery).

The striking platform and proximal bulbar end of convergent tools from Nahr Ibrahim are typically unmodified. Only 3.9 percent of all Central Gallery and 2.7 percent of all North Gallery convergent tools exhibit this type of proximal alteration. Bulbar thinning and platform removal are often interpreted as strong indicators of preparation for hafting. However, studies by Shea (1991), Beyries (1988) and Anderson-Gerfaud (1990) indicate that removal of the bulb of percussion and striking platform are not necessary, and that very effective hafted implements can be produced without this type of modification. Shanidar Cave presents a different situation in which 9.1 percent of all analyzed convergent tools in this study were modified by removal of the bulb and striking platform. The smaller size of raw material at Shanidar prohibited to a degree the production of end products of a standardized shape, thinness, and size. This necessitated the use of greater amounts of lateral edge and proximal retouch to produce tools of a desired shape.

In contrast to convergent tools, sidescrapers from the Central Gallery were more frequently modified along the striking platform and bulbar area (26.2 percent) but the functional data suggests that the majority were hand-held and not hafted (Panagopolou 1985:105). The lack of proximal modification on convergent flakes has been documented for other Levantine Mousterian sites (Shea 1991). Technologically it is not feasible to create stemmed or notched haft elements on broad-based highly convergent flakes. A haft element would remove considerable edge necessary for tool function and render the flake useless. As a consequence, the methods of hafting were adapted so that little modification of these flakes was necessary. In instances from Nahr Ibrahim where the proximal end was modified it

was only the basal edge that was retouched and little of the lateral edge or flake convergence were compromised.

Experimental studies by Dibble, Whittaker, and Speth (Dibble 1981, Dibble and Whittaker 1981; Speth 1971., 1975) have demonstrated the interplay between various technological attributes and flake size and shape. The exterior platform angle is influential upon the dimensions of length and thickness and type of flake termination. Striking platform thickness is related to variability in flake thickness and length while striking platform width controls flake width. Metric studies of convergent tools from Nahr Ibrahim demonstrate that North Gallery specimens are somewhat more elongated than Central Gallery implements. Levallois convergent tools from the Central Gallery are dominated by broader and shorter triangular flakes. The differences in blank shape and elongation can be correlated to the principle methods of dorsal surface preparation prior to striking the flake from the core. The efficiency of the Levallois method in controlling dimensions of flake width and thickness can be observed in width/thickness index values. Higher values are associated with wider and thinner flakes. Levallois convergent tools from the Central and North Gallery have higher width/thickness indices than non-Levallois specimens. The difference between the various indices for Levallois and non-Levallois tools indicates that implements from the North Gallery are more uniform as a group than the Central Gallery. Again, this may be correlated with the predominance of unidirectional convergent core preparation prior to flake removal in the North Gallery.

There is no statistically significant intragroup difference between Levallois and non-Levallois convergent tool dimensions for the Central and North Galleries. There is, however, a consistently narrower range of variability for thickness and striking platform thickness of Levallois convergent tools but it is not significant. The lack of statistical significance between Levallois and non-Levallois convergent tools is arguably related to similarity in methods of preparation and manufacture. More

significantly, it is felt that at least some of the intragroup similarity documents the influence of a set of selective criteria on the part of Levantine Mousterian hominids. Selection criteria seems to have included overall flake convergence, suitable thickness, and sufficient size. Regardless of the method of flake production (Levallois or non-Levallois) the same set of criteria would have been employed for a flake to be selected for use as a tool. Other factors may have been important if the tool was hafted. The size and shape limitations for convergent tools would result in a homogenous cluster within each site or gallery. We have shown here that metric and technological analyses of convergent tools has isolated a distinct tool class composed of flakes produced by a variety of techniques.

Some degree of standardization of size and shape of Levallois points has been documented by other researchers. Crew (1975) documented certain technological differences between inland and coastal sites regarding Levallois points that were not apparent in metric attributes. Dimensions of points between these two zones displayed no statistically significant differences and overall similarity in size is probably related to functional requirements and limitations. Crew (1975:124-128) also suggested that culturally defined technological norms may have had some influence. According to Plisson (1988, citing work of Shchelinskii), although certain Mousterian tools were multifunctional, there was a degree of functional specificity that seems to be related to tool morphology. Certain tool types were probably manufactured according to specific standards of shape (Hayden 1993:122) for a limited range of tasks. Use-wear data from Nahr Ibrahim and other Levantine Mousterian sites certainly indicates that convergent flake tools were employed primarily as hafted hunting implements and hafted/unhafted butchering tools. The relationship between flake morphology, size, and tool function seems to be established for convergent tools of the Levantine Mousterian.

Convergent Tool Design and Functional Variability

Considerations of the specific design requirements of tools for certain tasks, amount and kind of raw material available, and the general amount of material to be processed by tools play important roles in developing the composition and organization of lithic tool assemblages (Hayden et al. 1996:9). Decisions that must be made by a group regarding these variables result in specific sets of strategies and logistical planning associated with the technology. The level of technological organization and complexity is directly related to the degree of planning and types of strategies employed by the group. Anticipatory behaviors and tactical and planning depth are the major cognitive factors related to technological organization. The resulting design and complexity of implements in a lithic assemblage is correlated with the decisions and strategies associated with settlement mobility and subsistence patterns.

Technologies have been considered as either maintainable, reliable, transferable or some combination of these patterns. The determination of maintainability or reliability is often based on technological and functional inferences associated with the lithic assemblage. Topics of interest include tool design, transport, curational or conservatory behavior, multiple use, recycling, and tool maintenance and discard. The translation of a number of these topics into meaningful statements for Levantine Mousterian convergent tools has hopefully placed these implements within the framework of Levantine Mousterian technological organization.

There is a range of task and technological constraints associated with the use of convergent flakes as tools. These constraints are related to the mode of prehension and the manner in which the tool was used. Convergent tools employed as projectile points and various cutting and scraping tools were subjected to both dynamic and static loading of points and lateral edges. The most probable areas of convergent tool breakage are across the distal portion of the blade and the lateral

corners of the proximal end (Shea 1995b:283). It is possible that the dorsal longitudinal ridges on the majority of convergent flakes could have increased the strength and resistance to breakage during use even though these ridges are a result of technological processes to produce convergence. Convergent flakes provide suitable lateral edges for cutting and scraping a variety of raw materials and the distal convergence is well-designed for piercing, drilling, awling, or graving tasks. Thin convergent distal tips that are not modified by retouch have qualities that provide an excellent piercing element with secondary cutting properties that make them very suitable for hafted hunting and dispatching weapons (Shea 1995b:286). Once broken, however, retouch would have shortened the tool. It was not possible to resharpen the majority of these implements due to the length and width which created small broad flakes initially. In most instances it was easier to replace a convergent tool rather than attempt extensive resharpening.

There is considerable technological variability among convergent tools from the Levantine Mousterian indicating the selection of both Levallois and non-Levallois flakes (this study and Shea 1991). Implements traditionally classified as convergent sidescrapers according to Bordes classification seem to have functioned as both hafted and unhafted cutting and scraping tools, not merely scrapers. The selection process associated with convergent flakes could have included two possibilities. First, it could reflect the specific production of Levallois points and convergent Levallois flakes for specific tools and the ad-hoc or expedient selection of non-Levallois convergent flakes to meet specific needs as they arose. Second, the selection of Levallois or non-Levallois flakes was not as critical as flake size, shape, and distal convergence. Certainly the use-wear data from Nahr Ibrahim and other Levantine Mousterian sites indicate that Levallois and non-Levallois convergent flakes were employed in the same range of activities. That more Levallois flakes were selected is probably related to the abundance of these end-products at different sites (Henry 1995b; Shea 1991, 1995b). The abundance of Levallois points and convergent flakes

could be influenced by higher production rates (more flakes produced per core or more core reduction compared to tool maintenance) or the transport of convergent tools into sites (Henry 1995b).

Socio-economic constraints that could be applied to convergent tools include mobility, transport capacity, potential labor investment, and storage (as flakes, finished tools, or prepared cores). Much of the data to address these issues are currently not robust enough for the Levantine Mousterian to effectively address them in behavioral terms. Most Middle Paleolithic sites in the Levant are located in areas adjacent or within reasonable distance to suitable sources of raw material and the lithic assemblages from many Levantine Mousterian cave sites indicate that the entire sequence of lithic production is represented. The effect of raw material scarcity in the region is documented for the Negev of Israel (Munday 1976) and the southern Levant in Jordan (Henry 1995a, 1995b). These problems were met by more intensive reduction of raw materials and the importation of raw material from adjacent regions. In the case of Tor Sabiha in Southern Jordan, Levallois points were imported from other areas on the Jordanian Plateau probably as part of personal toolkits. In Chapter VII, it was suggested that middens in rockshelters and cave sites could have functioned as informal areas of long-term storage of lithic material. Middens would certainly have served as suitable locations from which to select flake tools for expedient use. The transport of convergent tools would have been subject to the same limitations associated with most hunter-gatherer groups and would represent a part of personal gear and toolkits.

The reconstruction of tool motions associated with convergent tools (this study; Anderson-Gerfaud 1990; Beyries 1988; Lee 1987; Shea 1991) indicate use in a range of extractive and maintenance tasks. Tool motions associated with the extraction of animal food resources include projectile impact, cutting, and associated hafting traces of these implements. There is a greater variety of tool motions associated with maintenance activities which include tool manufacture, repair,

manufacture of perishable artifacts, and processing of non-food and non-animal resources. Maintenance tool motions include awl, grave, chop, adze, plane, shave. Scraping is associated with slightly greater numbers of Levallois flakes or equivalent proportions of Levallois and non-Levallois flakes. Cutting wear suggests that Levallois flakes were preferred and this may be associated with the greater use of Levallois flakes in extractive tasks. Higher rates of cutting wear on Levallois flakes is also correlated to greater numbers of these tools with hafting and projectile impact wear. Higher rates of cutting, projectile impact, and hafting wear on convergent Levallois flakes strongly suggests that there was a selective pattern for the production of these flakes as parts of composite tools. These implements were either part of a special extractive/hunting toolkit or were a common component of the individual toolkit. In all likelihood convergent tools functioned in both capacities. The association of convergent tools with other minor tool motions strongly suggests that these implements frequently were employed in a range of daily and subsistence related tasks or activities.

There is no statistically significant difference in the use of Levallois or non-Levallois flakes in any tool motion. The major differences lie in the abundance of Levallois versus non-Levallois convergent flakes in an assemblage which is probably related to the overall abundance of Levallois convergent flakes in an assemblage. Shea (1991, 1995b) noted that the numbers of Levallois points along the Levantine Mediterranean coastline and northern Levant proper are lower than in the southern Levant and marginal areas. The available data indicates that these differences are linked to the abundance of impact-damaged Levallois points in the southern Levant and that rates of Levallois point production may be an indirect measure of the importance of hunting. However, Shea (1995b:288-289) cautions us on the use of such measures. It is tantalizing to consider this as a possibility.

When the proportion of worked materials associated with convergent tools is considered then the use of these implements as hunting and animal processing

implements is even more apparent. When all samples of convergent tools are pooled then 31.5 percent of all worked materials are medium animal. A significant proportion are also associated with impact against unknown materials. This argues for both functional and task specificity of convergent tools. The differences in worked materials among all sites is what could be expected in a small region with significant environmental differences from the coast to the interior. Logistical differences at the time of tool use and discard probably provided a significant unknown degree of influence on the proportion of worked materials from each site assemblage. This is especially evident, for example, in assemblages from Kebara that are associated with archaic /Neanderthal hominid skeletal remains where medium animal materials varied from 15.7 percent to 39.8 percent. Differences among sites are effectively related to the performance of extractive and maintenance tasks suggesting that logistical differences in technological organization can be detected at the assemblage and type level.

