ex oriente e.V.

جامعة اليرموك

YARMOUK UNIVERSITY

bibliotheca neolithica Asiae meridionalis et occidentalis

Cooperating Institutions for Publishing this Volume:

Faculty of Archaeology and Anthropology, Yarmouk University, Irbid
Department of Antiquities, Amman

Financial Support for Printing this Volume:

Whitman College, Walla Walla
ex oriente e.V., Berlin

Managing Editor of this Volume, Layout:

Hans Georg K. Gebel

‘Ain Ghazal Excavation Reports
Volume 2

Evolution of Lithic Economies in the Levantine Neolithic: Development and Demise of Naviform Core Technology, as Seen at ‘Ain Ghazal

Leslie A. Quintero

bibliotheca neolithica Asiae meridionalis et occidentalis
&
Monograph of the Faculty of Archaeology and Anthropology
(Yarmouk University)

ex oriente, Berlin (2010)

address of the bibliotheca neolithica Asiae meridionalis et occidentalis:

ex oriente e.V., c/o Institut für Vorderasiatische Altertumskunde,
Freie Universität Berlin, Hüttenweg 7, 14195 Berlin, Germany

Printed in Germany by dbusiness GmbH, Berlin

ISSN 1616-9360 (bibliotheca neolithica Asiae meridionalis et occidentalis)
ISBN 978-3-9811888-4-4

Cover design by Yusuf Zu'bi, Yarmouk University (supported by G. Rollefson, Z. Kafafi, and S. Schaefer).
Cover photo of ‘Ain Ghazal MPPNB blade cache by author, of ‘Ain Ghazal Central Field 1993 by Yusuf Zu'bi.

‘AIN GHAZAL ARCHAEOLOGICAL RESEARCH PROJECT

Joint Enterprise of

the Institute of Archaeology and Anthropology
at Yarmouk University at Irbid,

the ‘Ain Ghazal Research Institute, Wembach (1992-1998),

the Department of Antiquities
of the Hashemite Kingdom of Jordan,

supported by

Department of Antiquities, Amman
Yarmouk University, Irbid
Desert Research Institute, Reno, Nevada
American Center for Oriental Research, Amman
National Endowment for Humanities (1988-1989, 1999, 2007)
National Geographic Society (1983-1985, 1988-1989)
‘Ain Ghazal Research Institute, Wembach (1992-1998)
United States Agency for International Development (1993)
Cobb Institute of Archaeology, Mississippi State University (1983-1984, 1988)
Agnese Haury Foundation (1988, 1996)
Friends of ‘Ain Ghazal (1995, 1998-1999)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

Chapter 7. DEBITAGE ANALYSIS

LIST OF TABLES

EDITORS' FOREWORD

Excavations at ‘Ain Ghazal were undertaken for 11 seasons from 1982-1985, 1988-1989, 1993-1996, and in 1998. Over those spans of time, enormous quantities of chipped stone artifacts were recovered. Each season our teams conducted preliminary lithics sorting, including debitage classes and tool classification. In-field sorting and classification was undertaken by the one of the authors (GOR) and by Alan Simmons (co-director of the ‘Ain Ghazal Project from 1983-1989), Deborah Olszewski, and Leslie Quintero.

Since the extent of ‘Ain Ghazal was so enormous in area (c. 14 hectares or more) and depth (up to 3 m in places) and time (for more than 3,000 calibrated radiocarbon years), the quantity of lithic artifacts each season was immense, to the point that sampling was necessary to obtain even a minimal appreciation of qualitative and quantitative features for each of the four major cultural periods represented at ‘Ain Ghazal: the dense Middle PPNB (MPPNB) layers in our samples produced more than 60,000 lithic artifacts (not counting debris and microflakes); for the Late PPNB, the samples totaled in excess of 15,000 specimens; for the PPNC the sample sum reached beyond 54,000 pieces, and for the Yarmoukian Pottery Neolithic the lithic sample was also more than 54,000 examples of sorted and classified artifacts. When one considers that our excavations sampled less than 1% of the area of ‘Ain Ghazal, the almost 300,000 in situ lithic artifacts in our preliminary field analysis samples was miniscule in relation to the probable real numbers contained in the deposits. (The collections from the MPPNB deposits come from the smallest areal sample, so the true number of artifacts almost becomes astronomical in effect).

One of the defining characteristics of the Early, Middle, and Late Pre-Pottery Neolithic periods of the Levant is the use of the naviform core-and-blade technique, a technology that was miserably understood until Leslie Quintero and her research partner and husband Philip Wilke finally explicated the method brilliantly through their ground-breaking experimental work. The use, development, and final abandonment of the naviform technique are at the heart of this volume, but Quintero's treatment goes far beyond the simple mechanics of this efficient method of blade production.

Quintero provides a broad overview of the state of knowledge of lithic technologies used prior to and during the Neolithic of the Levant, and she also includes a critical assessment of approaches to the opportunities for and limitations of interpretations based on contemporary approaches to lithics analysis. But beyond the mere technicalities of the naviform procedures, Quintero provides invaluable insights into the contexts of increasing social and economic complexity at ‘Ain Ghazal that led up to the adoption of the naviform techniques, and how this method played such a crucial role throughout the Levantine region. One outcome of her analysis is the identification of the naviform core-and-blade technique as a craft specialization, one of the oldest such livelihoods in the archaeological history of human development. In addition, she proposes that the roots of the abandonment of the naviform technique in the PPNC and Yarmoukian Pottery Neolithic periods lay in socioeconomic instability that grew more and more desperate as environmental conditions – both climatic and human-induced – became grimmer and grimmer.

Among her other contributions in this excellent volume, Quintero has also put to rest the controversy surrounding the popularity of the satiny purple-pink flint that was closely linked to the use of the naviform core-and-blade technology. In view of the absence of known exposures of this wonderful tool-stone, it had been claimed that purple-pink flint was the result of heat treatment of cruder flint nodules to produce the desired quality that was accompanied by a change in color to the hues so frequently found in naviform cores, blades, and debitage. But following up on some casual observations of a survey team led by Zeidan Kafafi, Alan Simmons, and Deborah Olszewski in 1987, Quintero was able to track down *in situ* naturally occurring purple-pink flint nodules in limestone cliffs within a couple of hours walk from ‘Ain Ghazal. Furthermore, she was able to document the mining techniques naviform specialists used to extract the valuable raw material they coveted so eagerly.

Altogether, Volume 2 of the ‘Ain Ghazal final reports is a refreshing look at one of the defining periods of human technological innovation and practice, a well-written view that would not have been possible without Quintero’s reliance on her replication work and experimentation. Reading her prose is as enlightening as it is enjoyable, and readers will come away with a much finer understanding of the conditions and effects associated with the naviform core-and-blade technology.

Gary O. Rollefson and Zeidan A. Kafafi

PREFACE AND ACKNOWLEDGMENTS

Naviform core-and-blade technology formed the basis of many flaked-stone industries in the early Neolithic of the Levant. The prevalence of the technology in Pre-Pottery Neolithic assemblages is clearly evident; however, the reasons for its appearance during this period of prehistory and for its importance to the Neolithic economy have not been well studied. This research accounts for the evolutionary history of naviform core technology by considering it in the broad context of changing economic conditions that occurred from the Epipaleolithic through Pottery Neolithic times. More specifically, the analysis traces the evolving character of the community of ʻAin Ghazal, as revealed through its lithic economy, as the settlement developed, flourished as a vigorous regional center, accommodated impressive population expansion, and ultimately collapsed into a small agrarian hamlet. While this is ʻAin Ghazal's story, it nevertheless speaks to comparable regional developments at other Neolithic communities.

This is, above all else, a lithic industrial study, and is heavily influenced by the developing research paradigms of the late 1990s, when this work was conducted, both in the United States and in the Near East. We owe much to the expanded views of the possibilities of such work that emerged from the joint influence of processual archaeology and *chaîne opératoire* at this time. The specific impetus for these changes in Levantine research, in my view, developed from the coalition of international scholars who configured the newly assembled Workshops on PPN Chipped Lithic Industries, commencing in Berlin in 1993. Since that time, the direction of lithic studies has evolved considerably, embracing new approaches and obtaining new insights into a wide array of ancient behaviors.

The research detailed here reflects these changes and some of the intellectual issues that emerged during this period. In this regard, this work is best viewed as a retrospective, an historical piece, and I must apologize for its tardy publication. Nonetheless, the data that it assembles and their interpretation, I believe, are as relevant today, and add to our understanding of ʻAin Ghazal's history and the character of Neolithic life at this time. References are made throughout the text, mostly in footnotes, to pertinent recent works, which I have limited for expediency to those that have appeared as final reports of research.

This publication is a revised version of my dissertation (filed 1998) and profited from the support of numerous individuals and institutions. I extend again my appreciation to those listed in the original volume. In particular I thank Gary Rollefson, of the ʻAin Ghazal Research Institute and Whitman College, Hans Georg K. Gebel of the Free University of Berlin, and Philip Wilke of the University of California for their intellectual support, good counsel, and warm friendship of several decades. They are unfailing, good colleagues.

This work benefited from my access to numerous collections made available by several scholars and I thank them. Yoshihiro Nishiaki shared portions of the Douara Cave collection. Muhammad Waheeb facilitated access to the ʻAin Jammam collection. Hans Georg K. Gebel provided access to the Basta collection. Avi Gopher and Ran Barkai provided access to several

Neolithic collections in Israel, and the late Tamar Noy shared her Neolithic research collections. Nigel Goring-Morris and Naama Goren-Inbar provided access to collections in Israel and shared their expertise. This work also was enhanced by encouragement from the late Wolfgang Taute, and from the impeccable scholarship of John Clark.

I am indebted to the members of my dissertation committee for their advice and support. Frank Hole of Yale University, Scott Fedick, Karl Taube, and Paul Gelles, all of the University of California, and Gary Rollefson, all edited earlier drafts of this document. The American Center of Oriental Research in Amman, Jordan, was an essential support base, and I thank its staff, especially Pierre and Patricia Bikai, and Kathy Nimri, for many kindnesses. Zeidan Kafafi of Yarmouk University facilitated my research at that institution. Ghazi Bisheh, then Director of the Department of Antiquities of Jordan, gave me permission to study the ‘Ain Ghazal collection. Glenn Goode, of Dripping Springs, Texas, donated precious Texas flint for the replication experiments. I am grateful also to several of my students at the Lithic Technology Laboratory, University of California - Riverside, in particular to Colleen Bell, for assistance in compiling data.

Finally, the intellectual realm of Neolithic research has been greatly enhanced by the enormous efforts of Hans G. K. Gebel. Without his encouragement and hard work this volume and many others would not have been published.

Portions of this research were extracted from the original dissertation and published prior to its completion. I thank Hans Georg K. Gebel, editor, ex oriente, and Genviève Dollfus and Eric Coqueugniot, past and current editors of *Paléorient*, for permission to recycle these materials here. Funding for this research was provided by the ‘Ain Ghazal Research Institute, the University of California - Riverside, and the National Science Foundation.

During all of these efforts, my colleague, friend, and husband, Philip Wilke provided invaluable assistance, creative insights, and significant discussion of many major issues. For this collaboration, I thank him and dedicate this work to him.

Leslie A. Quintero

Chapter 1

INTRODUCTION

This research considers Neolithic technological and economic adaptations in the Levantine portion of the Near East (Fig. 1.1). The general focus is the lithic economy that supported the initial, agrarian-based towns as they flourished (some developing into regional population centers), stabilized with food-producing economies, and temporarily waned during the later Neolithic. This "neolithization" process has been well studied for many decades, particularly in terms of the development of sedentism and agriculture, cultural evolution, and ecological adaptations (*e.g.*, Braidwood 1952; Childe 1952; Braidwood and Braidwood 1960; Braidwood and Howe 1960; Flannery 1969; Hole *et al.* 1969; Hole 1977; Braidwood *et al.* 1983). However, the concomitant lithic adaptations and the role that the production of stone tools played in the structure of these ancient economies is less well known.

It is not surprising that the ubiquitous stone artifact has long been used to frame cultural histories of the Levant. Abundant, well-preserved lithic deposits enabled numerous researchers to develop regional cultural chronologies that documented evolutionary successions from the preceding Epipaleolithic/Natufian hunter-gatherers, through the Neolithic florescence of agrarian economies, to their decline. For instance, studies of the Neolithic commencing in the early 1930s (*e.g.*, Neuville 1934; Crowfoot 1935; Garstang 1935) were instrumental in identifying archaeological cultures and their chronological sequences (*e.g.*, Perrot 1952, 1968; Kenyon 1957, 1960; Braidwood and Braidwood 1960; Stekelis 1972). This focus has guided Levantine lithic research to the present day, so that, while major synthetic schemes have been compiled (*e.g.*, Mellaart 1975; Bar-Yosef 1980; Moore 1982, 1985), their refinement continues, and empirically grounded assessments of how and why these changes took place are few.

Current archaeological data, including lithic assemblages, suggest that radical alterations in cultural adaptations occurred during the transitions from the Natufian to the Pre-Pottery Neolithic (*ca.* 10,500 B.P.), and from the Pre-Pottery to the Pottery Neolithic (*ca.* 8,000 B.P.). Yet, there is no clear understanding of how these changes relate to Neolithic socioeconomic developments or to dynamic ecological factors and an evolving paleoclimate. During the latter transition, restructuring of Neolithic communities was evidently so severe that many large towns were abandoned. Consequently, this period is viewed by many as a time of economic collapse during which existing Early Neolithic socioeconomic strategies failed (Rollefson and Köhler-Rollefson 1989; Gopher and Gophna 1993). Coincidentally, the lithic economy of this period was reconfigured as well; for unknown reasons, an economy based on the production of flake tools gradually gained importance, while blade-tool production declined (*e.g.*, Roodenberg 1986, 1989; Gopher 1989; Rollefson 1989a).