The basic design of Levantine Mousterian convergent tools does not seem to have varied in any detectable manner between industry variants or between assemblages associated with archaic/Neanderthal or anatomically modern hominids. Patterns of hafting are comparable between specimens damaged by projectile impact and those damaged through cutting, scraping, awling and other functions. Certain attributes that make convergent flakes suitable for use as hafted hunting weapons also make them suitable hafted or unhafted cutting implements. These include distal convergence with a sharp point and a central dorsal ridge complex that would provide strength across the width and down the length of the flake. The presence of impact damage indicates that these implements were designed to be reliable but the distal convergence, short length, and increased width mean that much of the proximal end must be in the haft and that there was probably little room for repair of broken or dulled implements. This type of hunting weapon design argues against the use of spear throwers and foreshafts which meant that Levantine Mousterian and Zagros

Mousterian hunters employed encounter or close-in hunting methods or relied on entrapment when feasible.

The use of convergent tools as butchering implements is somewhat negatively correlated with the abundance of projectile impact on these implements in Levantine Mousterian assemblages. It is probable that this negative correlation is the result of differential locations of animal resource procurement and processing although not entirely. There is no significant correlation between hafting and butchering tools. Other studies have suggested that unhafted flakes are more efficient and easier to use than hafted flakes due to the amount of tool manipulation that must occur during the process. The presence of retouch on 33.7 percent of all Levantine Mousterian convergent tools employed in butchery is evidence that tool maintenance was probably associated with the tool use episode. Shea has documented a preference for points over flakes and blades as butchering tools. As with hunting weaponry, the costs of individual transport of hafted or unhafted butchering tools would probably have been low.

Evidence of bone contact on Levantine Mousterian convergent tools indicates that some of the wear is from the contact of tools with bone during butchering and other processing activities while a small but significant portion of the wear is from the deliberate modification of bone. There is a significant proportion of all EU with bone wear that exhibit modification by retouch (57.6 percent) which is associated with working such dense materials and the need for sturdy durable edges. Cutting and scraping were the most common tool motions (92.3 percent combined) with only 7.7 percent due to engraving, awling, and chopping. Engraving and awling of bone could have been associated with the manufacture or maintenance of artifacts of bone, antler, or horn. Bone contact wear was present on 10.1 percent of all EU of convergent tools from the Central Gallery of Nahr Ibrahim and on 12.1 percent from the North Gallery. The presence of use-wear attributed to bone has been identified in

a number of Middle Paleolithic sites from Europe and Southwest Asia (Anderson-Gerfaud 1990; Beyries 1988; Shea 1991).

Hafting wear is potentially as significant as damaged projectile points from a tool design perspective. Hafting is typically associated with the manufacture of tools in anticipation of need providing direct evidence of foresight and planning for a portion of the Levantine Mousterian technological record. Hafting has been associated with a variety of tool motions and inferred tasks in the Levantine Mousterian such as woodworking (14.5 percent, hideworking, 22.5 percent, and tools with bone contact (57.1 percent). At Shanidar Cave 19.5 percent of all non-projectile impact EU were associated with haft wear. Haft wear was also observed on 61.7 percent of all butchery EU of convergent tools from the Levantine Mousterian. Hafted butchering implements may have been employed during hunting forays that were organized at some distance from the habitation site. The data also suggests that hafting was occasionally employed to facilitate other tasks such as hideworking and light-duty woodworking.

Activities such as soft plant processing and heavy-duty woodworking are only occasionally represented among convergent tools being more typically associated with oval flakes, blades, and massive angular stone fragments. The design limitations of convergent tools suggest that they were not designed to be employed in tasks requiring mass such as heavy woodwork. The use of convergent tools in tasks such as soft plant processing and heavy duty woodworking are good evidence for the use of these implements as situational gear following Binford's (1979:264-266) definition. Tasks involving chopping, adzing, and wedging usually involve the use of larger tools or fragments with considerable mass and durability to withstand harsh use and are often associated with the procurement of materials away from a habitation site. Frequently these tools are also expedient and discarded at the locus of use (Hayden 1981). The presence of certain wear types and inferred activities

among convergent tools is influenced by the organization of tasks and the location in which those activities were performed.

Convergent tools associated with light-duty woodworking provide some evidence of the staging of material processing reflecting the manipulation of previously procured material into final form. These implements represent the manufacture, maintenance, and repair of perishable artifacts or the perishable components of composite artifacts such as handles and spearshafts. These EU represent 14.5 percent of all Levantine Mousterian convergent tool EU and included a range of cutting and piercing tool motions. Sites or assemblages with greater than 80 percent EU associated with extractive tasks exhibit less than 10 percent of light-duty woodworking EU. Shea (1991) has additionally identified this pattern for entire assemblages of the Levantine Mousterian.

The proportion of hideworking evident among EU of Levantine Mousterian assemblages is variable and is slightly negatively correlated with the proportion of EU associated with extractive tasks (Shea 1991). The disparity between hideworking and extractive EU may be an indication of the distance at which game was taken. When this trend is examined for convergent tools there is no clear pattern which emerges which may be related to the type of flakes selected for hideworking versus extractive tasks. Shea's analysis indicated that oval flakes were more often selected for use in hideworking and other scraping tasks. In addition, convergent tools were usually used in piercing hides probably for the manufacture of leather goods rather than the processing of procured hides (indicated by scraping). It is a mistake to associate all hide scraping and cutting wear on convergent tools with hide processing as they probably represent the manufacture of leather items from previously procured and prepared hides and skins.

Use-intensity, Curation, and Resharpener of Convergent Tools

An examination of the use intensity of convergent tools indicates that Phase 1 (Tabun D) implements have a higher number of EU per tool suggestive of patterns of more intensive tool use. Phase 2 (Tabun C) and Phase 3 (Tabun D) convergent tools exhibit similar average numbers of EU per tool. I expected that unhafted implements would have greater numbers of EU per tool than hafted convergent tools but there was not a direct correspondence between the rate of hafting and the number of EU per tool.

The patterns of tool use seem to vary between these industrial variants with Phase 2 (Tabun C) assemblages typically higher in the proportion of maintenance tasks and an overlap between Phase 1 (Tabun D) and Phase 3 (Tabun B) extractive/maintenance ratios. These trends do not appear to be detectable at the level of individual tool categories probably due to such behaviors as tool replacement and tool discard patterns. The only significant difference is associated with Tor Faraj C in Southern Jordan with a high extractive/maintenance ratio of 27.6 suggesting that convergent tools were almost exclusively employed in extractive tasks. These ratios certainly can be influenced by the selection of other flake types for use in maintenance tasks. Convergent tool samples with higher ratios could arguably be interpreted as representing a greater degree of functional specificity of convergent tools.

Levantine Mousterian convergent tools were not associated with intensive reuse or periods of extensive resharpener or maintenance. Retouched artifacts are not abundant in Levantine Mousterian assemblages with most retouch implements representing only occasional resharpener. The lack of direct indication for convergent tool maintenance and evidence that may be variously interpreted as curatorial indicates that Levantine Mousterian hominids invested less time in stone tool maintenance and repair activities and that more time was directed toward tool replacement (retooling). Reasons for this include technology, tool design, and

functional variability. Tip and lateral edge damage and wear on convergent tools which could easily be repaired on elongated forms such as bifaces frequently meant that the entire tool was replaced. The convergent design and broad proximal dimension required about one-third of the tool to be incorporated into the haft element. The Levallois technique apparently was employed to gain as much length from the flake as possible and maintain the convergent form. These implements were primarily employed in various extractive tasks associated with processing significant amounts of material via butchering. Such tasks frequently require the production of tools in which the distal tip and lateral edges are desired elements of design. Convergent tools include both of the design elements at the cost of some aspects of maintainability (ease of resharpening). Less effort expended in resharpening and repair of the stone component also suggests increased emphasis on blank production. Cores and convergent flakes were probably a significant portion of the Levantine Mousterian toolkit.

According to Shea (1991:237-238) the majority of retouch was conducted either for manual or haft prehension or to regularize an edge before use. Light and moderate levels of retouch were observed on convergent tools from the North and Central Gallery of Nahr Ibrahim. Unmodified EU are dominant in the Central Gallery. The North Gallery has roughly equal proportions of modified and unmodified EU. A greater number of modified EU in the North Gallery is suggestive of increased use-intensity that may also be associated with the higher average number of EU per tool and a higher extractive/maintenance ratio for this gallery. These patterns may have been associated with organizational differences in technology between the North and Central Gallery. The majority of modified EU from other Levantine Mousterian sites were associated with shaving, scraping, awling, and cutting with cutting and scraping dominant (Shea 1991:177). Retouched EU on Levantine Mousterian convergent tools were predominantly associated with cutting (43.8 percent) and scraping (16.9 percent). Hafting is represented on 16.1

percent of all retouched EU and impact damage on 10.6 percent. Awl wear is present on 9.3 percent of all modified tips of convergent tools. Only 3.3 percent of all retouched EU have other types of wear associated with shaving, adzing, and drilling. These values do not include data on Shanidar Cave. The proportions of different wear types associated with modified EU from Shanidar differ from Levantine Mousterian samples. For Shanidar, the majority of modified EU were employed in scraping (56.7 percent), cutting (18.3 percent), impact damage (10 percent), hafting (8.3 percent) and awl wear (6.7 percent). With the exception of scraping and cutting wear, the majority of wear types observed for retouched EU at Shanidar compare favorably with those from Levantine Mousterian sites suggesting that convergent tools of the Zagros and Levantine Mousterian were employed in roughly similar ways.

Differences are probably more attributable to variability in technological organization, the periodicity or rate at which certain tasks were performed, settlement/subsistence differences, and technology. These factors can influence the role that stone tools play in adaptation and how the lithic technology is integrated into the overall framework of adaptive strategies. The proportion of unmodified to modified edges among convergent tools from the Levantine and Zagros Mousterian does not seem to be related to industry type so much as tool motion or task and the relative frequency with which convergent tools were employed in those tasks. The volume of material processed in these tasks may also have been a factor in the number of edges utilized and the number of edges modified.

The morphology of utilized edges varies between the Zagros and Levantine Mousterian. The data indicate that the Zagros Mousterian is typically associated with more retouched lateral edges and retouched distal tips than convergent tools of the Levantine Mousterian. Technological differences in blank size and shape are probable significant factors in the greater degree of retouch of tool edges from Shanidar. Functional differences such as a greater use of convergent tools in

scraping tasks at Shanidar has also influenced the abundance of retouched edges and edge morphology. Convergent tool users in the Levantine Mousterian selected primarily for convex and straight edges and points. The proportion of unmodified convex and straight lateral edges varies from 65.3 to 70.6 percent. The proportion of different unmodified edge shapes reflects a slight preference for convex edges (29.3 percent) but straight, concave and recurved edges are essentially equivalent in representation varying from 11.4 percent to 17.5 percent. Convex and straight lateral edges are characterized by a greater proportion of retouch than concave and recurved edges. This pattern is partially attributed to maintenance and retouch of unmodified edges which could have originally been any shape. The pattern of lateral edge variability in the Levantine Mousterian is also influenced by the range of edge shapes that would occur on convergent flakes in general but is further biased by cultural selection for tool use. There is some suggestion that edge morphology is guided in part by the dorsal surface scar pattern and the use of unidirectional convergent methods of core preparation (Meignen 1995:373-375). Tip morphology is principally guided by unidirectional convergent reduction methods. The majority of tips of Levantine Mousterian convergent tools are unmodified and trihedral in cross-section. All tips of convergent tools from Shanidar are modified but are trihedral in cross-section due to unifacial retouch of flakes that are essentially triangular in cross-section prior to modification.

Patterns of Convergent Tool Provisioning

Convergent tools of the Zagros and Levantine Mousterian were primarily associated with the procurement and processing of animal resources but also played an important role in other ancillary non-subsistence activities that probably occurred on a daily basis. Convergent tools played a dual role in Middle Paleolithic society and technology serving both individual and group needs.

Convergent implements of various types were employed by individuals in technologically assisted hunting and game processing. Hunting requires a level of foresight and planning well in advance of the event that is associated with preparation of individual gear. The preparation of individual gear could include replacement of worn tools and damaged projectile points, checking and securing hafting, and the manufacture of additional tools and weapons as needed. The composition of the individual toolkit would have varied dependent upon the anticipated needs of the individual or group (Kuhn 1994). The hunting toolkit should have include replacement parts for field repair in addition to the tools and weapons. Levallois products (including cores, flakes, and tools) were frequently transported over significant distances as parts of mobile toolkits (Henry 1995a, 1995b; Marks 1988; Marks et al. 1991; Munday 1976; Rensink et al. 1991; Roebroeks et al. 1988; Siman 1991; Simek 1991). Convergent tools would have been an important portion of the individual toolkit because of the potential use of these types of flakes.

Components of the individual toolkit frequently represent curated and heavily maintained gear. In the case of Levantine Mousterian convergent tools there is no significant evidence to suggest that the flakes themselves were either heavily maintained or curated. In fact, these flakes seem to have been replaced quite frequently given the low effort at resharpening and maintenance. Use-wear analysis strongly supports the inference that the majority of these tools had fairly short use-lives before discard. Curation of toolkit components is usually associated with the stone tool portion of the kit but as pointed out by Kuhn (1994) stone tools actually represent only a small portion of the total personal kit carried by hunter-gatherer groups. In the case of the Levantine Mousterian, curation has been inferred by Binford (1989) to have been negligible and the data from stone tools seems to support his conclusions. However, the objects of curation were probably the perishable portions of the stone tools which would include the haft elements and spearshafts. This would appear a logical possibility given the absence of bifacial artifacts which

can remain functional for longer periods of time by repeated resharpening than flake tools. If curation was oriented toward the perishable portion of the toolkit then this suggests that other portions of the personal kit would have included prepared cores and tool blanks.

In addition to forming a portion of the individual toolkit, convergent implements played a significant role in the organization of various activities in which tools were manufactured as needed. These implements typically have very short use-lives usually for the duration of the task or until non-functional from use. Rates of retouch and resharpening and curation are low. Unhafted implements may have served a greater role in the provisioning of activities than hafted versions.

Although there is no direct evidence (caches of tools, tool blanks, or raw material) that Levantine or Zagros Mousterian hominids provisioned places with stone tool material or tool blanks it should be considered as a possibility. Kuhn (1992:189) suggested that places that are provisioned should reflect less emphasis on tool maintenance and resharpening and more emphasis on tool replacement. The abundance of raw material for retooling to occur rather than tool maintenance to be a possibility is critical. The majority of rockshelter and cave sites in the Levant are adjacent to or within range of suitable sources of raw material that appear to have been stable throughout much of the Late Pleistocene. This is also suggested by the abundance of manufacturing debris present in these sites (Shea 1991). The presence of middens within the caves could have been a source of tool material, at least for more expediently used flakes, chips, and chunks. That this type of procurement occurred is supported by the abundance of cortical flakes, fragments and pieces of shatter that were utilized as expedient tools at Levantine Mousterian sites (Shea 1991). The actual level of provisioning of places may have been very conservative and limited to unprocessed raw material that occurred naturally in the area of the site negating the need for storage of finished tool blanks or prepared cores. Although the evidence for place provisioning is mostly circumstantial it is worth considering in

light of the abundance of unmodified and minimally modified and resharpened convergent tools in Levantine Mousterian assemblages. Undoubtedly, the patterning that is reflected within convergent tools is a reflection of multiple provisioning strategies and discard patterns and it is not possible to factor out each strategy given the limitations of the current database and our knowledge of Middle Paleolithic technological organization.

REFERENCES CITED

Ahler, S.A.

- 1989 Mass Analysis of Flaking Debris: Studying the Forest Rather Than the Tree. In *Alternative Approaches to Lithic Analysis*, edited by D.O. Henry and G.H. Odell, pp. 85-118. Archeological Papers of the American Anthropological Association 1. Washington, D.C.
- 1992 Use-Phase Classification and Manufacturing Technology in Plains Village Arrowpoints. In *Piecing Together the Past: Applications of Refitting Studies in Archaeology*, edited by J.L. Hofman and J.G. Enloe, pp. 36-62. BAR International Series 578. British Archaeological Reports, Oxford.

Ammerman, A.J., and M.W. Feldman

- 1974 On the "Making" of an Assemblage of Stone Tools. *American Antiquity* 39(4):610-616.

Anderson, P.C.

- 1979 A Microwear Analysis of Selected Flint Artefacts from the Mousterian of Southwest France. *Lithic Technology* 9:32.
- 1980 A Testimony of Prehistoric Tasks: Diagnostic Residues on Stone Tool Working Edges. *World Archaeology* 12:181-194.

Anderson-Gerfaud, P.

- 1981 *Contribution Methodologique à l'Analyse des Microtraces d'Utilisation sur les Outils Préhistoriques*. Unpublished Ph.D. dissertation, University of Bordeaux I, Bordeaux, France.
- 1990 Aspects of Behaviour in the Middle Paleolithic: Functional Analysis of Stone Tools from Southwest France. In *The Emergence of Modern Humans: An Archaeological Perspective*, edited by P. Mellars, pp. 389-418. Cornell University Press, Ithaca, New York.

Bamforth, D.

- 1985 The Technological Organization of Paleo-Indian Small Group Bison Hunting on the Llano Estacado. *Plains Anthropologist* 30(109):243-258.
- 1986 Technological Efficiency and Tool Curation. *American Antiquity* 51(1):38-50.
- 1988 Investigating Microwear Polishes with Blind Tests: The Institute Results in Context. *Journal of Archaeological Science* 15:11-23.

- 1991 Technological Organization and Hunter-Gatherer Land Use: A California Example. *American Antiquity* 56(2):216-234.
- Bamforth, D. B., G.R. Burns, and C. Woodman
 1990 Ambiguous Use Traces and Blind Test Results: New Data. *Journal of Archaeological Science* 17:413-430.
- Bar-Yosef, O.
 1980 The Prehistory of the Levant. *Annual Review of Anthropology* 9:101-133.
 1989a Geochronology of the Levantine Middle Paleolithic. In *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, edited by P. Mellars and C. Stringer, pp. 589-610. Princeton University Press, Princeton, New Jersey.
 1989b Upper Pleistocene Cultural Stratigraphy in Southwest Asia. In *The Emergence of Modern Humans: Biocultural Adaptations in the Later Pleistocene*, edited by E. Trinkaus, pp. 154-180. Cambridge University Press, New York.
 1994 The Contributions of Southwest Asia to the Study of the Origin of Modern Humans. In *Origins of Anatomically Modern Humans*, edited by M.H. Nitecki and D.V. Nitecki, pp. 23-66. Plenum Press, New York.
- Bar-Yosef, O., and P. Goldberg
 1988 An Outline of the Chronology of the Middle Paleolithic in the Levant. In *L'Environnement*, edited by M. Otte, pp. 13-20. *L'Homme de Néandertal*, vol. 2. Études et Recherches Archéologiques de l'Université de Liege, Liege, France.
- Bar-Yosef, O., and L. Meignen
 1992 Insights into Levantine Middle Paleolithic Cultural Variability. In *The Middle Paleolithic: Adaptation, Behavior, and Variability*, pp. 163-182. University Museum Press, Philadelphia, Pennsylvania
- Bar-Yosef, O., B. Vandermeersch, B. B. Arensburg, A. Belfer-Cohen, P. Goldberg, H. Laville, L. Meignen, Y. Rak, J.D. Speth, E. Tchernov, A-Marie Tillier, and S. Weiner
 1992 The Excavations at Kebara Cave, Mt. Carmel. *Current Anthropology* 33:497-550.

Baumler, M.F.

- 1987 *Core Reduction Sequences: An Analysis of Blank Production in the Middle Paleolithic of Northern Bosnia, Yugoslavia*. Ph.D. dissertation, University of Arizona. University Microfilms, Ann Arbor, Michigan.
- 1988 Core Reduction, Flake Production, and the Middle Paleolithic Industry of Zobiste (Yugoslavia). In *Upper Pleistocene Prehistory of Western Eurasia*, edited by H. Dibble and A. Montet-White, pp. 255-274. University Museum Press, University of Pennsylvania, Philadelphia.
- 1995 Principles and Properties of Lithic Core Reduction: Implications for Levallois Technology. In *The Definition and Interpretation of Levallois Technology*, edited by H.L. Dibble and O. Bar-Yosef, pp. 11-23. Prehistory Press, Madison, Wisconsin

Baumler, M., and C. Downum

- 1989 Between Micro and Macro: A Study in the Interpretation of Small-Sized Lithic Debitage. In *Experiments in Lithic Technology*, edited by D. Amick and R. Mauldin, pp. 101-116. BAR International Series 528. British Archaeological Reports, Oxford.

Beyries, S.

- 1987 *Varibilite de l'Industrie Lithique au Mousterien: Approche Fonctionnelle sur Quelques Gisements Francais*. BAR International Series 328. British Archaeological Reports, Oxford.
- 1988 Functional Variability of Lithic Sets in the Middle Paleolithic. In *Upper Pleistocene Prehistory of Western Eurasia*, edited by H.L. Dibble and A. Montet-White, pp. 213-223. University Museum Press, University of Pennsylvania, Philadelphia.

Beyries, S., and H. Roche

- 1982 Technologie et Traces d'Utilisation: Application à de Industries Acheuleennes (Carrieres Thomas, Casablanca, Maroc). In *Tailler! Pour Quoi Faire: Prehistoire et Technologie Lithique II*, edited by D. Cahen, pp. 267-277. Musee Royal de l' Afrique Centrale, Tervuren, Belgium.

Binford, L.R.

- 1973 Interassemblage Variability: The Mousterian and the 'Function Argument'. In *The Explanation of Culture Change: Models in Prehistory*, edited by C. Renfrew, pp. 227-254. Duckworth, London.

- 1977 Forty-Seven Trips: A Case Study in the Character of Archaeological Formation Processes. In *Stone Tools as Cultural Markers: Change, Evolution and Complexity*, edited by R.V.S. Wright, pp. 24-36. Australian Institute of Aboriginal Studies, Canberra.
- 1978a Dimensional Analysis of Behavior and Site Structure. Learning from an Eskimo Hunting Stand. *American Antiquity* 43:330-361.
- 1978b *Nunamiut Ethnoarchaeology*. Academic Press, New York.
- 1979 Organization and Formation Processes; Looking at Curated Technologies. *Journal of Anthropological Research* 35(3):255-273.
- 1980 Willow Smoke and Dogs Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45:1-17.
- 1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1:5-31.
- 1984 An Alyawara Day: Flour, Spinifex Gum, and Shifting Perspectives. *Journal of Anthropological Archaeology* 4:292-327.
- 1985 Human Ancestors: Changing Views of Their Behavior. *Journal of Anthropological Archaeology* 4:292-327.
- 1986 An Alyawara Day: Making Men's Knives and Beyond. *American Antiquity* 51:547-562.
- 1987 Searching for Camps and Missing the Evidence: Another Look at the Lower Paleolithic. In *The Pleistocene Old World: Regional Perspectives*, edited by O. Soffer, pp. 19-31. Plenum Press, New York.
- 1989 Isolating the Transition to Cultural Adaptations: An Organizational Approach. In *The Emergence of Modern Humans: Biocultural Adaptations in the Later Pleistocene*, edited by E. Trinkaus, pp. 18-41. Cambridge University Press, New York.
- Binford, L.R., and S.R. Binford
- 1966 A Preliminary Analysis of Functional Variability, in the Mousterian of Levallois Facies. In *Recent Studies in Paleoanthropology*, edited by J.D. Clark and F.C. Howell. *American Anthropologist* 68(2):238-295.
- Binford, L.R., and C.K. Ho
- 1985 Taphonomy at a Distance: Zhoukoudian, "The Cave Home of Beijing Man". *Current Anthropology* 26(4):413-442.
- Bleed, P.
- 1986 The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51(4):737-747.

Boëda, E.