Of particular interest here is the process of flaked-stone tool production as a dynamic, techno-

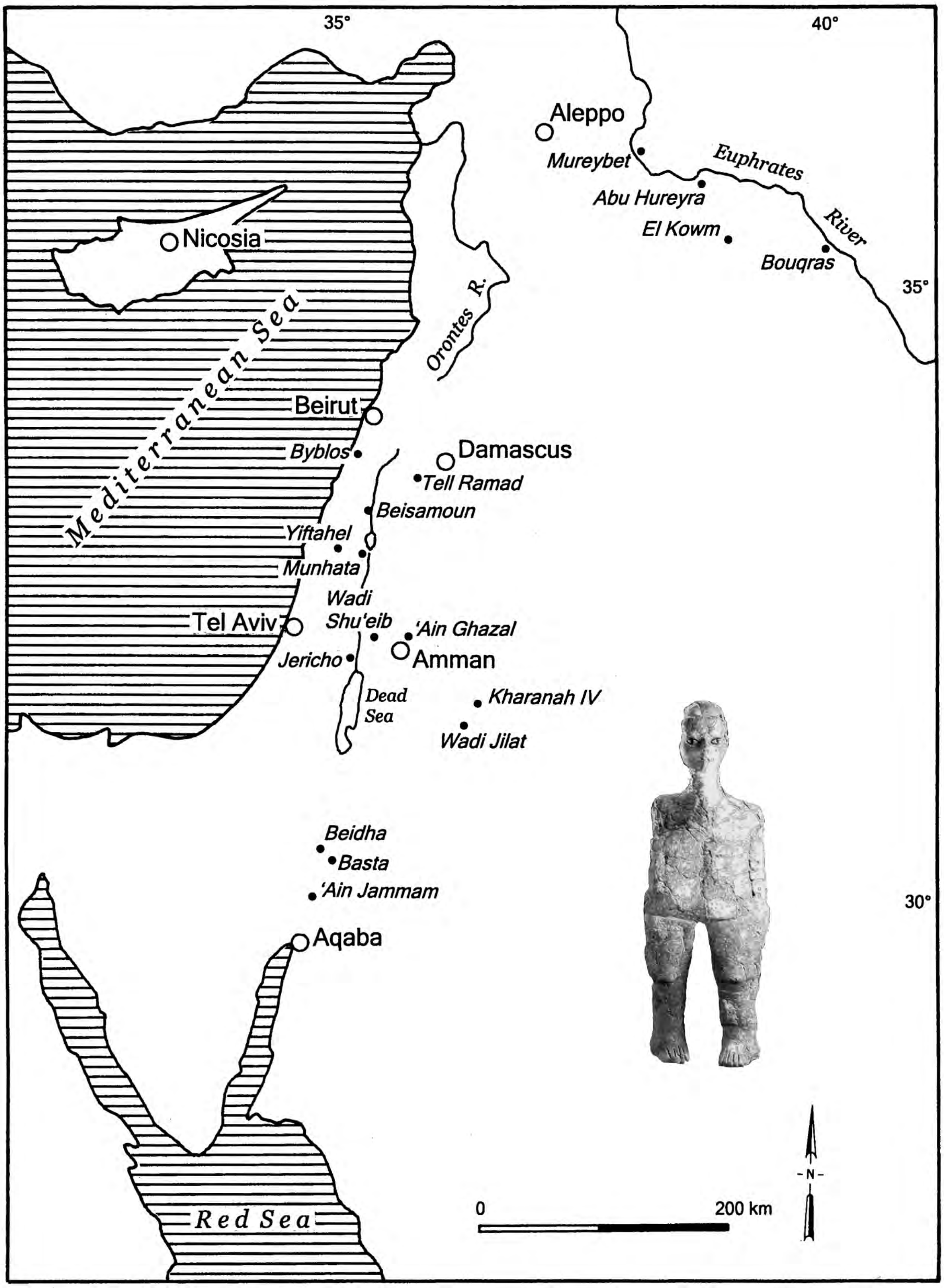


Fig. 1.1. Map of the Levant showing major sites discussed in the text.

logical activity, one that was an integral part of a changing Neolithic economy.[1] Processual analyses of Neolithic stone-tool technologies and their underlying economic structures generally are lacking in Levantine research. Hence, little is known about the production of ordinary subsistence tools used by these first townspeople, or the organization of stone-tool production, or how lithic economies related to changes in prevailing economic systems. The research presented here addresses these issues and is, above all else, technological in nature. It sets forth a foundation of information that can be used to understand the character of the economies, such as the selection and acquisition of tool-stone by Neolithic stone-workers, flint-knapping techniques used to produce cores and blanks for tools, variable characteristics of blanks and production debitage, etc. And, importantly, it discloses the flint-knapping behaviors and decisions that very likely created the industries. The goal is twofold, however, for it includes not only the technological events, but the economic ones as well. It is assumed that the organization of stone-tool manufacturing processes and associated technological and economic behaviors were interrelated with the general economic structures of the communities (after Clarke 1978). Therefore, an analysis of the lithic economies of these periods has the potential to reveal not only their individual economic characters, but also aspects of the more encompassing economic situations and their evolution.

NEOLITHIC ECONOMIES

While there have been many reasoned evaluations of the socioeconomic structure of early settlements in the Levant, historically, the primary concern has been subsistence economics, and how settlement and demographic issues interrelated with agrarian development to embody the "Neolithic." This interest continues and is incorporated into regional socioecological models,[2] and expansive syntheses (*e.g.*, Mellaart 1975; Redman 1978; Gebel 1984; Moore 1985). The array of concerns has broadened in recent research, however, reflecting current interests in a wide range of anthropological topics. Joining ecological evaluations, for example, are considerations of social realms, such as gender roles (Crabtree 1991), the emergence of ritual and religious practices and symbols (Rollefson 1986; Rollefson and Simmons 1987; Bar-Yosef and Belfer-Cohen 1989a; Cauvin 1994; Kuijt 1995; Tubb and Grissom 1995), and community planning (Banning and Byrd 1987; Byrd 1994). Nonetheless, interest in the economy of technological systems continues to be rare, and there remain many gaps in our understanding of Neolithic economic life, gaps that should diminish with the benefit of comprehensive technological evaluations of lithic economic adaptations. Such information is invaluable for reconsidering long-standing anthropological models of socioeconomic conditions in Neolithic settlements in the Levant. For instance, Redman's (1978: 205) early model suggesting that communities such as Beidha and Munhata had egalitarian, nonstratified tribal structures without craft specialization, has been widely used. Yet, his synthesis is based on archaeological data of the 1970s and on Service's (1962) and Fried's (1967) paradigms for sociopolitical structures elaborated in the 1960s, and clearly lacks the benefit of modern data and interpretations (*e.g.*, Gebel *et al.* 1988; Gopher 1989, 1994; Rollefson 1989a; Gebel 1994). More recent information suggests that the

[1] This research is limited to concerns of core technologies and the production of flaked-stone tool blanks, which included the production of blades as blanks. An equally important and generally neglected aspect of Neolithic stone economies was the production of milling stones. Although not considered in the current work, Neolithic milling-stone production is addressed elsewhere (see Wilke and Quintero 1996).

[2] *e.g.*, Braidwood 1952; Braidwood and Braidwood 1960; Flannery 1969; Smith and Young 1972; Hassan 1977; Cauvin 1978, 1994; Bar-Yosef 1980; Moore 1983; Hole 1984; Bar-Yosef and Belfer-Cohen 1989b, 1992; Henry 1989a, 1995; McCorriston and Hole 1991.

Neolithic economic environment was more complex, and may well have included a degree of economic specialization (*e.g.*, Redman 1983; Stech 1990; Voigt 1990; Quintero and Wilke 1995; Gebel and Bienert 1997).[1] Findings are presented here that allow further evaluation of Redman's model and speak to the variable nature of Neolithic economic behavior in the Levant.

NAVIFORM CORE-AND-BLADE TECHNOLOGY

This research concentrates on two periods, the Pre-Pottery Neolithic (*ca.* 9,500 - 7,500 B.P.) and the Pottery Neolithic (*ca.* 7,500 - 6,000 B.P.), and the disparate lithic economies that were created by stone-workers during these periods. The central questions are these: (1) What were the lithic economic adaptations of these two periods? (2) What technological and/or economic factors brought about the drastic change in tool production that occurred during the transition to the Pottery Neolithic? And, (3) how do changes in the lithic economy relate to the more general economic restructuring that characterizes this dynamic period in the Levant? The specific focus is the evolutionary history of the extraordinary naviform core-and-blade technology that formed the basis of blade-tool production during the Middle Pre-Pottery Neolithic in much of the Levant, and the economic organization that its development entailed.

Naviform core technology was the industrial mainstay of the earlier portion of the Neolithic, providing the bulk of the blade-tool blanks and blade tools that supported the emerging agrarian economies. The technology clearly came to dominate Pre-Pottery Neolithic blade-tool production and distinguished this period of Neolithic development, so much so that naviform cores are recognized as *fossiles directeurs*, or artifactual index fossils, for this period. Yet the reasons for this dominance, indeed for its initial development during this period, are not known. It was preceded by the seemingly disparate Epipaleolithic industries, which are characterized largely by flake tools and microliths fashioned from bladelets. It flourished as the Neolithic towns flourished and subsequently ceased to exist in the ensuing Pottery Neolithic times. Why did it flourish? Why did it its role as a major industrial strategy end in the Pottery Neolithic? The research presented here attempts to understand this evolutionary sequence of events by considering the technological character of naviform cores and blades within the framework of the diverse economic environments of these changing times. This approach differs from previous studies of the technology in fundamental ways, as discussed below.

Several decades ago, Jacques Cauvin noted that the Pre-Pottery Neolithic assemblage from Tell aux Scies was dominated by large, boat-shaped, or "naviform," blade cores. Cauvin's characterization of the industry pointed out several of its major features:

> Ils sont d'un type à duex plans de frappe qu'on pourrait appeler « naviforme », tellement le bord opposé à la surface d'éclatement ressemble, avec son arête et ses enlèvements bifaces, à une carène de navire. . . . Très allongés, ils sont servi à donner de longues lames, celles-là mêmes que nous voyons utilisées pour les flèches, les faucilles et certains grattoirs.[2] (1968: 226)

---

[1] Additionally, craft specialization was suspected by some earlier researchers. For instance, Kirkbride (1966: 24) noted the presence of a stone-bead production workshop and suggested "a certain degree of specialization in the crafts" for the later levels of Neolithic Beidha.

[2] "They are a type [of core] with two striking platforms that we might call 'naviform,' the edge opposite the flaking surface, with its crest and bifacial detachments, resembles the hull of a ship. . . . Being very long, they are used to make long blades, the same that are used for arrow points, sickle blades, and some scrapers."

Similar early works, such as those of Crowfoot Payne (1983), Mortensen (1970), and Moore (1982) augmented this initial description and accentuated the significance of the naviform core technology in Neolithic cultural developments. These works epitomize research trends of this period as they integrated important typological data into regional chronological sequences, in addition to defining several aspects of the technology. While it was apparent to many that naviform cores furnished long, straight blade-blanks that were ideally suited for the production of Neolithic tools, few researchers considered the technological nature of the blade manufacturing process, or sought to understand why the technology was so successful.

During the ensuing decades, a small number of researchers, such as Suzuki and Akazawa (1971), Calley (1986a, 1986b), and Nishiaki (1994), proposed technological models of naviform blade-core assemblages that characterized several important aspects of the various industries but that were, in essence, theoretical constructions lacking in empirical evaluation. Compared to processual, technological studies, these works presented descriptive considerations of naviform core-and-blade industries that did not address the underlying technological behaviors that created the assemblages or their economic frameworks. An important barrier to the empirical examination of these models, therefore, and to processual studies in general, appears to have been the longstanding descriptivist orientation in Near Eastern lithic research. Without technological studies grounded in empirical tests, the development and significance of the naviform-core economy during the early Neolithic remained unresolved.

Technological analyses of reduction strategies, on the other hand, have the potential to reveal the processes of core-and-tool production and constraints that shaped the industries (such as the configuration of stone resources and technical difficulties in core production), as well as the tool requirements of the economy (Schild 1980a). When such information is coupled with aspects of the larger economic framework, such as tool-stone acquisition strategies and the organization of stone procurement methods, it is possible to characterize naviform core-and-blade technology and the rationale that prompted many of the underlying economic choices.

Therefore, an important element of the lithic economies of both the Pre-Pottery and Pottery Neolithic periods is the location of tool-stone resources and the organization of their exploitation. However, stone resource data are scarce. While many researchers have noted that local resources were exploited for the production of flake cores by late Neolithic townspeople, to date, the sources of the high-quality flint used for most of the early Neolithic blade cores are unknown. Moreover, with the exception of Taute (1994),[1] who analyzed a flint quarry and adjacent axe-production site in Israel, there are no substantive studies of Neolithic tool-stone acquisition. This lack of data has led to considerable conjecture about the organizational structure of lithic resource acquisition, particularly for production of naviform cores during the Pre-Pottery Neolithic. Gopher (1989) and others maintained that flint for blade production was imported to southern Levantine communities via long-distance trade networks. But, Crowfoot Payne (1983), and Bar-Yosef and Belfer-Cohen (1989b), for example, suggested that local flint was used for blade cores, but that it was thermally altered by Neolithic flint-workers to produce desirable knapping characteristics. At the present time, there is no consensus among researchers regarding these issues, and the degree of complexity of the underlying lithic economy is obscure.

Consequently, preliminary work for the research presented here was conducted to investigate

---

[1] This work was completed posthumously by Schyle (2007) who contributed additional economic analyses. His work was aided by a field study by Barkai *et al.* (2007).

the technological nature of the naviform core-and-blade assemblage from the Neolithic town of ‘Ain Ghazal in Jordan, and to understand the resource selection strategies and core-preparation and blade-production processes that were used by Pre-Pottery Neolithic stone-workers (Wilke and Quintero 1994; Quintero and Wilke 1995; Quintero 1996). These works considered why naviform core configurations were selected for use over other strategies of lithic reduction (i.e., their technological “fitness”), and how naviform blade-core technology likely fit into the early Neolithic economic pattern. More detailed presentation of this research and a broader interpretation of the Neolithic stone-tool economy at ‘Ain Ghazal are the concerns of the current work. The collection of lithic artifacts amassed from this site constitutes the primary data base used here to evaluate the evolving development of its lithic economy and to gain a better understanding of the more general economic situation that prevailed in the Levant during these periods.