- 1982 Etude Experimentale de la Technologie des Pointes Levallois. *Studia Praehistorica Belgica* 2:23-56.
- 1986 *Approche Technologique du Concept Levallois et Evaluation de son Champ d'Application*. These de IIIeme Cycle, Universite de Paris.
- 1988 Le Concept Levallois et Evaluation de Son Champ d'Application. In *La Technique*, edited by M. Otte, pp. 13-26. *L'Homme de Néandertal*, vol. 4. Études et Recherches Archeologiques de l'Universite de Liege, Liege, France.
- 1990 Identification de Chaînes Operatoires Lithiques du Paléolithique Ancien et Moyen. *Paleo* 2:43-80.
- 1993 Le Debitage Discoïde et le Debitage Levallois Recurrent Centripete. *Société Préhistorique Française* 90(6):392-404.
- 1995 Levallois: A Volumetric Construction, Methods, A Technique. In *The Definition and Interpretation of Levallois Technology*, edited by H.L. Dibble and O. Bar-Yosef, pp. 41-68. Prehistory Press, Madison, Wisconsin.

Boëda, E., J-M. Geneste, and M. Meignen

- 1990 Identification de Chaînes Operatoires Lithiques du Paléolithique Ancien et Moyen. *Paleo* 2:43-80.

Bordaz, J.

- 1968 Stone Age Implements. In *Readings in Anthropology*, edited by M. Fried, pp. 419-508. Thomas Y. Crowell, New York.
- 1971 *Tools of the Old and New Stone Age*. The Natural History Press, Garden City, New York.

Bordes, F.

- 1955 Le Paléolithique Inférieur et Moyen de Jabrud (Syrie) et la Question du Pre-Aurignacien. *L'Anthropologie* 59:486-507.
- 1961 *Typologie du Paléolithique Ancien et Moyen*, 2 Volumes. L'Institut de Prehistoire, Universite de Bordeaux, Memoire 1. Delmas, Bordeaux.
- 1968 *The Old Stone Age*. McGraw-Hill, New York.
- 1972 *A Tale of Two Caves*. Harper & Row, New York.

Bousman, C.B.

- 1993 Hunter-Gatherer Adaptations, Economic Risk, and Tool Design. *Lithic Technology* 18(1-2):59-86.

- Boutie, P.
1981 *L'Industrie Moustérienne de la Grotte de Kebara, Mont Carmel, Israel*. Museum National d'Histoire Naturelle, Musée de l'Homme Memoire No. 10, Paris.
1989 Etude Technologique de l'Industrie Moustérienne de la Grotte de Qafzeh (pres de Nazareth, Israel). In *Investigations in South Levantine Prehistory/Prehistoire du Sud-Levant*, edited by O. Bar-Yosef and B. Vandermeersch, pp. 213-230. BAR International Series 497. British Archaeological Reports, Oxford.
- Braidwood, R.J.
1967 *Prehistoric Men*. Scott, Foresman and Company, Glenview, Illinois.
- Buckley, D.H.
1981 *Surface Effects in Adhesion, Friction, Wear, and Lubrication*. Elsevier Scientific, New York.
- Butzer, K.W.
1958 *Quaternary Stratigraphy and Climate in the Near East*. Bonner Geographische Abhandlungen, Herausgegeben vom Geographischen Institut der Universität Bonn, Heft 24. Bonn, Germany.
- Callahan, E.
1979 The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts. *Archaeology of Eastern North America* 7(1):1-180.
- Callow, P.
1986 The Flint Tools. In *La Cotte de St. Brelade, 1967-1978: Excavations by C.B.M. McBurney*, edited by P. Callow and J.M. Cornford, pp. 251-314. Geo Books, Norwich, England.
- Cammilli, E.
1988 Lithic Raw Material Selection and Use in the Desert Basin of South-Central New Mexico. *The Kiva* 53(2):147-163.
- Chase, P.G.
1986 *The Hunters of Combe Grenal: Approaches to Middle Paleolithic Subsistence*. BAR International Series 286. British Archaeological Reports, Oxford.

- 1988 Scavenging and Hunting in the Middle Palaeolithic: The Evidence from Europe. In *Upper Pleistocene Prehistory of Western Eurasia*, edited by H.L. Dibble and A. Montet-White, pp. 225-232. University Museum Press, University of Pennsylvania, Philadelphia.
- 1989 How Different was Middle Palaeolithic Subsistence? A Perspective on the Middle to Upper Palaeolithic Transition. In *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, edited by P. Mellars and C. Stringer, pp. 321-337. Princeton University Press, Princeton, New Jersey.
- 1991 Symbols and Paleolithic Artifacts: Style, Standardization, and the Imposition of Arbitrary Form. *Journal of Anthropological Archaeology* 10:193-214.
- 1993 An Economic Perspective on the Concept of Chaine Operatoire. Paper presented at The Definition and Interpretation of Levallois Technology, University Museum, University of Pennsylvania, Philadelphia.
- Chase, P.G., and H.L. Dibble
- 1987 Middle Paleolithic Symbolism: A Review of Current Evidence and Interpretations. *Journal of Anthropological Archeology* 6:263-296.
- Clark, G.A., and J.M. Lindly
- 1989 The Case for Continuity: Observations on the Biocultural Transition in Europe and Western Asia. In *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, edited by P. Mellars and C. Stringer, pp. 626-676. Princeton University Press, Princeton, New Jersey.
- Coinman, N., G. Clark, and J. Lindly
- 1986 Prehistoric Hunter-Gatherer Settlement in the Wadi el'Hasa, West-Central Jordan. In *The End of the Paleolithic in the Old World*, edited by L. Straus, pp. 129-169. BAR International Series 284. British Archaeological Reports, Oxford.
- Collins, M.B.
- 1975 Lithic Technology as a Means of Processual Inference. In *Lithic Technology, Making and Using Stone Tools*, edited by E.H. Swanson, pp. 15-34. Mouton, The Hague, Netherlands.
- Coon, C.S.
- 1962 *The Story of Man: From the First Human to Primitive Culture and Beyond*. Knopf, New York.

Copeland, L.

- 1975 Middle and Upper Paleolithic of Lebanon and Syria in Light of Recent Research. In *Problems in Prehistory: North Africa and the Levant*, edited by F. Wendorf and A.E. Marks, pp. 317-350. Southern Methodist University Press, Dallas.
- 1978 The Middle Palaeolithic of Adlun and Ras el-Kelb: First Results from a Study of the Flint Industries. *Paleorient* 4:33-57.
- 1981 Levallois or Non-Levallois? Reflections on Some Technical Features of Hummal, Level IA (El-Koum, Syria). 10th International Congress, International Union of Prehistoric and Protohistoric Sciences, Mexico City. (Preprint).
- 1983 The Palaeolithic Industries of Adlun. In *Adlun in the Stone Age: The Excavations of D.A.E. Garrod in the Lebanon, 1958-1963*, edited by D.A. Roe, pp. 89-365. BAR International Series 159 (2 Volumes). British Archaeological Reports, Oxford.

Cotterell, B.

- 1972 Brittle Fracture in Compression. *International Journal of Fracture Mechanics* 8(2):195-208.

Cotterell, B., and J. Kamminga

- 1979 The Mechanics of Flaking. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 97-112. Academic Press, New York.
- 1987 The Formation of Flakes. *American Antiquity* 52(4):675-708.
- 1990 *Mechanics of Pre-Industrial Technology*. Cambridge University Press, New York.

Crabtree, D.E.

- 1972 *An Introduction to Flintworking*. Occasional Papers of the Idaho State University Museum 28, Boise.

Crew, H.L.

- 1975 *An Examination of the Variability of the Levallois Method: Its Implications for the Internal and External Relationships of the Levantine Mousterian*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Davis.
- 1976 The Mousterian Site of Rosh Ein Mor. In *Prehistory and Paleoenvironments in the Central Negev*, vol. I, edited by A.E. Marks, pp. 75-112. Southern Methodist University Press, Dallas.

Deacon, H.J.

- 1989 Late Pleistocene Palaeoecology and Archaeology in the Southern Cape, South Africa. In *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, edited by P. Mellars and C. Stringer, pp. 547-564. Princeton University Press, Princeton, New Jersey.

Debenath, A., and H.L. Dibble

- 1993 *Handbook of Paleolithic Typology, vol. 1, Lower and Middle Paleolithic of Europe*. University Museum Press, University of Pennsylvania, Philadelphia.

Del Bene, T.A.

- 1979 Once Upon a Striation: Current Models of Striation and Polish Formation. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 167-177. Academic Press, New York.

Diamond, G.

- 1979 The Nature of So-Called Polished Surfaces on Stone Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 159-166. Academic Press, New York.

Dibble, H.L.

- 1981 *Technological Strategies of Stone Tool Production at Tabun Cave (Israel)*. Ph.D. dissertation, University of Arizona, Tucson. University Microfilms, Ann Arbor, Michigan.
- 1984 Interpreting Typological Variation of Middle Paleolithic Scrapers: Function, Style, or Sequence of Reduction. *Journal of Field Archaeology* 11:431-436.
- 1985 Raw-Material Variation in Levallois Flake Manufacture. *Current Anthropology* 26(3):391-393.
- 1987 Reduction Sequences in the Manufacture of Mousterian Implements in France. In *The Pleistocene Old World: Regional Perspectives*, edited by O. Soffer, pp. 33-45. Plenum Press, New York.
- 1988 The Interpretation of Middle Paleolithic Scraper Reduction Patterns. In *La Technique* edited by M. Otte, pp. 49-58. *L'Homme de Néandertal*, vol. 4. Études et Recherches Archéologiques de l'Université de Liege, Liege, France.
- 1991 Mousterian Assemblage Variability on an Interregional Scale. *Journal of Archaeological Research* 47(2):239-258.

- Dibble, H.L., and S.J. Holdaway
1993 The Middle Paleolithic Industries of Warwasi. In *The Paleolithic Prehistory of the Zagros-Taurus*, edited by D. Olszewski and H.L. Dibble, pp. 75-99. University Museum Press, University of Pennsylvania, Philadelphia.
- Dibble, H.L., and J.C. Whittaker
1981 New Experimental Evidence on the Relation Between Percussion Flaking and Flake Variation. *Journal of Archaeological Science* 8:283-296.
- Dockall, J.E.
1991a *Chipped Stone Technology at the NAN Ranch Ruin, Grant County, New Mexico*. Unpublished M.A. thesis, Department of Anthropology, Texas A&M University, College Station.
1991b A Functional Analysis of Some Mousterian Pointed Tools from Nahr Ibrahim Lebanon. Ms. on file, Anthropology Program, Texas A&M University, College Station.
1993 Functional Variability of Pointed Tools from the Middle Paleolithic at Shanidar Cave, Iraq. Paper presented at the 48th Annual Meeting of the Society for American Archaeology, St. Louis.
1994 Oval Biface Celt Variability During the Maya Late Preclassic. *Lithic Technology* 19(1):52-68.
1997 Recognition of Wear Traces Associated with Projectile Impact: A Survey of the Experimental and Archaeological Evidence. *Journal of Field Archaeology*, in press.
- Dockall, J.E., and H.J. Shafer
1993 Testing the Producer-Consumer Model for Santa Rita Corozal, Belize. *Latin American Antiquity* 4(2):158-179.
- Driskell, B.N.
1986 *The Chipped Stone Tool Production/Use Cycle: Its Potential in Activity Analysis of Disturbed Sites*. BAR International Series 305. British Archaeological Reports, Oxford.
- Ellul, J.
1980 *The Technological System*. Continuum, New York.
- Fagan, B.M.
1995 *People of the Earth: An Introduction to World Prehistory*. HarperCollins College Publishers, New York.

Farrand, W.R.

- 1982 Environmental Conditions During the Lower/Middle Palaeolithic Transition in the Near East and the Balkans. In *The Transition from Lower to Middle Palaeolithic and the Origin of Modern Man*, edited by A. Ronen, pp. 105-108. BAR International Series 151. British Archaeological Reports, Oxford.
- 1994 Confrontation of Geological Stratigraphy and Radiometric Dates from Upper Pleistocene Sites in the Levant. In *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean*, edited by O. Bar-Yosef and R.S. Kra, pp. 33-53. Radiocarbon, University of Arizona, Tucson.