NEOLITHIC ‘AIN GHAZAL

The 8th-7th millennium town of ‘Ain Ghazal is located in the northwestern highlands of modern Jordan (Fig. 1.1), in a geologic environment dominated by limestone plateaus that are steeply cut by an extensive network of wadis. These drainages bisect the highlands as they extend generally westward down into the Jordan Rift Valley. The townsite extends over 600 m along the banks of what is currently a small stream in the Wadi Zarqa (Plate 1.1; Fig. 1.2), although there is evidence that in Neolithic times the wadi may have contained a stream that was periodically of substantial size (G. Rollefson personal communication 1996). The current biogeographical setting is an impoverished oak woodland bordering the steppic-desert terrain that typifies much of eastern Jordan. However, considerable faunal and paleobotanical data from ‘Ain Ghazal attest to a Neolithic environment that was quite rich in wild game, was forested with oaks, pistachio, and fig trees, and contained diverse pulses, and nut and seed resources (Simmons *et al.* 1988; Rollefson *et al.* 1992). All subsistence data attest to the exploitation of varied ecozones that provided fruitful wild, and eventually domestic, resources.

‘Ain Ghazal evidently had a significant position within the context of early agricultural settlements in the Near East. Its occupational span has been traced through radiocarbon dating, and ceramic and lithic correlations to over 2,200 years of use. Ten field seasons, spanning 1982-1996, have disclosed a dynamic occupational sequence during which ‘Ain Ghazal grew from a small hamlet of about four hectares in size in the earlier PPNB, *ca.* 9,250 B.P.,[1] to a major town of substantial size, approximately 13 hectares at its largest extent (Rollefson 1987b, 1989a, 1992.), making it one of the largest well-documented Neolithic sites in the Levant. At this point, *ca.* 8,500 B.P., there is evidence that ‘Ain Ghazal was a major center of commerce in the southern Levant, and that it had established connections for a modest importation of some exotic lithic materials, such as small quantities of malachite and carnelian that probably originated in southern Jordan, basalt for millstone production perhaps from the Black Desert of northeastern Jordan, very small amounts of Anatolian (?) obsidian, and turquoise, possibly from the Sinai (Rollefson 1987b, 1993; Rollefson *et al.* 1992). During this period ‘Ain Ghazal was substantially

[1] In the Pre-Pottery Neolithic B Phase (PPNB). The current chronological framework for the Neolithic, and the one used here, is divided into the following phases (uncalibrated ^{14}C years before present): Pre-Pottery Neolithic A (PPNA), *ca.* 10,500 - 9,500 B.P.; Pre-Pottery Neolithic B (PPNB), *ca.* 9,500 - 8,000 B.P.; Pre-Pottery Neolithic C (PPNC), *ca*. 8,000 - 7,700 B.P.; Pottery Neolithic (PN), *ca*. 7,700 - 6,000 B.P.

Plate 1.1. Views of ‘Ain Ghazal.
upper view south showing Wadi Zarqa and the South and Center fields of the excavation to the right of the wadi, 1989. The East Field is left of the wadi out of view.
lower view west of South and Central fields, and excavation units, 1993.

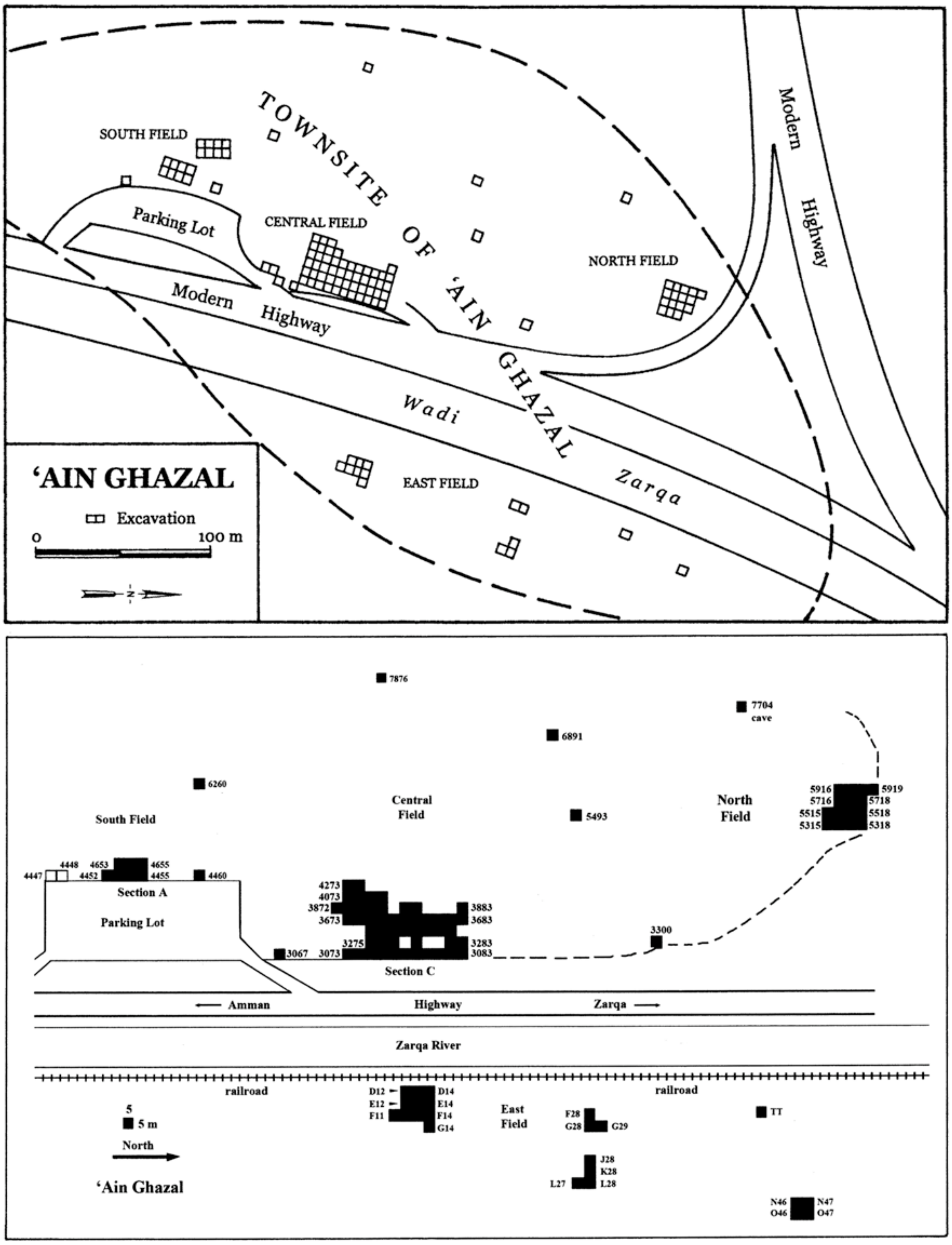


Fig. 1.2. ‘Ain Ghazal maps.
upper boundary of site and position of excavation fields (after map by G. Rollefson).
lower schematic of ‘Ain Ghazal excavation units, 1982-1998
(by G. Rollefson, after plans by A. Omari and M. Bataineh).

larger than contemporary neighboring towns and most other settlements in the Levant that are currently known. For example, Mureybet and Tell Ramad in Syria, Jericho in the West Bank, and Beidha in southern Jordan are thought to have been under 3 or 4 hectares at their maximum extent. Only a handful of extensive sites like ‘Ain Ghazal are known to have existed. They include Basta and Wadi Shu‘eib also in Jordan, Beisamoun in Israel, and Abu Hureyra in Syria. Together, they give evidence for a Levantine “interaction sphere” (Rollefson 1987b; Bar-Yosef and Belfer-Cohen 1989b) that facilitated the exchange of ideas and commodities throughout the region.

The lengthy exploration of ‘Ain Ghazal has documented its position of importance in providing increased awareness of the neolithization process in the Levant. As one of the earliest villages in the southern extremity of the Fertile Crescent, its record of such cultural developments as the domestication of plants and animals, of architectural sequences, and ritual and religious life has been instrumental in shaping regional cultural chronologies and our current perceptions of Neolithic adaptations in this area (Rollefson *et al.* 1991, 1992; Rollefson and Köhler-Rollefson 1989; Gopher and Gophna 1993). For instance, the Pre-Pottery Neolithic C Phase was recognized and configured initially from ‘Ain Ghazal data (Rollefson 1990a; Rollefson and Köhler-Rollefson 1993).

‘Ain Ghazal continued to be occupied until *ca*. 7,000 B.P., well into the early Pottery Neolithic, as evidenced by the typical Yarmoukian material culture. Thus, its immense lithic assemblage, one of the most extensive collections from the Levantine Neolithic, reflects over 2,000 years of stone-tool production, and a broad pattern of lithic economic adjustments during a large portion of the Neolithic (Rollefson *et al.* 1992; Gopher and Gophna 1993). Insights from its study address not only the economic character of the town, but the more general technological and economic circumstances that prevailed in the southern Levant.

Chapter 2

CULTURAL BACKGROUND

The economic transformation that led to the emergence of village farming in the Near East involved significant changes in technology, subsistence, cultural geography, and human lifestyles. The interrelated nature of these domains is such that none can be understood well individually. It is fruitful, therefore, to consider certain aspects of lithic technology in more encompassing socioeconomic terms, and to view stone-tool technologies in conjunction with more notable Neolithic adaptations, such as sedentism, domestication, and pastoralism, and less well understood climatic circumstances, as components of interconnected cultural-ecological structures. Although naviform core-and-blade technology is essentially specific to the Pre-Pottery Neolithic, its evolution must be considered and understood within the larger sequence of cultural and economic developments that led to its appearance in the Near East.

EPIPALAEOLITHIC/NATUFIAN

The general paleoenvironmental and climatic setting of the Levantine Epipaleolithic (*ca.* 20,000 - 10,500 B.P.) reflects the effects of the Late Glacial Maximum, which included pronounced climatic fluctuations accompanied by expansion and contraction of biogeographic zones (Luz 1982; Van Zeist and Bottema 1982; Van Zeist 1985; COHMAP Members 1988; Baruch and Bottema 1991; Rossignol-Strick 1993). While cultural expressions of the Epipaleolithic are geographically and temporally diverse, there is, in many respects, an underlying unity suggested by these Late Glacial adaptations (Henry 1983; Solecki and Solecki 1983). It is commonly accepted that Epipaleolithic technologies supported a hunting-gathering adaptation that in most regions included exploitation of a wide array of small mammals, and, at some sites, concentrated exploitation of significant numbers of large mammals, such as wild goats (*Capra* spp.) and gazelles (*Gazella* spp.) (Henry 1983, 1995; Bar-Yosef 1990). In addition, well-preserved fish bones from some early lacustrine sites, such as Ohalo II on the western shore of Lake Tiberius (Nadel 1990), attest to the importance of fish to some regional economies. As suggested by recent assessments of both botanical and artifactual data (*e.g.*, Henry 1983, 1989a; Bar-Yosef and Valla 1991; Kislev *et al.* 1992),[1] exploitation of plants also was varied and included a reliance on wild cereal grasses and nuts such as pistachios and acorns. Epipaleolithic subsistence practices are commonly viewed, therefore, as broad-based economies that were responsive to regionally diverse flora and fauna.

---

[1] See Olszewski (1993) and McCorriston (1994) for a discussion of the probable importance of acorn use in the Levantine Epipaleolithic. Also, Epipaleolithic sickle blades and milling stones give ample evidence for an extensive use of plant products (*e.g.*, Edwards 1991). The extent to which plant cultivation existed in Natufian contexts is problematic, however. Some researchers (*e.g.*, Unger-Hamilton 1989, 1991; Henry 1989a) have argued that artifacts such as glossed sickle blades and abundant milling equipment in Natufian contexts are evidence of plant cultivation. However, while microwear studies of sickle blades support the use of sickles to harvest grasses, data supporting the domestication, or even the cultivation, of cereal grasses at this early date are equivocal (see Olszewski 1993).

In the southern Levant the most studied archaeological aspect of the final Epipaleolithic is the Natufian culture (*ca.* 12,500 - 10,500 B.P) and its regional equivalents. The appearance and distribution of these cultural assemblages has been linked to climatic amelioration in the form of rising temperatures in the Levant and broadening of Mediterranean woodland ranges (*e.g.*, Henry 1983, 1989a; Bar-Yosef 1990). Many researchers have traditionally viewed the final Epipaleolithic, in particular the Natufian adaptation, as a period of marked and rapid cultural changes, including intensification of subsistence activities that focused on a wider selection of small-animal resources (*e.g.*, Henry 1989a, 1995).[1] Conventional interpretations further suggest that Natufian settlements generally were larger and more concentrated than those of the preceding phases. Consequently, a more "complex" foraging pattern has been proposed for the Natufian, in contrast to a "simple" foraging adaptation claimed for earlier Epipaleolithic phases (Henry 1989a, 1995; for an overview see McCorriston and Hole 1991). Concomitant population growth, sedentism, and social complexity are commonly linked to Natufian and related cultural expressions (*e.g.*, Henry 1989a, 1995; Bar-Yosef and Belfer-Cohen 1991, 1992).

Recent reevaluation of site data, however, argues that the Natufian is better viewed within the context of continuity of Epipaleolithic adaptations. Rather than signaling the abrupt and dramatic cultural change that has traditionally been proposed, Natufian assemblages would represent the final manifestation of a longstanding pattern of gradual evolution of cultural patterns during the entire Epipaleolithic period (*e.g.*, Kaufman 1992; *cf.* Hole 1984), possibly as normal adjustments to continual climatic oscillations. It has also been proposed that earlier Epipaleolithic periods possessed a larger range of site sizes and more complex and varied adaptations than previously realized (*e.g.*, Kaufman 1992). While some sites provide data supportive of some form of sedentism, these data are seen as ambiguous, so that there is no agreement on the nature or significance of these sites, or on the likelihood that sedentism was a real cultural pattern.[2] Likewise, the notion that social complexity originated with the Natufians has been seriously questioned (Olszewski 1991).

A generally accepted view, however, is that the Natufian adaptation reflects a wide range of foraging and collecting practices, and that sites of varying sizes were created throughout a core area largely characterized by Mediterranean woodlands (Tchernov 1981; Baruch and Bottema 1991; Kaufman 1992). To a lesser degree, related adaptations were present in marginal, steppe or desert, environments, as in the Negev (Goring-Morris 1987) and southern Jordan (Henry 1995). Demographic data inferred from the sizes and distributions of Natufian sites imply some degree of seasonal mobility (Bar-Yosef 1981, 1983). Compared to the Neolithic, Natufian settlement sizes and distributions, and concomitant subsistence data, suggest that fairly small, hunter-gatherer population clusters were widely dispersed over the landscape, a pattern that is consistent with earlier Epipaleolithic adaptations.

Natufian lithic assemblages are, in many regards, representative of the more general, final

---

[1] The "broad-spectrum" pattern of exploitation has long been interpreted as a fundamental aspect of Epipaleolithic adaptations that eventually led to population growth, sedentism and the development of Neolithic societies (*e.g.*, Binford 1968; Flannery 1969; Hassan 1977).

[2] Some large sites, such as Wadi Hammeh 27 (Edwards 1991) in Jordan, Ein Mallaha (Perrot 1966; Valla 1981) and Hayonim Terrace (Henry and Leroi-Gourhan 1976) in Israel, and Mureybet (Cauvin 1979) and Abu Hureyra (Moore 1975) in Syria, have some form of architecture. However, the interpretation of these structures as valid evidence for sedentary living is problematic (see Edwards 1989). Further, it has been suggested (*e.g.*, Tchernov 1984) that rodent faunal remains in sites may indicate animal commensalism and that this circumstance is evidence for human sedentism; nonetheless, there is no consensus on this issue at the present time (see Perlès and Phillips 1991).

Epipaleolithic pattern in the Levant.[1] In the core area, they are characterized by milling-stone assemblages that often are quite elaborate (Henry 1989a),[2] and a flaked-stone industry based on the production of flakes from unstandardized cores. Of particular interest are percussion-blade cores of various forms, including a wide array of technological types of bladelet cores.[3] Blade-core assemblages from Natufian and related contexts attest to the presence of opposed-platform, bidirectional blade(let) cores, a reduction approach that has long-standing Paleolithic affinities. The production of "microliths" created from small percussion blades and bladelets is a fundamental feature of Natufian sites (Crowfoot Payne 1983; Byrd 1988); microliths are generally considered to be elements of composite tools or weapons. Microliths in the form of lunates typify Natufian assemblages and seriation analyses of lunate sizes and types commonly are used for chronological differentiations and assessments of affinities with the Natufian complex.

PRE-POTTERY NEOLITHIC

Coincident with deteriorating environmental conditions of the Younger Dryas (from *ca.* 11,000 - 10,000 B.P.), Natufian and related adaptations ultimately were replaced by the earliest Neolithic developments (Henry 1989a; Baruch and Bottema 1991; Bar-Yosef and Belfer-Cohen 1991, 1992). The first phase of the Neolithic sequence, the PPNA (*ca.* 10,500 - 9,500 B.P.), represents a transition during which settled village life became a common pattern. Cultural adjustments to the effects of an increasingly cold and arid climate led to a short-lived archaeological expression, the Khiamian, in the early PPNA (*ca.* 10,500 - 10,300 B.P.). Although poorly represented, Khiamian sites appear to reflect final Natufian occupations in well-watered locations, primarily within low-lying areas of oak woodlands (Henry 1989a; Bar-Yosef and Belfer-Cohen 1992). Lithic assemblages with microliths attest to Natufian affinities, but the occurrence of El Khiam projectile points and increased production of blades, rather than bladelets, are evidence of new technological choices.

The latter portion of the PPNA (*ca.* 10,300 - 9,500 B.P.), corresponds to a period of increased rainfall and the onset of global warming (Baruch and Bottema 1991). Archaeological cultures of this period, generally referred to as the Sultanian, give evidence for the first conspicuous "neolithic" adaptation, unequivocal sedentism and village living. Sultanian communities range up to 3 hectares in size and have circular, mud brick and stone structures, some with plaster floors and internal stone-lined hearths, as at Jericho in the West Bank (Kenyon 1981; Crowfoot Payne 1983), Netiv Hagdud (Bar-Yosef *et al.* 1980; Bar-Yosef and Gopher 1997), and Gilgal 1 (Noy *et al.* 1980) in Israel, and Dhra' (Kuijt 1996) and 'Iraq ed-Dubb (Kuijt *et al.* 1991) in Jordan. Clear evidence for the presence of cultigens is elusive in PPNA sites, however, and research continues in an effort to determine the precise setting of the earliest cultivation of domestic plants (see Hole 1984; *cf.* Kislev 1992; Zohary 1992).[4] Archaeological and paleoecological data have led some

---

[1] For an overview of Epipaleolithic and transitional lithic assemblages of sites in Iraq and Syria, see Olszewski (1988), Henry (1989a), and Ohnuma (1997).

[2] See, for example, those at Wadi Hammeh 27 in Jordan (Edwards 1991).

[3] Blade(let) core reductions occur on a broad array of core blanks and diverse types of reduction manipulations were used, so that single-platform, opposed-platform, and numerous forms of multi-platform, percussion cores are common. Currently, there are no convincing data that support the reduction of cores by pressure at Natufian sites. East of the Levantine corridor, the Tigris and Euphrates rivers mark a technological boundary between percussion-blade industries that dominated to the west and pressure-blade industries that developed and flourished eastward and northward. Causes of this regional technological diversity presently are unknown (see Wilke 1996; Ohnuma 1997).

[4] Of note is recent research at Wadi Faynan in Jordan (Jenkins and Rosen 2007; Mithen and Finlayson 2007).

researchers to suggest that this event initially occurred in the highlands of the Levant, possibly beginning in Transjordan and spreading from there to the Jordan Valley and the Middle Euphrates (Bar-Yosef 1989: 58; McCorriston and Hole 1991). Other researchers working in the northern Levant argue that the Neolithic began there and spread southward (Cauvin 1978, 1979).[1]

A significant technological change that marks the PPNA transition to established Neolithic lifeways was a shift in blade-core reduction strategies (Crowfoot Payne 1983; Bar-Yosef 1989). Reliance on small, unstandardized bladelet cores for the production of tool blanks was gradually replaced by the use of larger, more regularized blade cores as composite tools with microlithic insets gave way to tools made on bigger blades towards the end of this phase. Of particular significance was the refinement of bidirectional, opposed-platform, blade-core technology, and its increasing importance during this and the ensuing PPNB phase.[2]

In spite of expected regional cultural variations, the Levant is marked by economic shifts of widespread similarity during the PPNB (*ca.* 9,500 - 8,000 B.P.) (see Moore 1985). As global warming continued, mobile hunter-gatherer adaptations were replaced by fully sedentary village life and a reliance on cultivated plants, mainly cereals and legumes, some of which were domesticated (Bar-Yosef and Kislev 1989; Zohary 1989; Sauer 1993). Current research suggests that initially there was a diversified subsistence strategy combining hunting, the exploitation of both wild and, perhaps, cultivated plant species, and, possibly, animal husbandry (Clutton-Brock 1979; Hecker 1982; Köhler-Rollefson *et al.* 1988, 1993; Becker 1991; Köhler-Rollefson 1989; Kislev 1992; Rollefson *et al.* 1992; Zohary 1992; *cf.* Hole 1984). Important botanical analyses by Kislev (1992) argued for a relatively late date (possibly 8,900 - 8,600 B.P.) for full domestication of cereal grains in the Levant.[3] This view is supported by actualistic studies of sickle blade glossing patterns and their relationship to harvesting behavior during the Neolithic (Quintero *et al.* 1997). The amount of time needed for the preceding developmental process is not clear, however, so that reliance on wild plant species and/or cultigens may have been long-lasting.[4] Gradually an agrarian economy and domestication of selected animal species, notably goats and sheep, prevailed over the use of wild species. As seen from Levantine data, widespread sedentism, population increases, and the proliferation of ever-expanding villages ensued (see Gebel 1984,1996; Moore 1985; Nissen *et al.* 1987, 1991; Rollefson 1987b, 1989b, 1996; Gebel *et al.* 1988). These events continued throughout the Middle PPNB (MPPNB) so that ultimately in the Late PPNB (LPPNB) a few townsites, such as ‘Ain Ghazal, Basta, and Wadi Shu‘eib in Jordan, and Beisamoun in Israel became extremely large "central settlements."[5]

These well-known developments often overshadow the concomitant technologies that

---

[1] Archaeological studies of diffusion are inherently handicapped by sampling biases and a general lack of chronologic refinement, so that such studies are best viewed with caution. For the current research, the occurrence and direction of possible diffusion is irrelevant.

[2] Kuijt and Goring-Morris (2002) suggested the following scheme of updated Cal.^{14}C years B.P. that accommodates more recent data and better definition of the early PPNB: EPPNB, 10,500 - 10,100; MPPNB, 10,100 - 9,250; LPPNB, 9,250 - 8,700; PPNC, 8,600 - 8,250.

[3] Tanno and Wilcox (2006) assessed archaeological botanical remains from several major Levantine sites and concluded that the domestication of cereal grasses was a long process, which took about a thousand years for completion, a view that supports Kislev's earlier work.

[4] Interestingly, well-preserved, desiccated acorns of tabor oak (*Quercus ithaburensis*) were discovered in the late PPNB deposits of Nahal Hemar Cave (Kislev 1988) in the Judean Desert, 80 km from the nearest known Neolithic range of the species, providing strong evidence that acorns continued to be exploited as an important resource in some localities during latter portions of the PPNB.

[5] See, for example, the many articles in *Central Settlements in Neolithic Jordan* (Bienert *et al.* 2004), and the final report of investigations at Wadi Shu‘eib (Simmons *et al.* 2001).

supported them, and that appeared over a broad area from Anatolia southward through the Levant. Of note was the development of a diverse, blade-based industry, the crucial element of which was the bidirectional opposed-platform naviform core. The PPNB is characterized by a proliferation of blade tools, such as sickle blades, projectile points, knives, and burins, all made from blades that were struck from naviform cores. The use of the naviform core is a unique occurrence in Neolithic developments in the Levant, and predominated within a fairly restricted period. Hence, the naviform core is considered a type specimen, or index fossil, for the PPNB.

The end of the Pre-Pottery Neolithic (*ca.* 8,000 - 7,700 B.P.) is traditionally characterized as a period of accelerated environmental degradation and aridity during which economic instability forced the abandonment of the southern Levant (Perrot 1968; Moore 1973, 1982, 1983). The degree to which human activities such as deforestation, overgrazing, and other cultural practices may have exacerbated an ecological crisis is a matter of some debate (Köhler-Rollefson 1988; Rollefson and Köhler-Rollefson 1989, 1993; Goldberg and Bar-Yosef 1990; Rossignol-Strick 1993; Rollefson 1996). However, the suggested hiatus at the end of the Pre-Pottery Neolithic is now at least partially discounted by a newly defined transitional phase designated the PPNC (Rollefson 1990a). Instead of complete abandonment of the region, it appears that economic instability led to population dispersal and resettlement in smaller hamlets, or in a few well-situated large towns such as ‘Ain Ghazal. In this manner, many Neolithic settlements were deserted as populations shifted to regions of more favorable moisture, such as near the Mediterranean Coast and in higher elevations of Jordan, Syria, and Lebanon (Gopher 1993; Gopher and Gophna 1993; Rollefson and Köhler-Rollefson 1993; Rollefson 1996).

Many researchers also propose that a new settlement and subsistence pattern developed involving both village farming and nomadic pastoralism (Rollefson and Köhler-Rollefson 1989; Ducos 1993; Gopher and Gophna 1993; Goring-Morris 1993; Perrot 1993; Garrard *et al.* 1994; Rollefson 1996).[1] While the mix of these two strategies may have varied from place to place, it seems likely that this pattern emerged during the PPNC as a response to environmental and ecological uncertainty, and that it continued during the ensuing Pottery Neolithic. In general terms, the PPNC is noted for its insubstantial architecture (in comparison to the PPNB), and for less formally ritualized burial practices. In technological terms, the PPNC lithic economy is not yet well defined, but the phase seems to reflect basic changes in the production of stone tools so that blade production declined and flake industries became dominant.

POTTERY NEOLITHIC

Environmental conditions during the long interval of the Pottery Neolithic (*ca.* 7,500 - 6,000 B.P.) are not well understood. However, the climate is thought to have been more favorable than during the PPNC, and there is some indication that temperatures fluctuated with marked seasonal extremes (i.e., hotter summers than today, and cooler, possibly wetter, winters) (Luz 1982; Van Zeist and Bottema 1982; Van Zeist 1985; COHMAP Members 1988; Goldberg and Bar-Yosef 1990; Rossignol-Strick 1993). The Pottery Neolithic encompasses a number of regional expressions that appear to represent discrete cultural adjustments to slightly improved environmental conditions (Stekelis 1972; Moore 1973, 1982; Garfinkel 1993; Gopher 1993; Gopher and Gophna 1993; Goring-Morris 1993; Kafafi 1993; Rollefson 1993). In the southern

[1] In fact, this ancient dual pattern of *the Desert and the Sown* appears to have its origin in the LPPNB-PPNC and has persisted to the present day (*cf.* Köhler-Rollefson 1992; Quintero *et al.* 2004).

Levant the Yarmoukian cultural adjustment included reoccupation of territory that formerly was abandoned but again became habitable, especially with more diversified economic strategies. Many Pottery Neolithic settlements appear to have been located in well-watered areas where plant cultivation was possible. In contrast to the large Pre-Pottery Neolithic towns, most Pottery Neolithic settlements were small, consisting of hamlets of semi-subterranean dwellings and insubstantial structures. Domesticated sheep, goats, pigs, and possibly cattle became common resources in the Pottery Neolithic, and it is likely that seasonal nomadism was a major aspect of the subsistence strategy of the time (Köhler-Rollefson 1988, 1989; Köhler-Rollefson *et al.* 1988, 1993; Rollefson *et al.* 1992).