Faulkner, A.

- 1972 *Mechanical Principles of Flintworking*. Ph.D. dissertation, Washington State University. University Microfilms, Ann Arbor, Michigan.

Fischer, A., P.V. Hansen and P. Rasmussen

- 1984 Macro and Micro Wear Traces on Lithic Projectile Points. *Journal of Danish Archaeology* 3:19-46.

Fish, P.R.

- 1979 The Interpretive Potential of Mousterian Debitage. *Arizona State University Anthropological Research Papers* 15.

Forde, C.D.

- 1957 *Habitat, Economy, and Society: A Geographical Introduction to Ethnology*. E.P. Dutton & Co. Inc., New York.

Frison, G.C.

- 1968 A Functional Analysis of Certain Flaked Stone Tools. *American Antiquity* 33(2):149-155.
- 1974 *The Casper Site: A Hell Gap Bison Kill on the High Plains*. Academic Press, New York.
- 1979 Observations on the Use of Stone Tools: Dulling of Working Edges of Some Chipped Stone Tools in Bison Butchering. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 259-268. Academic Press, New York.

Frison, G.C., and B.A. Bradley

- 1980 *Folsom Tools and Technology at the Hanson Site, Wyoming*. University of New Mexico Press, Albuquerque.

Gardner, H.

- 1972 *The Quest for Mind: Piaget, Levi-Strauss, and the Structuralist Movement*. Random House, New York.

Garfunkel, Z.

- 1988 The Pre-Quaternary Geology of Israel. In *The Zoogeography of Israel: The Distribution and Abundance at a Zoological Crossroad*, edited by Y. Yom-Tov and E. Tchernov, pp. 7-34. Dr. W. Junk Publishers, Boston.

Garrard, A.N.

- 1984 Community Ecology and Pleistocene Extinctions in the Levant. In *Hominid Evolution and Community Ecology: Prehistoric Human Adaptation in Biological Perspective*, edited by R. Foley, pp. 261-277. Academic Press, New York.

Garrod, D.A.E.

- 1937 Part I, Description and Archaeology. In *The Stone Age of Mount Carmel: Excavations at the Wadi el Mughara*, vol. I. by D.A.E. Garrod and D.M.A. Bate, pp. 3-90. Clarendon Press, Oxford.
- 1956 Acheuleo-Jabrudien et 'Pre-Aurignacien' de la Grotte de Taboun (Mont Carmel): Etude Stratigraphique et Chronologique. *Qauternaria* 3:39-59.

Garrod, D.A.E., and D.M.A. Bate

- 1937 *The Stone Age of Mount Carmel: Excavations at the Wadi el Mughara*, vol. I. Clarendon Press, Oxford.

Garrod, D.A.E., and G. Henri-Martin

- 1961 Rapport Preliminaire sur la Fouille d'une Grotte au Ras el-Kelb. *Bulletin du Musee de Beyrouth* 16:61-67.

Garrod, D.A.E., and D. Kirkbride

- 1961 Excavation of the Abri Zumoffen. *Bulletin du Musee de Beyrouth* 16:1-20.

Gautier, A.

- 1970 The Fauna of Masloukh. *Bulletin du Musee de Beyrouth* 23:135.

Geneste, J-M.

- 1985 *Analyse Lithique d'Industries Moustériennes du Perigord: Une Approche Technologique du Comportement des Groupes Humains au Paléolithique Moyen*. These de Doctorat, Université de Bordeaux I, Bordeaux, France.
- 1988 Systèmes d'Approvisionnement en Matières Premières au Paléolithique Moyen et au Paléolithique Supérieur en Aquitaine. In *La Mutation*, edited by M. Otte, pp. 61-70. *L'Homme de Néandertal*, vol. 8. Études et Recherches Archéologiques de l'Université de Liege 35, Liege, France.

Gibson,, K.R.

- 1993 Tool Use, Language and Social Behavior in Relationship to Information Processing Capacities. In *Tools, Language and Cognition in Human Evolution*, edited by K.R. Gibson and T. Ingold, pp. 251-269. Cambridge University Press, New York.

Gisis, D., and O. Bar-Yosef

- 1974 Handaxe Industries in Israel and the Near East. *World Archaeology* 2:131-152.

Goldin, S.E., and P.W. Thorndyke

- 1981 *An Analysis of Cognitive Mapping Skill*. Rand, Santa Monica, California.

Goodyear, A.C.

- 1979 *A Hypothesis for the Use of Cryptocrystalline Raw Materials Among Paleoindian Groups of North America*. Research Manuscript Series 156. South Carolina Institute of Archaeology and Anthropology, University of South Carolina, Columbia.
- 1989 *A Hypothesis for the Use of Cryptocrystalline Raw Materials Among Paleoindian Groups of North America*. In *Eastern Paleoindian Lithic Resource Use*, edited by C.Ellis and J.C. Lothrop, pp. 1-9. Westview, Boulder, Colorado.

Gordon, D.

- 1993 Mousterian Tool Selection, Reduction, and Discard at Ghar, Israel. *Journal of Field Archaeology* 20:205-218.

Gowlett, J.A.J.

- 1984 Mental Abilities of Early Man: A Look at Some Hard Evidence. In *Hominid Evolution and Community Ecology*, edited by R. Foley, pp. 167-192. Academic Press, New York.

- Grace, R.
 1989 *Interpreting the Function of Stone Tools: The Quantification and Computerisation of Microwear Analysis*. BAR International Series 474. British Archaeological Reports, Oxford.
- Grace, R., I.D.G. Graham, and M.H. Newcomer
 1985 The Quantification of Microwear Polishes. *World Archaeology* 17(1):112-120.
- Grimaldi, S., and C. Lemorini
 1995 Technology and Microwear: The Predetermined Flakes of the Mousterian Site of Crotta Breuil (Monte Circeo, Italy). In *The Definition and Interpretation of Levallois Technology*, edited by H.L. Dibble and O. Bar-Yosef, pp. 143-155. Prehistory Press, Madison, Wisconsin.
- Grun, R., and C.B. Stringer
 1991 Electron Spin Resonance Dating and the Evolution of Modern Humans. *Archeometry* 33:53-99.
- Gunn, J., and F. Weir
 1976 Tool Kit Hypotheses: A Case of Numerical Induction. *Newsletter of Lithic Technology* 5(3):31-39.
- Hayden, B.
 1981 *Palaeolithic Reflections: Lithic Technology and Ethnographic Excavations among Australian Aborigines*. Humanities Press, New Jersey.
 1993 The Cultural Capacities of Neandertals: A Review and Re-Evaluation. *Journal of Human Evolution* 24:113-146.
- Hayden, B., and J. Kamminga
 1979 An Introduction to Use-Wear: The First CLUW. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 1-13. Academic Press, New York.
- Hayden, B., N. Franco, and J. Spafford
 1996 Evaluating Lithic Strategies and Design Criteria. In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by G.H. Odell, pp. 9-45. Plenum Press, New York.

Hays, M.

- 1993 A Functional Analysis of the Lithic Material from Burrone Sierra I, Calabria, Italy. Published abstract in Abstracts of the 58th Annual Meeting of the Society for American Archaeology, St. Louis, Missouri.

Held, C.C.

- 1989 *Middle East Patterns: Places, Peoples, and Politics*. Westview Press, San Francisco.

Henry, D.O.

- 1982 The Prehistory of Southern Jordan and Relationships with the Levant. *Journal of Field Archaeology* 9:417-444.
- 1989 *From Foraging to Agriculture: The Levant at the End of the Ice Age*. University of Pennsylvania Press, Philadelphia.
- 1992 Transhumance During the Late Levantine Mousterian. In *The Middle Paleolithic: Adaptation, Behavior, and Variability*, edited by H.L. Dibble and P. Mellars, pp. 143-162. University Museum Symposium Series vol. IV, University Museum Press, Philadelphia.
- 1995a *Prehistoric Cultural Ecology and Evolution: Insights from Southern Jordan*. Plenum Press, New York.
- 1995b The Influence of Mobility Levels on Levallois Point Production, Late Levantine Mousterian, Southern Jordan. In *The Definition and Interpretation of Levallois Technology*, edited by H.L. Dibble and O. Bar-Yosef, pp. 185-200. Prehistory Press, Madison, Wisconsin.

Henry, D.O., S.A. Hall, H.J. Hietala, Y.E. Demidenko, V.I. Usik, A.M. Rosen, and P.A. Thomas

- 1996 Middle Paleolithic Behavioral Organization: 1993 Excavation of Tor Faraj, Southern Jordan. *Journal of Field Archaeology* 23:31-53.

Holdaway, S.

- 1989 Were There Hafted Projectile Points in the Mousterian? *Journal of Field Archaeology* 16:79-85.
- 1990 Mousterian Projectile Points-Reply to Shea. *Journal of Field Archaeology* 17:114-115.

Holmes, W.H.

- 1919 Handbook of Aboriginal American Antiquities, Part I, Introductory: The Lithic Industries. *Bureau of American Ethnology* vol. 60. Smithsonian Institution, Washington D.C.

Ho Ho Nomenclature Committee

- 1979 The Ho Ho Classification and Nomenclature Committee Report. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 143-158. Academic Press, New York.

Horowitz, A. (editor)

- 1979 *The Quaternary of Israel*. Academic Press, New York.

Hours, F.

- 1975 The Lower Paleolithic of Lebanon and Syria. In *Problems and Prehistory: North Africa and the Levant*, edited by F. Wendorf and A. Marks, pp. 249-271. Southern Methodist University, Dallas.
- 1980 Le Paléolithique Inférieur de la Syrie et du Liban: Le Pont de la Question en 1980. In *Prehistoire du Levant*, edited by J. Cauvin and P. Sanlaville, pp. 165-191. CNRS, Paris.

Hours, F., L. Copeland, and O. Aurenche

- 1973 Les Industries Paléolithiques du Proche Orient. *L'Anthropologie* 77(3-4):229-280 and 77(5-6):437-496.

Howell, F.C.

- 1994 A Chronostratigraphic and Taxonomic Framework for the Origins of Modern Humans. In *Origins of Anatomically Modern Humans*, edited by M.H. Nitecki and D.V. Nitecki, pp. 253-319. Plenum Press, New York.

Hurcombe, L.

- 1988 Some Criticisms and Suggestions in Response to Newcomer et al. (1986). *Journal of Archaeological Science* 15:1-10.

Ingold, T.

- 1993a Tool-use, Sociality, and Intelligence. In *Tools, Language, and Cognition*, edited by K.R. Gibson and T. Ingold, pp. 429-445. Cambridge University Press, New York.
- 1993b Tools, Techniques, and Technology. In *Tools, Language, and Cognition*, edited by K.R. Gibson and T. Ingold, pp. 337-388. Cambridge University Press, New York.

Isaac, G.L.

- 1977 *Olorgesailie: Archeological Studies of a Middle Pleistocene Lake Basin in Kenya*. The University of Chicago Press, Chicago.

- 1978 The Food Sharing Behavior of Proto-Human Hominids. *Scientific American* 238(4):90-108.

Jelinek, A.J.

- 1975 A Preliminary Report on Some Lower and Middle Paleolithic Industries from the Tabun Cave, Mount Carmel (Israel). In *Problems in Prehistory: North Africa and the Levant*, edited by F. Wendorf and A. Marks, pp. 297-316. Southern Methodist University, Dallas.
- 1981 The Middle Paleolithic in the Southern Levant from the Perspective of the Tabun Cave. In *Prehistoire du Levant*, edited by J. Cauvin and P. Sanlaville, pp. 265-280. Centre Nationale de la Recherche Scientifique, Paris.
- 1982a The Middle Paleolithic in the Southern Levant, with Comments on the Appearance of Modern Homo Sapiens. In *The Transition from the Lower to the Middle Paleolithic and the Origin of Modern Man*, edited by A. Ronen, pp. 57-104. BAR International Series No. 151. British Archaeological Reports, Oxford.
- 1982b The Tabun Cave and Paleolithic Man in the Levant. *Science* 216:1369-1375.
- 1990 The Amudian in the Context of the Mugharan Tradition at the Tabun Cave (Mount Carmel), Israel. In *The Emergence of Modern Humans: An Archaeological Perspective*, edited by P. Mellars, pp. 81-90. Cornell University Press, Ithaca, New York.
- 1991 Observations on Reduction Patterns and Raw Materials in Some Middle Paleolithic Industries in the Perigord. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 7-31. Publications in Anthropology 19, University of Kansas, Lawrence.
- 1994 Hominids, Energy, Environment, and Behavior in the Late Pleistocene. In *Origins of Anatomically Modern Humans*, edited by M.H. Nitecki and D.V. Nitecki, pp. 67-92. Plenum Press, New York.