The Pottery Neolithic is notable for the development of ceramics and for flint industries that are markedly different from those of the Pre-Pottery Neolithic period. The lithic economy reflects a strong emphasis on flake production from numerous types of flake cores. Flake tools, especially awls and borers, are common. The Pottery Neolithic is also noted for the appearance of small arrow points made from flakes and blade segments, and for short, notched or strongly denticulated, sickle blade elements that are often truncated, heavily backed, and pressure-flaked (Cauvin 1968; Contenson 1971, 1993; Stekelis 1972; Crowfoot Payne 1983; Garfinkel 1993; Gopher and Gophna 1993; Kafafi 1993; Rollefson 1993). While blades and blade tools are present in PN sites, evidence for the production of blades, and for the reduction of naviform cores during this period appears scanty and problematic.

Chapter 3

ANALYTICAL METHODS AND THEIR HISTORY

The research documented here employs an unconventional methodology, one intended to augment those that currently typify Near Eastern research. Since the major concern is the evolution of Neolithic flaked-stone tool economies as revealed by technological processes of tool-stone acquisition and reduction, the approach is necessarily a systemic one (after Clarke 1978), and the concept of an artifact "use-life" with varying stages of acquisition, production and alteration, and a depositional history is an important consideration (Schiffer 1976, 1987). The approach is also functional in that it seeks to understand technologically functional types of artifacts and processes (such as resource procurement, and core-manufacturing strategies), and their economic roles during the various occupations of the Neolithic community. A basic tenet of this study is that, while the lithic economy may be only a small portion of the overall economy, it nonetheless may speak to the capacity of the community for a particular degree of complexity or type of economic organization (*contra* Speth 1988: 69),[1] even though it may not make explicit statements about the nature of other aspects of the economy. Consequently, a processual, technological analysis of stone-tool manufacturing is a valid means of understanding the changing organizational framework of 'Ain Ghazal's economy during its occupational phases, since the town both supported and required specific lithic technologies during its evolution.

While studies of this nature are at present uncommon in Levantine Neolithic research, interest in the organizational structure of early Neolithic towns is longstanding. Fundamental and lasting concepts of Neolithic economic organization were formed by V.G. Childe's (1951: 72-82) consideration of modes of production during the "Neolithic Revolution," in which he proposed the existence of economically autonomous villages with unspecialized, household level, craft production. Similar perceptions were offered by Redman (1978), as mentioned earlier. There is, of course, ample modern precedent for economic assessments of lithic technological systems. General treatises exploring this subject include edited volumes of case studies concerned with methodology, such as Schild (1980b), Johnson and Morrow (1987), Torrence (1989), and Montet-White and Holen (1991), and economic overviews like those by Brumfiel and Earle (1987), and Nelson (1991). Pertinent more focused discussions include Parry and Kelly's consideration of expedient core technologies (1987), and J. Clark and Parry's (1990) reconsideration of the development of specialized economies. Processual studies of lithic economic systems address a broadly international subject matter, such as Maya lithic economies (*e.g.,* Sheets 1975; Shafer and Hester 1983; J. Clark 1986a, 1987; Hester and Shafer 1994; King and Potter 1994), the economic organization of bead-drill manufacturing in prehistoric North American cultures (Pitzer *et al.* 1974; Prentice 1983; Arnold 1985, 1987; Yerkes 1989), craft specialization for the production of blades during the Balkan Chalcolithic (Evans 1973, 1978), and the organization of Neolithic stone (and other) economies in Greece (Perlès 1992).

[1] Speth noted the need for processual studies of lithic technology in order to understand their underlying economic structures; nonetheless, the breadth of behavioral information accessable from such studies, particularly via technological systems analysis, needed further consideration.

Importantly, a number of analyses have been based on technological insights gained from lithic replication experiments (Flenniken 1981; Wilke and Quintero 1994; Quintero and Wilke 1995; J. Clark 1997), so that, while there are many economic analyses of technological systems, technological studies of economic systems are also notable contributions. However, Levantine studies of either orientation are rare.

It is worthwhile to compare the research foci mentioned above with major assessments of Neolithic sites, such as Beidha in Jordan, Jericho in the West Bank, Munhata in Israel, and Byblos in Lebanon. These studies are among the leading Levantine works with extensive and well-documented lithic analyses. As such, they reflect prevailing approaches to lithic analysis in the Levant, and illustrate both the purpose and the confines of their largely typological dispositions. For example, Crowfoot Payne's (1983) analysis of the Jericho assemblage and extensive comparative data resulted in her seminal, descriptive framework of Neolithic cultural sequences. Mortensen (1970) and Cauvin (1968) used similar approaches to evaluate data from their sites, and the study of Munhata by Gopher (1989) generally follows suit, contributing much to the detail and clarity of regional cultural histories. Undoubtedly such research reflects monumental effort and is essential for constructing and refining cultural definitions and chronologies. Nonetheless, it does not, nor is it intended to, address the technological behaviors and processes or the economic structures that created the industries that constitute these data bases. Since differing types of lithic artifacts are commonly used to define cultural entities and to set forth diachronic schemes, it is important to understand the impact that technological factors may have had on the types that shape cultural and chronological definitions (*e.g.*, Dibble 1984, 1987, 1995; Flenniken and Wilke 1989). The implications of these methodological differences require more in-depth discussion.

The following reconsiders the longstanding traditional framework that has guided lithic studies in the Near East and assesses some recent analytical methods, including those used here, that are particularly fruitful in providing reasoned interpretations of technological behaviors. The capacity of these approaches to address problems concerning Neolithic stone technologies and their relationship to the broader patterns of socioeconomic development in Neolithic cultures is explored. The larger issue has historical familiarity, i.e., the merits of processual *versus* descriptivist archaeology; the second matter is less well known and concerns the value of replicative systems analysis as opposed to the French *chaîne opératoire*.

HISTORICAL FRAMEWORK OF NEAR EASTERN RESEARCH

In a practical sense, lithic technologists, like most archaeologists, have a straightforward problem, to maneuver from the data, or facts of the archaeological record, to convincing statements (i.e., interpretations) about prehistoric behavior. While the primary goal may be quite clear (for instance, a reasoned understanding of the structure and organization of past lithic industries), it is well known that the method of obtaining the goal is often elusive and likely to be preconfigured by various biases that direct the path of inquiry (*cf.* Kuhn 1962; Binford and Sabloff 1982; G. Clark 1993). Diverse paradigms tend to result in diverse conceptual frameworks, methodologies, and, indeed, in diverse goals. For this reason, it is important to understand both the Old World and New World paradigms that direct Near Eastern lithic research.

Near Eastern prehistoric archaeology has a lengthy historical connection to Old World European, particularly French, systems of inquiry, such that the French school has been the major paradigm in Near Eastern research for several decades (*cf.* Audouze and Leroi-Gourhan 1981; Sackett 1981, 1991; Binford and Sabloff 1982; G. Clark 1991, 1993). The traditional approach, clearly molded by François Bordes, continues to guide Near Eastern researchers from many countries, including those of the "Bordesian" school in the New World (*e.g.*, Kenyon 1957; Braidwood and Braidwood 1960; Kirkbride 1966; Perrot 1968; Mortensen 1970; Contenson 1971; Stekelis 1972; Lechevallier 1978; Jelinek 1981; Moore 1982; Redman 1982; Hole 1983; Byrd 1988; Copeland 1989; Gopher 1989). Its descriptive-classificatory analyses are historically connected to studies of the European Paleolithic (*e.g.*, Sonneville-Bordes 1954; Bordes 1961b; Brézillon 1983; see also Audouze and Leroi-Gourhan 1981; Sackett 1981, 1991; G. Clark 1991, 1993).

While not strictly adhered to by some modern researchers, of note is the general perception of archaeological cultures as the remains of discrete ethnic or cultural groups that are constant in time and space (Sackett 1981; Bar-Yosef 1991b; G. Clark 1991, 1993; for applications see Sonneville-Bordes 1954; Bordes 1961a, 1973; Bar-Yosef 1991a). In terms of their lithic inventories, cultural entities are manifested archaeologically by patterned groups of artifacts that are derived primarily from descriptive, morphological typologies of formal tool types (*e.g.*, Perrot 1952, 1968; Kenyon 1957; Bordes 1961b; Mortensen 1970; Stekelis 1972; Tixier 1974; Moore 1982; Brézillon 1983; Crowfoot Payne 1983). Artifacts generally are viewed as static forms in that variations in their morphologies are interpreted as distinct regional variants, or *faciès*, of a parent cultural tradition. *Fossiles directeurs* are used in conjunction with cultural trait lists to trace cultural traditions and chronological periods. Alternative causes of variation, such as technological constraints on form, or artifact use-life trajectories, generally are uncommon considerations.

Hence, the prevailing methodology emphasizes the construction of comparative, descriptive taxonomies that frame culture histories, what Sackett termed "schemes of time-space systematics" (1981: 87). Changes that occur in archaeological assemblages tend to be construed as the result of migrations of peoples or diffusions of traits rather than as the consequence of technological processes, differences in site function, or of internal social or economic evolution (see, for example, Perrot 1968; Bordes 1973; Cauvin and Cauvin 1993; Cauvin 1994). As Binford and Sabloff noted of the effects of Old World systematics,

> Here we see very different cultures living side by side in the same regions, characterized by a lack of geographical continuity sometimes described as "parallel phyla." We see a past where tenaciously unchanging cultures replace one another in confusing historical patterns within a similar region, and a lack of temporal continuity described as "alternating industries." (1982: 145)

> If "la méthode Bordes" is followed rigorously, it absolutely prevents us from ever seeing any organizational facts about past systems beyond those which may be manifest within a single occupation or a single level at a site. (1982: 146)

While it should be pointed out that there are numerous regional cultural syntheses, many of which reflect a broad ecological orientation that incorporates, for instance, paleoenvironmental and settlement distribution data (*e.g.*, Henry 1983, 1989a; Solecki and Solecki 1983; Moore 1985; Goring-Morris 1987; Rollefson 1992; Bar-Yosef and Belfer-Cohen 1989a, 1989b, 1992;

Rollefson and Köhler-Rollefson 1989, 1993; Goldberg and Bar-Yosef 1990; Gopher and Gophna 1993; Gopher 1994), clearly the prevailing paradigm has not fostered studies of technological processes, or broad issues concerning the nature of lithic economic structures or interpretations of their evolution. Traditional Old World systematics remains, as Sackett pointedly observed,

> . . . grounded in extreme positivism and uninformed by any larger agenda. . . . Its reification of stone tools and industries as active agents in their own right might suggest an attempt to imbue them with meaning. But in fact they act only within the narrow confines of taxonomic schemes. . . . Such reification actually serves to abrogate the need to refer them in any systematic fashion to a paleoethnological domain that would provide them with meaning in some broad sense. (1991: 136)

In such a system, the path of inquiry leads fairly directly to typological classifications of lithic artifacts that describe assemblage character, and frame an ethnic reality for archaeological cultures. Generally lacking are technological studies of lithic tool production and use, lithic economic organization (including resource procurement), intersite functional variation and intrasite activities, regional patterns of the organization of lithic economies, etc. In short, interpretations of many archaeological patterns of past behaviors have seldom been issues for study.

It is apparent that the traditional focus of Near Eastern lithic research is somewhat parallel to that of American archaeology prior to the 1960s in that both have descriptivist, classificatory methodologies and rely primarily on numerical attribute analyses and typologies to frame cultural chronologies (what is sometimes good-naturedly termed a "measure-mentalist" stance).[1] As American post-1960 archaeology was restructured by researchers like Clarke (*e.g.*, 1978), Binford (*e.g.*, 1962), and Schiffer (*e.g.*, 1976, 1987), a similar school developed in the Old World due primarily to the influence of Leroi-Gourhan and Lemmonnier who advocated the retrieval of behavioral information from "ethnographic digging" (Audouze and Leroi-Gourhan 1981: 175), or analyses of spatial distribution, and from detection of patterns of actions, or "gestures," (Audouze and Leroi-Gourhan 1981: 172; see also Lemmonnier 1983; Leroi-Gourhan 1993; Sellet 1993) representing discrete activities. The American school has flourished, replacing, albeit somewhat tentatively at times, the old paradigm with concerns about cultural processes and behavioral systems. In the main, Near Eastern archaeologists have held to descriptivist archaeology, the now-famous function-verses-culture debate of Binford and Bordes still exemplifying the disparate orientations of the two schools (*cf.* Binford 1968; Binford 1973; Bordes 1973, 1981; also see Rigaud 1978; Valla 1995: 185).

NEW DIRECTIONS IN LITHIC RESEARCH

Several recent events have simultaneously occurred and encouraged lithic research in a new direction. "New archaeology" methods are inexorably impacting the insular, Old World tradition in Near Eastern research, so that concerns are expressed more frequently about site formation processes and the importance of addressing more encompassing anthropological issues (*e.g.*, Bar-Yosef 1991a, 1991b). In 1981, Sabloff offered the insights below to members of the American Schools of Oriental Research:

[1] H.G. Gebel, personal communication 1992.

> How can archaeologists convert the static archaeological record of today into knowledge of the dynamic conditions that helped produce the record? Only after the archaeological record is given dynamic meaning can archaeologists proceed rigorously to test hypotheses about human behavior and culture change through time and space. (1981: 3)

> If the traditional Old World concerns with technique and method could be wedded to the new theoretical and methodological structure currently being built by some “new archaeologists,” the completion of this task may become a realistic possibility. (1981: 5)

Coincidentally, a small number of behaviorally oriented lithic studies, primarily conducted in the Negev and in Jordan, also encouraged new inferential directions. Of note are technological assessments of lithic reduction sequences (*e.g.*, Marks and Volkman 1983; Volkman 1983; Dibble 1984, 1987; Wilke and Quintero 1994; Quintero and Wilke 1995), debitage and tool production (*e.g.*, Marks and Kaufman 1983), intrasite patterning and formation processes (*e.g.*, Coinman *et al.* 1989; Barton and G. Clark 1993), settlement distributions (*e.g.*, Garrard *et al.* 1985; G. Clark *et al.* 1987; Henry 1989b; G. Clark 1992; Rollefson 1992; Schuldenrein and G. Clark 1994), and raw material acquisition strategies (*e.g.*, Taute 1994; Quintero and Wilke 1995; Quintero 1996). Extensive studies of Neolithic Near Eastern obsidian trade must be acknowledged here (*e.g.*, Renfrew and Dixon 1977). Perhaps because of these events, and certainly because of influence from the budding French behavioralist school (Audouze and Leroi-Gourhan 1981), concern has grown among some Near Eastern researchers that descriptive typologies alone are not adequate analytical tools. It has become increasingly apparent that analyses are confounded by typological ambiguity. As Mueller-Wille and Dickson noted (1991: 52),

> . . . typologies are mixtures of morphological, functional, stylistic, and what might be called ‘lateral recycling’ (after Dibble 1987) attributes . . . . Since it cannot partition sources of variation, such a mixture renders any analysis based on it impossible to interpret.

In recognition of the need to develop a basic technological foundation for lithic studies, new approaches are beginning to be used to infer meaning and behavior from lithic industries. Researchers from both the Old and New Worlds, comprising a new empirical school, are concentrating on analyses of the technological systems that structure lithic industries.[1] A major analytical tool used for this endeavor is replicative experimentation. This is the methodological framework used in the current study.

TECHNOLOGICAL SYSTEMS ANALYSES

Most researchers would agree with Mueller-Wille and Dickson’s (1991: 51) statement that “while we are past the point of purely descriptive lithic analyses . . . simply substituting function for culture to account for variability is equally perilous.” Without realistic perceptions of technological processes, the behavioral implications of technology are not accessible and there can be no clear understanding of how technological constraints affected the archaeological

[1] This awareness is an important aspect of a recent international movement to restructure Neolithic research in the Near East. The first Workshop on PPN Chipped Lithic Industries held in Berlin in 1993 (with subsequent meetings and workshops in Poland, Italy, Turkey, France, and England) framed as an important goal the promotion of technological analyses of lithic assemblages as fundamental to sound interpretations and explanations of archaeological data.

record. For this reason, there is increasing realization that experimental replication of ancient lithic industries is essential to establish a fundamental technological base for processual analyses (*e.g.*, Jochim 1989: 111). As Mueller-Wille and Dickson (1991: 52) observed, "strictly 'technical' lithic studies are also needed to provide solid inferences on behavior." Acknowledging this premise, analyses of technological systems have three major goals: (1) to understand past lithic industries and their concomitant behaviors as technological systems; (2) to elucidate the economic role of technology within the greater cultural system and to account for change in this role; and, (3) to delimit strictly technological parameters of lithic industries in order that nontechnological behaviors, such as those related to cultural traditions, style, etc., can be isolated and studied.

Behavioral Background

For these reasons, interpretations of technological behaviors have high priority. The influence of both the Old World and New World behavioralist paradigms are keenly important here. Especially significant in France is the authority of Leroi-Gourhan (Perlès 1991) who prescribed the strength and supremacy of technological explanation:

> Technological explanation had to be given greater importance than social or religious explanations because the probability [of it being correct] was higher and because mechanical contingencies and technological determinism were easier to detect (Audouze and Leroi-Gourhan 1981: 172).

The technological determinism of Leroi-Gourhan parallels the views of Schiffer (1974); both recognize the analytical power of behavioral correlations based on the mechanical constraints of technology. Schiffer's now-famous behavioral systems analyses and lithic use-life trajectories (1976, 1987) are echoed by Leroi-Gourhan's operational chains, or *chaînes opératoires* (*e.g.*, 1993; see also Lemmonnier 1983; Pelegrin *et al.* 1988; Sellet 1993). Both are heuristic devices that present technological schemata, or simplified models of processes, so that the dynamic nature of a technology is reduced into sequential stages or actions. These stages are generally depicted with flow-chart models that organize technological processes into meaningful, although generalized, behaviors. The approaches differ, however, in two fundamental ways (see Sellet 1993). First, Schiffer's (1976: 42-57) use-life models essentially are theoretical constructs devised to explain complex processes of industrial behavior. Consequently, they promote fluid modeling of lithic economic organization and its dynamic transformations from one state to another, for instance, from resource procurement, through tool production, use and maintenance, modification and reuse, lateral recycling into new tool forms, etc., and finally, discard. Processual lithic studies within this domain that rely on replicative experimentation are also referred to as replicative systems analyses (Flenniken 1981). *Chaînes opératoires*, as applied to modern lithic studies, are broader conceptual devices used to depict normative technological stages and tend to be less dynamic conceptually than use-life models.

Secondly, an essential element incorporated into use of *chaînes opératoires* is the researcher's assessment of the cognitive system that framed the technological one. Thus, the *chaîne opératoire* not only characterizes the general technological system, but it incorporates inferences of "the detailed intentions exhibited by the prehistoric worker, his mental patterns and preferred ways of doing things" (Pelegrin *et al.* 1988: 56; also see Pelegrin 1985, 1990, 1991a; Binder and Perlès 1990; Perlès 1991). Ideally, *chaînes opératoires* are devised to expose the mind of the stone-worker, to reveal intentionality as well as technological choices. Researchers also strive to understand the hierarchical structure of goals and purposes, of cultural as well as individual preferences that motivated the flint-knapper's actions. Most processual archaeologists would argue that the many technological behaviors and choices, as well as the expanded aims mentioned above, become most evident during the course of replicative systems analyses, which are intimately tied to the actual process of creating stone tools. This is a pragmatic view based on the known dynamic nature of working stone, a view that fosters a realistic appraisal of the human and cultural attributes of lithic technologies.

Replication-Based Analogies

A fundamental analytical tool for both replicative analyses and *chaînes opératoires* is experimental replication of lithic technologies via stone-working (or flint-knapping). Both aspects of the new empirical school rely on analogies produced by replicative studies to understand production processes, their economic structure, and underlying behaviors. Thus, experimental replication is seen as the key to behavioral inferences. The strength of its ability to lead to valid interpretations resides in what Binford called "actualistic studies" (1981: 32; *e.g.*, Ingersoll *et al.* 1977), and upon experiential analogies.

> Since the only access a researcher has to dynamics is through contemporary experience, all research directed toward . . . inferences about the past must be conducted with documented dynamic situations generally in the present. Such knowledge of "connections" between statics and dynamics must derive from experimental research conducted with documented living systems . . . or where the relevant dynamics may be replicated (experimental archaeology). (Binford 1981: 27, 32)

The strength of analogies based on lithic replication warrants further discussion. Wylie's "source and subject-side strategies" for establishing the relevance and effectiveness of analogies serves well here (1985: 100-105). The inferential strength of an analogy resides in the relevance of the "principles of connection" between the source (in this case, stone-working replication), and the subject (here, the archaeological technology). The principles of connection between modern stone-working experimentation on the one hand, and past replicated technologies on the other hand are well established. Because variability is highly constrained by (1) the mechanical properties of lithic reduction, (2) physical and chemical properties of stone, and by (3) biological and physical characteristics of people, the probability of a correct interpretation of a technological process is thought to be very good (Schiffer 1974; Bradley and Giria 1996).

These connecting principles are assumed to be valid, indeed powerful, hence past researchers alluded to "technological determinism" (Audouze and Leroi-Gourhan 1981; Leroi-Gourhan 1993) and to "correlation laws" of lithic replication (Schiffer 1974). But it was Binford who pointed out that strong connecting principles are so because of their uniformitarian nature (1977b, 1981). They obtained in the past in the same way that they obtain in the present. In the case of lithic replication experiments, the connecting principles are so strongly uniformitarian, so predictable and constraining, that the degree of accuracy of the analogy is extremely high.

According to Wylie (1985), the strength of an analogy can be increased if the goodness of fit between the source and subject behaviors is expanded, and if the base of interpretation is broadened. Lithic replication satisfies these criteria as it requires constant reference to the archaeological data to adjust techniques and strategies in an effort to duplicate archaeological technologies. Additionally, core reconstructions (or refitting studies) of both the archaeological and replicated material are essential aspects of analyses. An important precept is that modern stone-workers must understand the broad scope of technological knowledge of past artisans by constant experimentation with every possible type of knapping strategy. In this way, the base of interpretation is not constrained by provincialism, the accuracy of inferences is increased, and the strength of the analogy is enhanced.

Replicative Analyses and *Chaînes Opératoires*

In spite of its clear interpretive potential and the utility of replication-based analysis for constructing middle-range theory, its application in the Near East is very recent and far from extensive.[1] The two distinct methods discussed above, *chaînes opératoires* and replicative analyses, evolved along divergent paths. Both approaches are firmly grounded in long histories of stone-working studies, essentially stemming from the flint-knapping traditions of François Bordes and Jacques Tixier in France, and of Don Crabtree in the United States (Crabtree 1968, 1972, 1982; Bordes and Crabtree 1969; Tixier 1974; Tixier *et al.* 1980; also see Johnson 1978). However, the implementation of these traditions is quite different.

Because of the extreme reductionism of the schemata of *chaînes opératoires*, the intricacies of stone-knapping processes and their variability are not central issues. The research goal is a broad model that depicts technologically relevant shifts along a behavioral chain, so that the primary considerations may be, for example, lithic resource acquisition and the general reduction stages present in an assemblage. Hence, researchers do not necessarily need stone-working experience or expertise to evaluate data once a general technological framework derived from replicative experimentation is devised. Such a technological framework exists in literary works like *Préhistoire de la Pierre Taillée I: Terminologie et Technologie* by Tixier *et al.* (1980), and *Technology of Knapped Stone* by Inizan *et al.* (1992). The *chaîne opératoire* method, therefore, is widely accessible to lithic analysts who may do little or no actual stone-working, but may rely instead on the expertise of others, and on core refitting and microwear studies. Clearly, many works of such scholars provide valuable insights about past technological behaviors. Without question, *chaînes opératoires* have the greater influence on Near Eastern archaeology, and the method is increasingly used.

Replicative analyses, on the other hand, are more comprehensive analytical processes that are designed to reveal not only the broad, normative, economic stages of a technology but also its inherent variability and dynamic character. Thus they require flint-knapping skills in order to reconstruct entire stone-working procedures, including sources of variation that may be due, for instance, to the use of diverse resources and knapping strategies, to production errors, to core-maintenance procedures, etc. It is assumed that the more closely an archaeological technology is duplicated, the greater the interpretive value of the analysis. Clearly, the investment in research time to gain flint-knapping expertise and to replicate a technology can be great. This fact undoubtedly impedes easy access to the method and hinders its use by many researchers.[2] While

---

[1] In fact, the advantages of replication-based analogies for constructing middle-range theory is overlooked occasionally in New World research as well, as this quote from Mueller-Wille and Dickson reveals:

> Interpretation of lithic data in explicating past behavior has been noticeably less advanced than that of environmental or faunal studies, in part because . . . the causes of artifact variability are not understood, and in part because the middle range theory that would allow the transformation of artifact variability into patterns of behavior remains relatively rudimentary. (1991: 51)

[2] Flint-knapping skills are costly to obtain, requiring extensive time and experience, just as most specialized skills do. However, this fact should not hinder use of experimental replication as a standard aspect of ordinary analyses, nor should it preclude recognition of its value as an analytical method (see Odell *et al.* 1996: 380-381). Lithic collections simply require specialized analyses, just as faunal and fiber studies generally do.

replicative analysis has greater acceptance in Scandinavia and the United States, its application to Near Eastern lithic research is very recent and modest. Nonetheless, its greater interpretive potential is demonstrated by the following examples.

Functional Studies

Analyses of artifact function are relatively few, but they tend to consider broad categories of artifacts, are rarely site-specific, and often involve extensive behavioral inferences. For instance, current research addresses the analytical difficulties of sickle-blade classifications in the Levant. Many sickle blades that are commonly found in Pottery Neolithic deposits are small blade segments that are strikingly serrated and bifacially pressure flaked, thus contrasting markedly with the large, modestly retouched Pre-Pottery Neolithic sickle blades of the previous period. Microwear analyses by Cauvin (1968) and others suggested that Pottery Neolithic blades were serrated because they were used as reed harvesting knives rather than for reaping cereal grasses, yet their exclusive appearance in the Pottery Neolithic is unexplained. Also puzzling was the perceived shortage of sickle-blades during the later Pre-Pottery Neolithic at some sites, a period of increasing reliance on domesticated cereals. Recent replicative studies of the lithic economies of the two periods and of the harvesting performances of disparate sickle-blade types support behavioral explanations for these patterns. It appears likely that many Pre-Pottery Neolithic blades of poor quality were scavenged by Pottery Neolithic flint-workers from these older deposits, and that these required extensive retouching to create usable, serrated, tool elements. This behavioral adaptation accommodated changes in the supporting economic structure of Neolithic villages. Further analyses demonstrated that many sickle blades were present in later Pre-Pottery Neolithic assemblages, but were not being recognized as such because their use-life trajectories and the physical characters of the domesticated cereal grasses that they harvested had not allowed them to develop diagnostic glossing from reaping (Quintero *et al.* 1997).

Experimental replication studies of Neolithic technologies are needed to address other typological problems and functional ambiguities.[1] For instance, we lack comprehensive studies of use-wear and breakage patterns, and the effects of resharpening and retooling on the classification of Neolithic projectile points. Currently, projectile point typologies are a main source of cultural and chronological differentiations in Near Eastern research (*e.g.*, Gopher 1994). The inferential value of replicative experimentation is illustrated by the well-known assessment of Upper Paleolithic stone artifacts from Ksar ‘Akil in Lebanon. Replication and experimentation were used to evaluate the functional classification of pointed blades as projectile points. It was concluded that impact-breakage patterns were present on these pointed blades, thereby supporting the interpretation that they indeed were used as projectiles points (Bergman and Newcomer 1983). The behavioral implications of this study are noteworthy as they relate to the evolution of cognitive and psychomotor abilities of fossil hominids, hominid hunting and gathering strategies, as well as to the appearance of technological innovations. Undeniable, empirical evaluations of artifacts and their assumed functions must precede assessments of meaning. Replicative analyses have the capability to address these concerns and resolve contradictory interpretations.

[1] Technological studies of this nature, including replicative experimentation, are just being conducted. Noteworthy are the works of Smith (*e.g.*, 2007) and Sayej (2004) concerning functional ambiguities of certain tool types in early Neolithic assemblages.