Johnson, J.K.

- 1986 Amorphous Core Technologies in the Midsouth. *Midcontinental Journal of Archaeology* 11:135-151.

Jonas, H.

- 1979 Toward a Philosophy of Technology. *The Hastings Center Report* 9:34-43. Institute of Society, Ethics, and the Life Sciences, Hastings-on-Hudson, New York.

- Jones, M.L.
1985 The Use of Technological Indices: A Case Study for the Levantine Mousterian. In *For Concordance in Archaeological Analysis: Bridging Data Structure, Quantitative Technique, and Theory*, edited by C. Carr, pp. 540-565. Westport Publishers, Inc., New York.
- Kamminga, J.
1979 The Nature of Use-Polish and Abrasive Smoothing on Stone Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 143-157. Academic Press, New York.
- Karlin, C., and M. Julien
1994 Prehistoric Technology: A Cognitive Science? In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew and E.B. Zubrow, pp. 152-164. Cambridge University Press, New York.
- Keeley, L.H.
1978 Appendix: Note on the Edge Damage of Flakes from the Lower Paleolithic Sites at Caddington. In *Paleoecology and Archeology of an Acheulian site at Caddington, England*, edited by C.G. Sampson, pp.151-152. Department of Anthropology, Institute for the Study of Earth and Man, Southern Methodist University, Dallas.
1980 *Experimental Determination of Stone Tool Uses*. University of Chicago Press, Chicago.
1982 Hafting and Retooling: Effects on the Archaeological Record. *American Antiquity* 47(4):798-809.
- Keller, C.M.
1966 The Development of Edge Damage Patterns on Stone Tools. *Man* 1(4):501-511.
- Kelly, R.L.
1988 The Three Sides of a Biface. *American Antiquity* 53:717-734,
- Klein, R.G.
1989 *The Human Career: Human Biological and Cultural Origins*. University of Chicago Press, Chicago.

- Knudson, R.
 1973 *Organizational Variability in Late Paleo-Indian Assemblages*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Washington, Seattle.
- Kuhn, S.L.
 1989 Hunter-Gatherer Foraging Organization and Strategies of Artifact Replacement and Discard. In *Experiments in Lithic Technology*, edited by D. Amick and R. Mauldin, pp. 33-47. BAR International Series 528, British Archaeological Reports, Oxford.
 1990 *Diversity Within Uniformity: Tool Manufacture and Use in the 'Pontinian' Mousterian of Latium (Italy)*. Ph.D. dissertation, University of New Mexico, Albuquerque. University Microfilms, Ann Arbor.
 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(3):185-214.
 1994 A Formal Approach to the Design and Assembly of Mobile Toolkits. *American Antiquity* 59(3):426-442.
 1995 *Mousterian Lithic Technology: An Ecological Perspective*. Princeton University Press, Princeton, New Jersey.
- Lawn, B.R., and R.R. Wilshaw
 1975 *Fracture of Brittle Solids*. Cambridge University Press, New York.
- Lawrence, R.A.
 1979 Experimental Evidence for the Significance of Attributes Used in Edge-Damage Analysis. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 113-121. Academic Press, New York.
- Leakey, M.D.
 1971 Excavations in Beds I and II, 1960-1963. In *Olduvai Gorge*, vol. 3, by M.D. Leakey. Cambridge University Press, Cambridge.
- Lee, C.M.
 1987 *A Functional Analysis of Levallois Points from Two Middle Paleolithic Sites in South Jordan: Results and Interpretations*. Unpublished Master's thesis, Department of Anthropology, University of Tulsa, Tulsa, Oklahoma.

Lee, R.B.

1979 *The !Kung San*. Cambridge University Press, Cambridge.

Lee, R.B., and I. Devore (editors)

1969 *Man the Hunter*. Aldine, Chicago.

Leroi-Gourhan, A.

1971 Pollens et Terrasses Marines au Liban. *Quaternaria* 15:249-259.

Levitt, J.

1979 A Review of Experimental Traceological Research in the USSR. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 27-37. Academic Press, New York.

Levi-Sala, I.

1988 Processes of Polish Formation on Flint Tool Surfaces. In *Industries Lithiques, Traceologie et Technologie, vol. 2: Aspects Methodologiques*, edited by S. Beyries, pp. 83-97. BAR International Series 411(ii). British Archaeological Reports, Oxford.

Lieberman, D.E.

1993 The Rise and Fall of Seasonal Mobility among Hunter-Gatherers: The Case of the Southern Levant. *Current Anthropology* 34(5):599-631.

Lieberman, D.E. and J.J. Shea

1994 Behavioral Differences Between Neandertals and Early Modern Humans in the Levantine Mousterian. *American Anthropologist* 96:300-332.

Lindley, J.M., and G.A. Clark

1990 Symbolism and Modern Human Origins. *Current Anthropology* 31:233-261.

Mansur, M.E.

1982 Microwear Analysis of Natural and Use Striations: New Clues to the Mechanism of Striation Formation. In *Tailler! Pour Quoi Faire: Prehistoire et Technologie Lithique II*, edited by D. Cahen, pp. 213-233. Musee Royal de l' Afrique Centrale, Tervuren, Belgium.

Marks, A.E.

- 1983 The Middle to Upper Paleolithic Transition in the Levant. In *Advances in World Archaeology*, vol. 2, edited by F. Wendorf and A. Close, pp. 51-96. Academic Press, New York.
- 1985 The Levantine Middle to Upper Paleolithic Transition: The Past and Present. In *Studi di Paleontologia in onore di Salvatore M. Puglisi*, edited by M. Liverani, M. Palmieri, and R. Peroni, pp. 123-136. Dipartimento di Scienze, Storiche, Archeologiche, e Antropologiche dell' Antichita, University di Roma La Sapienza, Roma.
- 1988 The Curation of Stone Tools During the Upper Pleistocene: A View from the Central Negev. In *Upper Pleistocene Prehistory of Western Eurasia*, edited by H.L. Dibble and A. Montet-White, pp. 275-284. University Museum Press, University of Pennsylvania, Philadelphia.
- 1992a Typological Variability in the Levantine Middle Paleolithic. In *The Middle Paleolithic: Adaptation, Behavior, and Variability*, edited by H.L. Dibble and P. Mellars, pp. 127-142. University Museum Symposium Series vol. IV, The University Museum, University of Pennsylvania, Philadelphia.
- 1992b Upper Pleistocene Archaeology and the Origins of Modern Man: A View from the Levant and Adjacent Areas. In *The Evolution and Dispersal of Modern Humans in Asia*, edited by T. Akazawa, K. Aoki, and T. Kimura, pp. 229-251. Hokusensha, Tokyo.

Marks, A.E., and D.A. Friedel

- 1977 Prehistoric Settlement Patterns in the Avdat/Aqev Area. In *Prehistory and Paleoenvironments in the Central Negev, Israel*, vol. II, edited by A.E. Marks, pp. 131-158. Southern Methodist University Press, Dallas.

Marks, A.E., and P.W. Volkman

- 1983 Changing Core Reduction Strategies: A Technological Shift from the Middle to the Upper Paleolithic in the Southern Levant. In *The Mousterian Legacy: Human Biocultural Change in the Upper Pleistocene*, edited by E. Trinkaus, pp. 13-33. BAR International Series 164. British Archaeological Reports, Oxford.

- Marks, A.E., J. Shokler, and J. Zilhao
 1991 Raw Material Usage in the Paleolithic: The Effects of Local Availability on Selection and Economy. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 127-139. University of Kansas Publications in Anthropology 19, Lawrence.
- Marshack, A.
 1988 The Neanderthals and the Human Capacity for Symbolic Thought; Cognitive and Problem-Solving Aspects of Mousterian Symbol. In *La Pensée*, edited by M. Otte, pp. 57-92. *L'Homme de Néandertal*, vol. 5. Études et Recherches Archéologiques de l'Université de Liege, Liege, France.
- McAnany, P.
 1989 The Effects of Lithic Procurement Strategies on Tool Curation and Recycling. *Lithic Technology* 17:3-11.
- McBurney, C.B.M.
 1967 *The Haua Fteah (Cyrenaica) and the Stone Age of the Southeast Mediterranean*. Cambridge University Press, New York.
- Meignen, L.
 1995 Levallois Lithic Production Systems in the Middle Paleolithic of the Near East: The Case of the Unidirectional Method. In *The Definition and Interpretation of Levallois Technology*, edited by H.L. Dibble and O. Bar-Yosef, pp. 361-379. Prehistory Press, Madison, Wisconsin.
- Meignen, L., and O. Bar-Yosef
 1988a Variabilité Technologique au Proche Orient: L'Exemple de Kebara. In *La Technique*, edited by M. Otte, pp. 81-95. *L'Homme de Néandertal*, vol. 4. Études et Recherches Archéologiques de l'Université de Liege, Liege, France.
 1988b Kebara et le Paléolithique du Mont Carmel (Israel). *Paleorient* 14(2):123-130.
- Mellars, P.
 1989a Technological Changes Across the Middle-Upper Paleolithic Transition: Economic, Social, and Cognitive Perspectives. In *The Human Revolution: Behavioural and Biological Perspectives on the Origin of Modern Humans*, edited by P. Mellars and C. Stringer, pp. 338-365. Edinburgh University Press, Edinburgh, Scotland.

- 1989b Major Issues in the Emergence of Modern Humans. *Current Anthropology* 30(3):349-385.
- 1996 *The Neanderthal Legacy*. Princeton University Press, Princeton, New Jersey.
- Miller, Jr., T.O..
- 1979 Stonework of the Xeta Indians of Brazil. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 401-407. Academic Press, New York.
- Mithen, S.
- 1994a Technology and Society During the Middle Pleistocene: Hominid Group Size, Social Learning and Industrial Variability. *Cambridge Archaeological Journal* 4(1):3-32.
- 1994b From Domain Specific to Generalized Intelligence; A Cognitive Interpretation of the Middle/Upper Paleolithic Transition. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew and E.B.W. Zubrow, pp. 29-39. Cambridge University Press, New York.
- Moir, J.R.
- 1914 The Striation of Flint Surfaces. *Man: A Monthly Record of Anthropological Science* 14(90):177-181.
- Montagu, A.
- 1976 Toolmaking, Hunting, and the Origin of Language. *Annals of the New York Academy of Sciences* 280:266-274.
- Moss, E.H.
- 1983 *The Functional Analysis of Flint Implements. Pincevent and Pont d'Ambon: Two Case Studies from the French Final Palaeolithic*. BAR International Series 177. British Archaeological Reports, Oxford.
- Movius, H.L., Jr.
- 1954 A Wooden Spear of the Third Interglacial Age from Lower Saxony. *Southwestern Journal of Anthropology* 6:139-142.
- Muhsen, S.
- 1992 The Transitional Lower-Middle Paleolithic Industries in Syria. In *The Evolution and Dispersal of Modern Humans in Asia*, edited by T. Akazawa, K. Aoki, and T. Kimura, pp. 51-65. Hokusen-sha, Tokyo.

Munday, F.C.

- 1976 Intersite Variability in the Mousterian Occupation of the Avdat/Aqev Area. In *Prehistory and Paleoenvironments in the Central Negev, Israel*, vol. I, edited by A. E. Marks, pp. 113-140. Southern Methodist University Press, Dallas.
- 1979 Levantine Mousterian Technological Variability: A Perspective from the Negev. *Paleorient* 5:87-104.