Technological Studies

Chaînes opératoires and replicative analyses offer alternative approaches to technological evaluations of site assemblages. Both can promote broad-spectrum assessments of economic strategies, as well as of intra-site patterning and the determination of site function. However, it is significant that the majority of *chaîne opératoire* studies to date address small, Upper Paleolithic and Epipaleolithic sites, rather than the larger, stratified Neolithic deposits. Quite possibly this predilection exists because small, single-component sites with well-defined subassemblages facilitate both core-refitting studies, which are more commonly used than replicative studies, and broad definitions of technological stages (*e.g.*, Bar-Yosef 1991a, 1991c; Phillips 1991).[1]

When *chaînes opératoires* are used to analyze the complex technologies of immense, stratified Neolithic townsites, interpretations are inhibited by the complexity of the data base. Refittable core reductions are nearly impossible to discover; consequently, technological and distributional patterning is elusive. In addition, technological processes are difficult to perceive without comprehensive replication studies; yet, few researchers have stone-working skills. As a result, analyses are likely to be based only on published manuals of standardized, technological typologies and generalized perceptions of lithic reduction strategies. *Chaînes opératoires* conceptualize general core-reduction sequences, but details of production strategies and the causes of variability often are misconstrued or are not considered. The view of technological economies that results is static and incomplete, and lacks the underlying behaviors and the rationales that created the industries and that structured the economies. In addition, comprehensive economic studies generally are lacking. The following are notable examples.

Naviform core-and-blade technology was the basis of the production of blade-tools in the early Neolithic of the Levant. Therefore, it is a major focus of technological studies. Three *chaînes opératoires* have been devised by various researchers and each illustrates significant interpretive issues that can arise from the *chaîne opératoire* method. Suzuki and Akazawa (1971), and Nishiaki (1994)[2] analyzed naviform core-and-blade industries from the Palmyria Basin in Syria, and suggested a stylized core-reduction strategy to account for the peculiar twisted form of the cores and blades. They proposed that these features represented cultural preferences in blade production, even though twisted blades were less useful as tool blanks than the straight blades that typify naviform-core technology elsewhere. Alternative interpretations that rely on replicative analyses suggest that the twisted shapes of cores and blades originated from unusual knapping procedures, specifically from knapping errors that produced canted core platforms. The slanted platforms, in turn, required unusual recovery strategies to produce blades. Such work resembles the efforts of inexperienced flint-knappers, which often can be found where practice knapping occurred (Wilke and Quintero, work in progress; *cf.* Johnson 1979; Cross 1983). These observations suggest that ordinary differences in flint-knapping skills should be expected as normal sources of technological variation in archaeological assemblages. Issues such as these also attest to the necessity of using stone-working experiments to address stone-working problems.

Naviform core-and-blade assemblages from Mureybet and the Neolithic site of Qdeir 1, both in Syria, were studied by Calley who proposed on the basis of her *chaîne opératoire* that regional

---

[1] While it does not deal with Near Eastern data, *chaîne opératoire* of a Late Paleolithic site in Bosnia by Montet-White (1988) is noteworthy.

[2] Also see the more recent expanded version of this research (Nishiaki 2000).

variations in core form were "cultural features" that represented "desertic faciès" of Neolithic cultural traditions (1984, 1986a, 1986b: 49). Replicative analyses have demonstrated (Wilke and Quintero 1994) that such variation often results simply from diverse knapping strategies and skill levels that accommodated different configurations of raw material, and thus are just as likely to result from technological constraints and behavioral limitations as from cultural traditions.

Finally, an interesting analysis of naviform core-and-blade assemblages found in sites along the Middle Euphrates (Abbès 1994; personal communication, Jalès, France, 1995)[1] presented an extensive *chaîne opératoire* in which the entire core reduction sequence was structured to produce a single primary goal, projectile-point blanks. Detachment of these blanks left their imprints (negative detachments scars) on the centers of core faces as the final detachments. Projectile-point blanks were proposed as the most desirable product and the most difficult products to produce, and hence the focus of core reductions. This view was not consistent with replicative analyses of naviform core-and-blade assemblages from Jordan (Wilke and Quintero 1994) that demonstrated both the ease of producing projectile-point blanks, and that the high occurrence of point blank negatives on core faces was likely to have been technologically determined, an artifact of a logical reduction sequence rather than an indication of their cultural value.[2] It is apparent from many archaeological collections that Neolithic stone-workers used a variety of knapping strategies to produce a wide array of desirable tool-blank forms, which were then fashioned into diverse tools. Before presumptions of difficulty and interpretations of cultural "value" are proposed we need to establish the basic technological constraints that formed an industry, and the pragmatic reasons behind the choices that were made. These data need to be empirically derived. Only then can we understand and appreciate purely cultural factors, like cultural traditions, mental templates, and style.

Economic Organization: Problems and Potential

A few *chaîne opératoire* studies and replicative analyses have yielded broadly construed assessments of technological systems and patterns of socioeconomic organization. This final discussion explores the significance of these studies and their interpretive capabilities.

Knowledge of technological strategies, such as techniques of flaking stone, can promote significant behavioral inferences. A focus of considerable research effort throughout the Near East is the evolution of pressure-blade production (Inizan 1991), and the relationship of this technology to the development of complex socioeconomic organization. It is generally accepted that pressure-blade production required a high degree of skill, and in some cases the technology required specialists and a socioeconomic structure that supported craft specialization (Crabtree 1968; Inizan and Lechevallier 1985, 1990; J. Clark 1986a, 1987; Inizan 1991). Near Eastern research has identified Neolithic microblade and large pressure-blade production in vast portions of northern and eastern Mesopotamia,[3] but it is not clear what the associated economic structures were.

[1] Also see Abbès (2003).

[2] The logical sequence of blade product removals took the blades from the sides of the core first to preserve curvature in the core face, then the center blank was removal, usually a point blank. In the last series of blade removals, this sequence of removals would tend to leave a point blank as the last blade detached prior to core exhaustion.

[3] *E.g.*, at Çatal Hüyük (Bialor 1962), Çayönü (Redman 1982), Ali Kosh and Chagha Sefid (Hole *et al.* 1969; Hole 1977), Jarmo (Hole 1983), Sarab (Hole 1994), and Karim Shahir (Howe 1983). For an overview and technological consideration of microblade production see Wilke (1996).

In order to address these issues, Inizan and Lechevallier (1985, 1990) conducted an intersite diachronic study of pressure-blade production in Baluchistan that bears on similar technological developments in the northern and eastern margins of the Near East. Their *chaînes opératoires* depicted the technological and economic organization that possibly occurred at the Mehrgarh locality from the Neolithic through the Bronze Age, and at several other Neolithic, Chalcolithic, and Bronze Age sites near the Indus Valley. Using debitage analyses and resource acquisition studies, they presented an evolutionary scheme suggesting the development of craft specialization that culminated with full-time specialization in the Bronze Age. They proposed further that a regionally diverse, Bronze Age economic structure supported lithic specialists and a large-scale distribution system coincident with urbanization.

This broadly conceived analysis is noteworthy in that it gave clear evidence for specialized, pressure-blade production within the framework of urbanization. This research would be enhanced by consideration of the concomitant organization of the lithic economy, the technological and socioeconomic significance of pressure blades that also appear throughout the preceding Neolithic and Chalcolithic periods (i.e., whether craft specialization also occurred earlier or if there was an incipient phase of craft specialization), or possible associations between these industries and those of the Bronze Age, etc. This work would substantiate the evolutionary framework and explain the developmental process; and, it could be addressed with a processual study of the lithic economies that included replication of the pressure-blade industries involved. Such an analysis has the capacity to reveal the requisite skills that were needed for blade production, the character of the individual industries, as well as the economic organizations necessary to maintain the technologies (J. Clark 1987; Wilke and Quintero 1994; Quintero and Wilke 1995).

It is clear from these examples that while *chaînes opératoires* and replicative analyses derived from similar behavioral orientations and often have similar intents, their frames of reference, methodological orientations, and approaches may be quite dissimilar. *Chaînes opératoires* appear most successful when used to interpret broad technological patterns and, in conjunction with micro-wear and refitting studies, the function and organizational structure of small sites. The reductionist framework of the method seems to preclude the interpretation of complex behaviors. While problems dealing with culture change may be addressed, as in the analysis of the development of pressure-blade production, interpretations tend not to be finely configured. Hence, the relationship of technological systems to overlying cultural frameworks is less likely to be considered. On the other hand, replicative systems analyses can have greater interpretive value, both because of the strength of their analogical connection to past technological behaviors and because of their more encompassing behavioral orientation.

SUMMARY REMARKS ON NEAR EASTERN METHODOLOGIES

In light of the above discussion, it is pertinent to consider the intentions and directions of lithic research in the Levant, as well as this research. The cultural-historical approach is a dominant, strongly supported analytical paradigm in Old World Near Eastern research because it does its job. It allows accurate descriptions of archaeological patterning that define assemblage characteristics, archaeological cultures, and their related chronologies. It does not divulge meaning, cultural processes, or “real behavior” in the “new archaeology,” processual sense of these terms. But it never was intended to do so. It would be a mistake, therefore, to conclude that it is not a successful paradigm; it simply does not take current research where many people want to go.

The rather newly implemented, empirically based focus discussed here clearly addresses a different type of archaeological question, and, in spite of its general state of infancy, it is encouraging more behaviorally-oriented studies. In this vein, replicative analyses have the capacity to provide sound insights on, for instance, technological systems, socioeconomic organizations, chronological changes in technological strategies, and so on. Of course, they can also be used to frame comparative culture-histories. It is especially important to appreciate that replicative analyses are firmly rooted to the reality of "hard-core" technology, and that this fact provides a very secure inferential base. Thus, the replicative method has valuable interpretive capacity.

Near Eastern lithic research is gradually shifting to a broader consideration of behavioral issues, and dealing with increasingly complicated concerns about human adaptations. Lithic replication studies, like ethnoarchaeological studies and other actualistic approaches (*e.g.*, Gould 1977), have the potential to be valuable analytical tools that allow the construction of middle-range theory as researchers proceed from the data to reasoned assessments of meaning and to reasonable interpretations. Clearly, replicative analyses have the capacity to effect significant changes in the direction of archaeological research and in our perception of the past. The research presented here is offered as an example, certainly not a perfect one but a sincere one nonetheless, of the value of this approach for addressing some of our current problems.

Chapter 4

RESEARCH OVERVIEW, IMPLEMENTATION, AND DATABASE

INTRODUCTION

Reconstructing the nature of stone-tool economies at ʻAin Ghazal and why the community came to depend on, and then ceased using, naviform core technology requires a consideration of two kinds of information. It is necessary to understand first the technological composition of the core-reduction industries and the related behaviors that each required. The second consideration is the associated organizational structure of the lithic economies. Although unrelated to the Levantine Neolithic, a considerable literature on various topics of this nature has been generated in recent years. Much of this research has been concerned with refining either our understanding of the technological behaviors that created individual industries (*e.g.*, Kelterborn 1981; Ohnuma and Bergman 1988; Pelegrin 1991b; Wilke 1996), or our perceptions of sociocultural circumstances that relate to particular economic adaptations, such as the development of specialized production economies and their variable contexts (*e.g.*, Evans 1973, 1978; Brumfiel and Earle 1987; J. Clark and Parry 1990; Costin 1991; Fowler 1991; Rice 1991; Cross 1993). Our first interest here is to combine these fields of inquiry, using lithic replication experiments as an analytical foundation, so that both classes of information are of benefit. In this regard, this project profited from a rich history of Polish investigations of flint mining and of blade-producing economies in Eastern Europe,[1] and from recent studies of Maya lithic technologies (*e.g.*, J. Clark 1986a, 1987, 1997; J. Clark and Parry 1990; J. Clark and Bryant 1997).

A further objective is to establish a procedural framework that leads to a comparison of lithic economic behavior during idealized points in time, primarily the PPNB and the Early PN, realizing that there was a developmental continuum, or gradual (?) evolution in lithic tool-production behaviors during more than 2,200 years. The subtle variations within the lithic economies along this continuum are undoubtedly many, but currently are inaccessible since an intricate, phase description of these events requires finely configured provenience assessments that are not yet available. Data are sufficient, however, to make comparisons of the larger, generalized periods, and to consider the trend of lithic production from the middle PPNB (MPPNB) through the early PN occupations. The data base for this study was selected accordingly, and is discussed below. The analysis is composed of interconnected levels of inquiry, all of which bear on the organization of lithic economies as revealed by the technological nature of tool-production industries. Each of these foci is introduced below and is examined in the appropriate chapters that follow.

[1] Of note are the proceedings of the several European International Flint Symposia, in particular the VIIth International Flint Symposium, Warsaw, 1995, Institute of Archaeology and Ethnology, Polish Academy of Sciences, *Archaeologia Polona* 33. Also see, Cahiers du Quarternaire 17, *Le Silex de sa Genèse à l'Outil*, Actes du Vth Colloque International sur le Silex, 1990.

ECONOMIC ORGANIZATION

Archeological research exploring economic organizational schemes, or "modes of production," commonly has focused on understanding expressions of specialized, as opposed to generalized, economies. Recent research (*e.g.,* Brumfiel and Earle 1987; J. Clark and Parry 1990; Costin 1991; Kenoyer *et al.* 1991) has pointed out that these dichotomous structures represent opposite ends of an organizational continuum, and that the ethnographic and archaeological records give evidence for an impressive variety of production modes. Nonetheless, efforts to understand economic structures rely on several basic schemes that incorporate these concepts and that have proven useful as heuristic devices. Such economic models, as discussed by Peacock (1981) and Rice (1991) in their studies on the organization of ceramic production, relate well to the needs of lithic research and portions of these models were used here.[1] These basic modes of production organization are (1) generalized household production, (2) household industries, or cottage industries, (3) workshop industries, and (4) nucleated workshops.[2] These modes are characterized in the following manner:

1. *Generalized*, or *unspecialized*, household production equates with autonomous tool production whereby each household takes care of its own tool needs. Some exchange of tools may occur as gifts or luxury items, but basic economic needs are met by family members.
2. *Household industries*, or *cottage industries* (*e.g.*, Prentice 1983: 18-19) rely on "part-time production-for-trade at the home level." They reflect specialized production in that part-time craftspersons supply products to nonhousehold members in exchange for necessary goods.
3. Workshop industries also rely on part-time craft specialization, but the organizational effort is more extensive than above, and entails the use of established workshops.
4. Nucleated workshops reflect full-time craft specialization and extensive organization of production that may entail nonlocal distribution networks.