Nelson, M.C.

- 1991 The Study of Technological Organization. In *Archaeological Method and Theory*, vol. 3, edited by M.B. Schiffer, pp. 57-100. University of Arizona Press, Tucson.

Neuville, R.

- 1934 La Prehistoire de Palestine. *Revue Biblique* 43:237-259.
- 1951 Le Paléolithique et le Méolithique du Désert de Judée. *Archives de l'Institut de Paleontologie Humaine* 24. Masson et Cie, Paris.

Newcomer, M.H., R. Grace, and R. Unger-Hamilton

- 1986 Investigating Microwear Polishes with Blind Tests. *Journal of Archaeological Science* 13:203-217.
- 1988 Microwear Methodology: A Reply to Moss, Hurcombe, and Bamforth. *Journal of Archaeological Science* 15:25-33.

Oakley, K.P., L.H. Keeley, and J.D. Clark

- 1977 A Reappraisal of the Clacton Spearpoint. *Proceedings of the Prehistoric Society* 43:13-30.

Odell, G.H.

- 1977 *The Application of Micro-Wear Analysis to the Lithic Component of an Entire Prehistoric Settlement: Methods, Problems, and Functional Reconstructions*. Ph.D. dissertation, Harvard University, Boston. University Microfilms, Ann Arbor, Michigan.
- 1979 A New and Improved System for the Retrieval of Functional Information from Microscopic Observations of Chipped Stone Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 329-383. Academic Press, New York.
- 1981 The Mechanics of Use-Breakage of Stone Tools: Some Testable Hypotheses. *Journal of Field Archaeology* 8:197-209.
- 1988 Addressing Prehistoric Hunting Practices Through Stone Tool Analysis. *American Anthropologist* 90:335-356.

- 1994 Prehistoric Hafting and Mobility in the North American Midcontinent: Examples from Illinois. *Journal of Anthropological Archaeology* 13:51-73.
- 1996a *Stone Tools and Mobility in the Illinois Valley*. International Monographs in Prehistory, Ann Arbor, Michigan.
- 1996b Economizing Behavior and the Concept of "Curation". In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by G.H. Odell, pp. 51-80. Plenum Press, New York.
- Odell, G.H., and F. Cowan
1986 Experimentation With Spears and Arrows Using Animal Targets. *Journal of Field Archaeology* 13:195-212.
- Odell, G.H., and F. Odell-Vereecken
1980 Verifying the Reliability of Lithic Use-Wear Assessments by "Blind Tests": The Low Power Approach. *Journal of Field Archaeology* 13:87-120.
- Odell, G.H., B.D. Hayden, J.K. Johnson, M. Kay, T.A. Morrow, S.E. Nash, M.S. Nassaney, J.W. Rick, M.F. Rondeau, S.A. Rosen, M.J. Shott, and P.T. Thacker
1996 Some Comments on a Continuing Debate. In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by G.H. Odell, pp. 377-392. Plenum Press, New York.
- Oswalt, W.H.
1973 *Habitat and Technology*. Holt, Rinehard and Winston, New York.
1976 *An Anthropological Analysis of Food-Getting Technology*. John Wiley, New York.
- Panagopolou, H.
1985 *Form Versus Function: Lithic Use-Wear Analysis and Its Application to a Class of Levantine Mousterian Tools*. Unpublished Ph.D. dissertation, Department of Anthropology, Columbia University, New York.
- Parry, W.J., and R.L. Kelly
1987 Expedient Core Technology and Sedentism. In *The Organization of Core Technology*, edited by J. Johnson and C. Morrow, pp. 285-304. Westview Press, Boulder, Colorado.

- Patterson, L.W.
1994 Identification of Unifacial Arrow Points. *Journal of the Houston Archeological Society* 108:19-24.
- Perrot, J.
1968 *La Préhistoire Palestinienne. Supplement du Dictionnaire de la Bible*, VII, Fascicle 43, pp. 286-446. Latouzy-Anne, Paris.
- Piaget, J.
1970 *Genetic Epistemology*. Columbia University Press, New York.
- Plisson, H.
1988 Technologie et Traceologie des Outils Lithiques Mousteriens en Union Sovietique: Les Travaux de V.E. Schelinskii. In *La Technique*, edited by M. Otte, pp. 121-168. *L'Homme de Néandertal*, vol. 4. Études et Recherches Archéologiques de l'Universite de Liege, Liege, France.
- Porat, N., and Schwarz, H.P.
1991 Use of Signal Subtraction Methods in ESR Dating of Burned Flint. *Nuclear Tracks Radiation Measurement* 18(1-2):203-212.
- Potts, R.
1984 Home Bases and Early Hominids. *American Scientist* 72:338-347.
1991 Why the Oldowan? Plio-Pleistocene Toolmaking and the Transport of Resources. *Journal of Archaeological Research* 47(2):153-175.
- Rensink, E., J. Kolen, and A. Spieksma
1991 Patterns of Raw Material Distribution in the Upper Pleistocene of Northwestern and Central Europe. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 141-159. University of Kansas Publications in Anthropology 19, Lawrence.
- Reynolds, P.C.
1993 The Complementation Theory of Language and Tool Use. In *Tools, Language, and Cognition in Human Evolution*, edited by K.R. Gibson and T. Ingold, pp. 407-428. Cambridge University Press, New York.

Ridington, R.

- 1982 Technology, World View, and Adaptive Strategy in a Northern Hunting Society. *Canadian Review of Sociology and Anthropology* 19(4):469-481.

Roe, D. (editor)

- 1983 *Adlun in the Stone Age*. BAR International Series 159. British Archaeological Reports, Oxford.

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(1):17-34.

Rolland, N.

- 1981 The Interpretation of Middle Paleolithic Variability. *Man* 16:15-42.

Rolland, N., and H.L. Dibble

- 1990 A New Synthesis of Middle Paleolithic Variability. *American Antiquity* 55:480-499.

Ronen, A.

- 1992 The Emergence of Blade Technology: Cultural Affinities. In *The Evolution and Dispersal of Modern Humans in Asia*, edited by T. Akazawa, K. Aoki, and T. Kimura, pp. 217-228. Hokusen-Sha, Tokyo.
- 1995 The Levallois Method as a Cultural Constraint. In *The Definition and Interpretation of Levallois Variability*, edited by H.L. Dibble and O. Bar-Yosef, pp. 293-304. Prehistory Press, Madison, Wisconsin.

Rowley-Conwy, P.

- 1994 Palaeolithic and Mesolithic: From Culture to Behaviour. In *Building on the Past: Papers Celebrating 150 Years of the Royal Archaeological Institute*. The Royal Archaeological Institute, London.

Rust, A.

- 1950 *Die Hohlenfunde von Jabrud (Syrien)*. Karl Wachholtz Verlag, Neumunster, Germany.

- Samuels, L.E., E.D. Doyle, and D.M. Turley
 1981 Sliding Wear Mechanisms. In *Fundamentals of Friction and Wear of Materials*, edited by D.A. Rigney, pp. 13-41. American Society of Metals, Metals Park, Ohio.
- Schiffer, M.B.
 1987 *Formation Processes of the Archaeological Record*. University of New Mexico Press, Albuquerque.
- Schlanger, N.
 1994 Mindful Technology: Unleashing the Chaine Operatoire for an Archaeology of Mind. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew and E.B. Zubrow, pp. 143-151. Cambridge University Press, New York.
- Schwarz, H.P., R. Grun, B. Vandermeersch, O. Bar-Yosef, H. Valladas, and E. Tchernov
 1988 ESR Dates for the Hominid Burial Site of Qafzeh in Israel. *Journal of Human Evolution* 17:733-737
- Sellet, F.
 1993 Chaine Operatoire: The Concept and Its Applications. *Lithic Technology* 18(1-2):106-112.
- Semenov, S.A.
 1950a "Izucheniye funktsi' Paleolitichskikh orudi' po sledam raboti" (The Study of the Functions of Paleolithic Tools By Traces of Use). *Materiali po Chervertichnomu Periodu SSSR Vypusk* 2:159-165. Moscow
 1950b "O protivostavlenii bol'shogo pal'tsa ruki Neandertal'skogo Cheloveka" (Concerning the Opposition of the Thumb of the Hande of Neanderthal Man). *Sovetskaya Etnograflya* 11:70-82. Moscow.
 1964 *Prehistoric Technology*. Barnes and Noble, New York.
- Service, E.R.
 1979 *The Hunters*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
- Shafer, H.J.
 1973 *Lithic Technology at the George C. Davis Site, Cherokee County, Texas*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Texas, Austin.

- 1983 The Lithic Artifacts of the Pulltrouser Area: Settlements and Fields. In *Pulltrouser Swamp: Ancient Maya Habitat, Agriculture, and Settlement in Northern Belize*, edited by B.L. Turner and P.D. Harrison, pp. 211-245. University of Texas Press, Austin.

Shea, J.J.

- 1987 On Accuracy and Relavance in Lithic Use-wear Analysis. *Lithic Technology* 16(2-3):44-50.
- 1988a Spear Points from the Middle Paleolithic of the Levant. *Journal of Field Archaeology* 15:441-450.
- 1988b Methodological Considerations Affecting the Choice of Analytical Techniques in Lithic Use-Wear Analysis: Tests, Results, and Application. In *Industrie Lithique: Traceologie et Technologie* (vol. I), edited by S. Beyries, pp. 65-81. BAR International Series 411. British Archaeological Reports, Oxford.
- 1989a A Functional Study of the Lithic Industries Associated with Hominid Fossils in the Kebara and Qafzeh Caves, Israel. In *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, edited by P. Mellars and C. Stringer, pp. 611-625. Edinburgh University Press, Edinburgh, Scotland.
- 1989b Tool Use in the Levantine Mousterian of Kebara Cave, Mount Carmel. *Mitekufat Haeven*, Journal of the Israel Prehistoric Society, 22:15-30.
- 1990 A Further Note on Mousterian Spear Points. *Journal of Field Archaeology* 17:111-114.
- 1991 *The Behavioral Significance of Levantine Mousterian Industrial Variability*. Ph.D. Dissertation, Harvard University, Boston, Massachusetts. University Microfilms, Ann Arbor, Michigan.
- 1993 Behavioral Factors Affecting the Application of the Levallois Technique in the Levantine Mousterian. Paper presented at The Definition and Interpretation of Levallois Technology conference, University of Pennsylvania Museum, Philadelphia.
- 1995a Lithic Microwear Analysis of Tor Faraj Rockshelter. In *Prehistoric Cultural Ecology and Evolution: Insights from Southern Jordan*, edited by D.O. Henry, pp. 82-105. Plenum Press, New York.
- 1995b Behavioral Factors Affecting the Production of Levallois Points in the Levantine Mousterian. In *The Definition and Interpretation of Levallois Technology*, edited by H.L. Dibble and O. Bar-Yosef, pp. 279-292. Prehistory Press, Madison, Wisconsin.

- Shick, T., and M. Stekelis
 1977 Mousterian Assemblages in Kebara Cave, Mount Carmel. *Eretz-Israel* 13:97-149.
- Shott, M.
 1986 Technological Organization and Settlement Mobility: An Ethnographic Examination. *Journal of Anthropological Research* 42(1):15-51.
 1989 Technological Organization in Great Lakes Paleoindian Assemblages. In *Eastern Paleoindian Lithic Resource Use*, edited by C.J. Ellis and J.C. Lothrop, pp. 221-237. Westview Press, San Francisco.
 1994 On Size and Form in the Analysis of Flake Debris. *Journal of Archaeological Method and Theory* 1:69-110.
 1995 How Much Is a Scraper? Curation, Use Rates, and the Formation of Scraper Assemblages. *Lithic Technology* 20(1):53-71.
- Siman, K.
 1991 Patterns of Raw Material Use in the Middle Paleolithic of Hungary. In *Raw Material Economies Among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 49-57. University of Kansas Publications in Anthropology 19, Lawrence.
- Simek, J.
 1991 Stone Tool Assemblages from Krapina (Croatia, Yugoslavia). In *Raw Material Economies Among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 59-71. University of Kansas Publications in Anthropology 19, Lawrence.
- Simmons, T., A.B. Falsetti, and F.H. Smith
 1991 Frontal Bone Morphometrics of Southwest Asian Pleistocene Hominids. *Journal of Human Evolution* 20:249-269.
- Singer, R., and J. Wymer
 1982 *The Middle Stone Age at Klasies River Mouth in South Africa*. The University of Chicago Press, Chicago.
- Skinner, J.H.
 1965 *The Flake Industries of Southwest Asia: A Typological Study*. Ph.D. dissertation, Columbia University, New York. University Microfilms, Ann Arbor, Michigan.
 1970 El Masloukh: A Yabroudian Site in Lebanon. *Bulletin du Musee de Beyrouth* 23:143-172.

- Smith, F.H.
1985 Continuity and Change in the Origin of Modern *Homo Sapiens*. *Zeitschrift für Morphologie und Anthropologie* 75:197-222.
- Solecki, R.L.
1992 More on Hafted Projectile Points in the Mousterian. *Journal of Field Archaeology* 19:207-212.
- Solecki, R.S.
1963 Prehistory in Shanidar Valley, Northern Iraq. *Science* 139(1551):179-183.
1970 Summary Report of the Columbia University Prehistoric Investigations in Lebanon, Season 1969. *Bulletin du Musee de Beyrouth* 23:95-128.
1971 *Shanidar, The First Flower People*. Knopf, New York.
1975 The Middle Paleolithic Site of Nahr Ibrahim (Asfourieh Cave) in Lebanon. In *Problems in Prehistory: North Africa and the Levant*, edited by F. Wendorf and A.E. Marks, pp. 283-295. Southern Methodist University Press, Dallas.
1983 A Ritual Middle Palaeolithic Deer Burial at Nahr Ibrahim Cave, Lebanon. In *Archeologie au Levant. Collection de la Maison de l'Orient Meditteraneen* 12(9):47-56.
- Solecki, R.L., and R.S. Solecki
1970 A New Secondary Flaking Technique at the Nahr Ibrahim Cave Site, Lebanon. *Bulletin du Musee de Beyrouth* 23:137-142.
1993 The Pointed Tools from the Mousterian Occupations of Shanidar Cave, Northern Iraq. In *The Paleolithic Prehistory of the Zagros-Taurus*, edited by D.I. Olszewski and h.L. Dibble, pp. 119-146. University Museum Press, University of Pennsylvania, Philadelphia.
- Sonnenfeld, J.
1962 Interpreting the Function of Primitive Implements. *American Antiquity* 28(1):56-65.
- Speth, J.D.
1981 The Role of Platform Angle and Core Size in Hard-Hammer Percussion Flaking. *Lithic Technology* 10(1):16-21.
1972 Mechanical Basis of Percussion Flaking. *American Antiquity* 37(1):34-60.
1975 Miscellaneous Studies in Hard-Hammer Percussion Flaking: The Effects of Oblique Impact. *American Antiquity* 40(2):203-207.

- Spier, R.F.G.
1970 *From the Hand of Man: Primitive and PreIndustrial Technologies*.
Houghton Mifflin Company, Boston.
- Stearnes, C.
1970 Observations on the Mughara el Asfourieh and on the Littoral Between
Halat and Amchit (Region of Jbail). *Bulletin du Musee de Beyrouth*
23:129-134.
- Stiner, M.C., and S.L. Kuhn
1992 Subsistence, Technology, and Adaptive Variation in Middle
Paleolithic Italy. *American Anthropologist* 94:306-339.
- Stringer, C., R. Grun, H.P. Schwarcz, and P. Goldberg
1989 ESR Dates for the Hominid Burial Site of Es Skhul in Israel. *Nature*
338(27):756-758.
- Suzuki, H., and I. Kobori
1970 *Report of the Reconnaissance Survey on Palaeolithic Sites in Lebanon
and Syria*. Saikon Company, Ltd., Tokyo.
- Sweeting, M.
1983 The Geological and Morphological Setting. In *Adlun in the Stone
Age*, edited by D.A. Roe, pp. 11-21. BAR International Series 159.
British Archaeological Reports, Oxford.
- Taha, M.F., S.A. Harb, M.K. Nagib, and A.H. Tantawy
1981 The Climate of the Near East. In *Climates of Southern and Western
Asia*, edited by K. Takahashi and H. Arakawa, pp. 183-256. World
Survey of Climatology 9, Elsevier Scientific Publishing Co., New
York.
- Tchernov, E
1989 Biochronology of the Middle Palaeolithic and Dispersal Events of
Hominids in the Levant. In *L'Environment*, edited by M. Otte, pp.
153-168. *L, Homme de Néandertal*, vol. 2. Universite de Liege,
Liege, France.

- Tchernov, E., and Y. Yom-Tov
1988 Zoogeography of Israel. In *The Zoogeography of Israel: The Distribution and Abundance at a Zoological Crossroad*, edited by Y. Yom-Tov and E. Tchernov, pp. 1-6. Dr. W. Junk Publishers, Boston.
- Teltser, P.
1991 Generalized Core Technology and Tool Use: A Mississippian Example. *Journal of Field Archaeology* 18:363-375.
- Torrence, R.
1983 Time Budgeting and Hunter-Gatherer Technology. In *Hunter-Gatherer Economy in Prehistory: A European Perspective*, edited by G. Bailey, pp. 3-21. Cambridge University Press, New York.
1989 Tools as Optimal Solutions. In *Time, Energy, and Stone Tools*, edited by R. Torrence, pp. 1-6. Cambridge University Press, New York.
- Tringham, R., G. Cooper, G. Odell, B. Voytek, and A. Whitman
1974 Experimentation in the Formation of Edge Damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology* 1:171-196.
- Trinkaus, E.
1984 Western Asia. In *The Origin of Modern Humans*, edited by F.H. Smith and F. Spencer, pp. 251-293. Alan R. Liss, New York.
1986 The Neandertals and Modern Human Origins. *Annual Review of Anthropology* 15:193-218.
- Tsirk, A
1979 Regarding Fracture Initiations. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 83-96. Academic Press, New York.
- Turville-Petre, F.
1927 *Researches in the Prehistoric Galilee, 1925-1926*. British School of Archaeology in Jerusalem, London.
- Unger-Hamilton, R.
1983 An Investigation Into the Variables Affecting the Development and the Appearance of Plant Polish on Flint Blades. In *Traces d'Utilisation sur les Outils Neolithiques du Proche Orient*, edited by M.-C. Cauvin, pp. 243-250. CNRS, Lyon, France.

Valladas, H., J.L. Joron, G. Valladas, B. Arensburg, O. Bar-Yosef, A. Belfer-Cohen, P. Goldberg, H. Laville, L. Meignen, Y. Rak, E. Tchernov, A.M. Tillier, and B. Vandermeersch

1987 Thermoluminescence Dates for the Neanderthal Burial Site at Kebara in Israel. *Nature* 330:159-160.

Valladas, H. J.L. Reyss, J.L. Joron, G. Valladas, O. Bar-Yosef, and B. Vandermeersch

1988 Thermoluminescence Dating of Mousterian "Proto-Cro-Magnon" Remains from Israel and the Origin of Modern Man. *Nature* 331:614-616.

Vandermeersch B.

1989 The Evolution of Modern Humans: Recent Evidence from Southwest Asia. In *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, edited by P. Mellars and C.B. Stringer, pp. 155-164. Princeton University Press, Princeton, New Jersey.

1993 The Near Eastern Hominids and the Origins of Modern Humans in Eurasia. In *The Evolution and Dispersal of Modern Humans in Asia*, edited by T. Akazawa, K. Aoki, and T. Kimura, pp. 29-38. Hokusen-sha, Tokyo.

Van Peer, P.

1992 *The Levallois Reduction Strategy*. Prehistory Press, Madison, Wisconsin.

1995 Current Issues in the Levallois Problem. In *The Definition and Interpretation of Levallois Technology*, edited by H.L. Dibble and O. Bar-Yosef, pp. 1-9. Prehistory Press, Madison, Wisconsin.

Vaughan. P.

1985 *Use-Wear Analysis of Flaked Stone Tools*. University of Arizona Press, Tucson.

Wiant, M.D., and H. Hassen

1985 The Role of Lithic Resource Availability and Accessibility in the Organization of Lithic Technology. In *Lithic Resource Procurement: Proceedings from the Second Conference on Prehistoric Chert Exploitation*, edited by S.C. Vehik, pp. 101-114. Occasional Paper No. 4, Center for Archaeological Investigations, Southern Illinois University, Carbondale, Illinois.

Wilmsen, E.N.

- 1967 *Lithic Analysis and Cultural Inference: A Paleo-Indian Case*. Ph.D. dissertation University of Arizona, Tucson. University Microfilms, Ann Arbor, Michigan.
- 1968 Functional Analysis of Flaked Stone Artifacts. *American Antiquity* 33:156-161.

Wynn, T.G.

- 1977 *The Evolution of Operational Thought*. Ph.D. dissertation, University of Illinois, Urbana-Champaign. University Microfilms, Ann Arbor, Michigan.
- 1979 The Evolution of Later Acheulean Hominids. *Man* 14:379-391.
- 1985 Piaget, Stone Tools, and the Evolution of Human Intelligence. *World Archaeology* 17:32-43.
- 1989 *The Evolution of Spatial Competence*. University of Illinois Press, Urbana.
- 1991 Archaeological Evidence for Modern Intelligence. In *The Origins of Human Behavior*, edited by R.A. Foley, pp. 52-66. Unwin Hyman, Boston.
- 1993 Layers of Thinking in Tool Behavior. In *Tools, Language, and Cognition in Human Evolution*, edited by K.R. Gibson and T. Ingold, pp. 389-405. Cambridge University Press, New York.

Zohary, D.

- 1982 *Vegetation of Israel and Adjacent Areas*. Beihefte Zum Tubinger Atlas des Vorderen Orients, Reihe A (Naturwissenschaften) 7, Wiesbaden, Germany.

Zohary, M.

- 1962 *Plant Life of Palestine: Israel and Jordan*. Ronold, New York.

Zumoffen, G.

- 1900 *La Phenicie Avant les Pheniciens. L'Age de la Pierre*. Imprimerie Catholique, Beirut, Lebanon.

VITA

John Edward Dockall was born July 24, 1961 in Andrews, Texas to Albert and Johnnie Dockall. Growing up in sandy West Texas enabled him to acquire an appreciation for prehistory at an early age and he was encouraged by his father to follow that interest. His mother provided the impetus to read about prehistory. By the fifth grade he knew he wanted to be an archaeologist. The most significant moment of his life was May 23, 1992 when he married Helen Danzeiser. Since 1991 he has variously served in GANT and Research Assistant positions in the Department of Anthropology, Texas A&M University. In 1995 he became a Tech II and field archaeologist for the Center for Environmental Archaeology, Texas A&M University and has conducted archaeological field and laboratory research pertaining to South, Central, and East Texas prehistoric hunter-gatherer groups. John has participated in archaeological fieldwork in Northern Belize, Southern New Mexico, and Southern Jordan and his research has included groups that have varied in social complexity from mobile hunter-gatherers, formative agriculturalists, and chiefdom/state-level societies. He received a B.A. in Anthropology from the University of Texas, Permian Basin in 1985; M.A. in Anthropology from Texas A&M University in 1991; Ph.D. in Anthropology from Texas A&M University in 1997. His research in lithic technology and archaeology has been published in regional, national, and international journals including *Bulletin of the Texas Archeological Society*, *La Tierra*, *Journal of the Houston Archeological Society*, *Latin American Antiquity*, *Journal of Field Archaeology*, *Southeastern Archaeology*, and *Journal of Lithic Technology*. His permanent address is Department of Anthropology, Texas A&M University, College Station, Texas 77843-4352.