The degree of economic commitment of specialists also is relevant.[3] J. Clark and Parry's (1990) ethnographic survey suggests that the occurrence of full-time specialists is linked to a variety of complex economic systems (for instance, those with a standard medium of exchange), but it is not apparent in less complex societies using simple economic systems.[4] In these latter cases, where specialization is present it is on a part-time basis and specialists retain a primary economic investment in subsistence activities.

Identifying the presence or absence of the modes of production discussed above in past cultural situations relies fundamentally on a clear perception of craft specialization and its archaeological correlates.

---

[1] Those economic systems pertaining solely to complex socioeconomic situations that relate to the development of urban societies are not particularly useful for the present discussion and are not considered.

[2] Both Peacock and Rice used more complex categories than are employed here since they were investigating more complex economic situations.

[3] The concepts of "independent" and "attached" specialists have sparked much discussion in recent literature (*e.g.*, Brumfiel and Earle 1987; Costin 1991; J. Clark 1995), but are not germane to this analysis since the concern here is with the origin of specialization rather than differentiation of degrees of complexity. It is assumed that specialists within this context would be independent artisans and not attached to some elite entity.

[4] Cobb (1996: 262) maintained that enough variability is evident in ethnographic examples to suggest that even small-scale societies might have had full-time specialization in the production of *staple* goods as well as prestige items. Nonetheless, he offered no supportive data for consideration.

Socioeconomic Conditions of Craft Specialization

Initial Concepts

The development of craft specialization is generally considered dependent upon a number of socioeconomic and technological conditions that most often are linked to politically complex, stratified societies (Cobb 1993; *e.g.*, Evans 1978; Michaels 1989). In the Near East, this association was proposed by early generalized discussions and syntheses, principally by Childe (1951) and expanded later by proposals of Redman (1978), that conceptualized craft specialization as an aspect of early market economies within urbanized environments. Ample research has documented this pattern and demonstrated that specialization of lithic economies was likely, for instance at Uruk-period sites such as Abu Salabikh in Iraq (Pope and Pollock 1995), at third-millennium B.C. sites in Turkey (Wattenmaker 1994), during the Early Bronze Age in the Levant (Rosen 1986, 1989), and at Balkan (Evans 1973, 1978) and Levantine sites (Rosen 1986) during the Chalcolithic. In most of these cases, specialization of lithic economies is thought to have been supported by an organizational framework that included an agricultural base with surpluses of goods, extensive distribution networks, and mechanisms for collecting and dispersing surpluses and manufactured products, as Redman's (1978: 216) model suggested.

Such associations may well characterize fully developed forms of craft specialization within urban settings, but are less likely to be appropriate for understanding economic organization in other situations, as in nonstratified societies where economies may have included part-time specialists, or when specialization first originated in its incipient phase. Several recent works and syntheses also have demonstrated that a variety of forms of craft specialization have existed in diverse socioeconomic situations in the past (Brumfiel and Earle 1987; J. Clark and Parry 1990; Costin 1991; J. Clark 1995), including those of small-scale societies (*e.g.*, Cross 1993; Cobb 1996). Importantly, craft specialization is now more broadly conceived so that the once-assumed exclusive connection to sociopolitical complexity has been challenged. As Cobb noted (1993), craft specialization is no longer seen to have a linear relationship to political complexity. Where correlations between specialization and political complexity occur, they relate to the industrial era. Consequently, the exclusive link between craft specialization and complex societies is no longer held valid by most researchers. Even Childe (1951) and Redman (1983) speculated that part-time specialization may have been an aspect of earlier, perhaps even Neolithic, economies that, presumably, retained household-level economies as well.

Levantine Framework

Emphasis in the current study is placed on the specific circumstances that likely fostered an initial form of specialization, a form that may have evolved within the context of nonstratified sociopolitical systems in these first Neolithic villages, perhaps as a part-time economic endeavor. Such a framework currently is viewed as probable for the Levantine PPNB and other areas of the Near East (Bar-Yosef and Belfer-Cohen 1989b, 1992; Rollefson 1989a; Voigt 1990; Byrd 1994; Gebel 1994,1996),[1] although data admittedly are tenuous and the scale of social complexity is far from clear. For instance, evidence exists for Neolithic accounting systems (Schmandt-Besserat 1990), exploitation and long -distance distribution of copper ores (Stech 1990; Hauptmann *et al.*

[1] Perlès (1992) suggested similar developments for Neolithic Greece.

1992), and extensive production of lime plaster for building constructions (Garfinkel 1987; Rollefson 1990b).

While specific documentation and testing often have been lacking, researchers working on Neolithic sites have long suspected that craft specialization may have been a part of some aspects of Neolithic stone-tool economies. Thus, Roodenberg (1986: 204) suggested that stone vessels from Bouqras were constructed by "skillful artisans" who may have used lathes. Kirkbride (1966: 25) described a specialist's bead-production "workshop" at Neolithic Beidha. According to Moore (1982: 15; also see 1981: 452), "an expansion of crafts" took place during the PPNB as specialist craftspeople at Abu Hureyra produced stone ornaments, structural plaster, and white-ware vessels. Finally, Mortensen noted the presence of "workshops" at Neolithic Beidha and suggested that "flint knapping had already become a specialized task by the period of the earliest Neolithic settlements . . . " (1988: 200). It is important to recall, however, that while these impressions of the presence of specialized lithic economies during the Neolithic may well be accurate, they remain essentially untested interpretations that need to be validated.

Current Concepts

Such initial forms of craft specialization are generally conceptualized quite simply as production activities performed on a part-time basis by relatively few individuals for the benefit of the larger population (*cf.* Cross 1993: 65).[1] This basic definition seems appropriate for the present investigation and is used here. Craft specialists are such, then, simply because they do something special for the community that others do not do. It also seems reasonable to suggest that the supporting cultural system that gave rise to an initial form of craft specialization differed markedly from the more complex structures present within contexts of fully developed craft specialization. Rudimentary forms of socioeconomic conditions usually linked to craft specialization may well have been present in the PPNB, however, and may provide circumstantial corroboration of the presence of some form of craft specialization at this time. Early observations by Braidwood are relevant:

> We suspect that the food-producing revolution was dominated by the technologico-economic factor, and especially so at its beginning. But with the establishment and growth of the peasant-village populations, release from continuous food-getting, and the appearance of craft specialization, the other aspects of culture would have undergone gradual change. (1952: 6)

This general evolutionary scenario establishes some primary relationships that are widely accepted. Consequently, a number of elementary socioeconomic conditions have been suggested as necessary for the development of village-based craft specialization (*e.g.*, Evans 1978; Michaels 1989), and are relevant here. The primary one appears to be an environment of demographic and economic growth. In the PPNB this circumstance was manifested by the development of substantial villages and small towns that housed growing populations. An equally important condition for craft specialization (and indeed for the emergence of settled village life) was an increasingly effective subsistence base, such as agriculture, to support sedentary living. This condition was met by the PPNB economy that experienced a growing reliance on crops and domesticated animals.

[1] There are numerous definitions of craft specialization (*e.g.*, Rice 1991; Tosi 1984; J. Clark and Parry 1990; Costin 1991), but all contain the same essential relationships: the production of goods by a few members of the community and exchange of these goods to other nonfamily community members.

Craft specialization is further thought to have arisen in the context of increasing social complexity as marked by role and status differentiation. While it is generally accepted that highly developed craft specialization occurs in the context of highly developed social stratification, these criteria are not applicable to the early Neolithic. Instead, elementary forms of differentiation of roles and social positions were likely to have been present in the PPNB; these may well have encouraged the origins of specialization. Given the wide variety of cultural options, one would expect much variability in the cultural manifestations of role and status differences, and most would leave no archaeological presence. Nonetheless, suggestions of such conditions in reported settlements include differential burial rituals, such as the selective modeling or plastering of skulls to recreate the image of the deceased, as at Jericho (Kenyon 1957; Strouhal 1973), Beisamoun (Ferembach and Lechevallier 1973), Nahal Hemar Cave (Yakar and Hershkovitz 1988), Tell-Ramad (Ferembach 1970), and ‘Ain Ghazal (Simmons *et al.* 1990). Selective decapitation of corpses and differential interment of community members is a relatively common PPNB feature, as noted by different burial treatments for adults and children, caches of skulls, etc., at sites such as ‘Ain Ghazal (Rollefson 1983, 1986; Rollefson and Simmons 1987), Jericho (Kenyon 1957), and Çayönü (M. Özdoğan, personal communication 1993). A further suggestion of selective ritual includes caches of substantial statuary figures, as at ‘Ain Ghazal, which are thought to represent mythical ancestors (Rollefson 1990b: 48-49, also see 1983, 1986; Rollefson and Simmons 1987), or alternatively, actual community members with special roles or status.

Taken together, the data presented above suggest that a socioeconomic environment appropriate for the origins of craft specialization was present during the PPNB. Additionally, technological features that are thought to give evidence for the presence of craft specialization need to be identified.

Technological Evidence of Craft Specialization

Certain technological conditions and characteristics have been used to evaluate lithic industries in other areas for evidence of organizational structures, specifically to identify craft specialization. The most useful of these features are generally thought to include (1) technical difficulty involved in production, (2) a high level of production skill and craftsmanship, (3) the ability to access raw material resources that are difficult or costly to acquire, and (4) the presence of workshops, or specialized work areas (*e.g.*, Evans 1978; Tosi 1984; J. Clark 1986a, 1987; Yerkes 1989). To these conditions Michaels added other common features, such as (5) standardization of the production process, (6) production efficiency, (7) standardization of products, (8) standard production tool kits, and (9) error-reduction strategies (1989: 146; see Cross 1983).[1]

Most of these attributes relate to evidence of specialized production expertise, production efficiency, or uniform manufacturing tactics that produced, either by design or inadvertently, a standardized product. Several presumptions underlie use of these attributes. Essentially, standardization results from a few highly-skilled craftspeople conducting repetitive tasks in the same or similar fashion from like materials. A certain degree of production efficiency is probably inherent in such situations, even when craftspeople produce goods on a part-time basis. I agree with Cobb (1993), however, that motives of profit and efficiency of production, as proposed by Costin (1991), need not be aspects of craft specialization in societies lacking complex socioeconomic structures. Consequently, one would not necessarily expect these traits to be

[1] Also, Rice (1991) and Costin (1986,1991) discussed similar attributes relating to the specialized production of pottery.

instrumental to economic systems where craft specialization originated.

While the applicability of these technological conditions seems sound, the many criteria set forth as indicators of craft specialization undoubtedly are subjective. Individually and collectively, all can characterize craft specialization. Nonetheless, some can as easily be applied to many aspects of lithic technology that do not involve organized craft specialization, such as pressure-flaking arrowheads, percussion-flaking a biface, or reducing a flake core. These tasks merely require a level of skill or proficiency that may and often did exist without craft specialization. Determining which of these two situations is indicated by the data requires broad consideration of the socioeconomic setting, and extensive experience in knapping stone.

Costin (1991: 33-40) quite rightly pointed out, for instance, that standardization and efficiency of production are somewhat difficult to interpret and need careful consideration before specialization may be inferred. It is the case, for instance, that pressure-blade technologies have been linked to craft specialization based on efficiency of stone use ("providing more cutting edge per unit of stone than any other technology"), the "intrinsically standardized" nature of blade products, and the assumption that the skills of a specialist were needed to produce blades. Nonetheless, lithic technologists will agree that blade technologies were not all "created equal" and that they are not inherently specialized. For instance, percussion-bladelet cores were an important technological aspect of the Epipaleolithic in the Levant, yet economic specialization has never been seriously considered for this period. To be sure, sociocultural factors conducive to specialization apparently were not present during this period, but, significantly, reduction of percussion-bladelet cores was neither so efficiently executed that quantities of surplus blades were produced, nor were the products so standardized that craft specialists appeared to have produced them. Perhaps most importantly, reduction of percussion-bladelet cores does not require the skills of specialists.

On the other hand, on the basis of efficiency of production, standardization of products, and requisite core-reduction skills, ample research has demonstrated that Mesoamerican pressure-blades were produced by craft specialists (J. Clark 1987, 1997). The point here is that each technology must be evaluated in terms of both its socioeconomic context, and its technological characteristics and constraints for a valid interpretation of craft specialization to be made. To evaluate one data set and not the other would be an error (*e.g.*, Pope and Pollock 1995). Keeping this caveat in mind, the technological characteristics discussed above were used in conjunction with available socioeconomic data to assess the ʻAin Ghazal lithic assemblages.

ORGANIZATION OF LITHIC ECONOMIES

The organizational structures of the various lithic industries at ʻAin Ghazal relate to a broad array of behaviors. Major issues are the types of lithic economic organizations that were in use during ʻAin Ghazal's occupancy, and whether evidence supports the presence only of unspecialized lithic economies during this lengthy period, as envisioned by Childe (1951) and Redman (1978; but see Redman 1983). Or, conversely, are there data that support the presence of some form of industrial specialization during a portion, or during all, of the time that ʻAin Ghazal was occupied?

The foci of this aspect of the analysis are strategies of tool-stone acquisition that were used during the PPN and PN at ʻAin Ghazal, and the characteristics and distribution of lithic-reduction loci for the production of cores, tool blanks, and tools. Therefore, this aspect of the research addresses intrasite patterning of lithic economic behaviors, and whether or not resources were locally available for community exploitation. It does not consider regional distribution patterns or exchange networks since the data are site specific.

Resource Procurement

Resource procurement strategies were investigated in order to understand the accessibility of tool-stone resources, that is, whether or not stone was locally available, whether stone was quarried or mined, or if raw material had to be transported long distances. A further consideration was the likelihood that a complicated organizational effort was used to obtain stone resources for community use.

Organization of Core-and-Blank Production

The character of debitage concentrations (i.e., cores, core-production and core-reduction debris, and production products such as tool blanks) and the distribution of these loci were studied to determine if they were production loci, and what type of production probably occurred at each locus. These data relate to whether core production and/or core reduction were generalized or specialized activities.

PRODUCTION TECHNOLOGY

The second objective was a technological characterization of core-and-blank production,[1] that is, the strategies that were used and decisions that were made to create the industries. This aspect of the analysis followed commonly used procedures of experimental replication (Crabtree 1968, 1972, 1982; Bordes and Crabtree 1969; Newcomer 1975; Dickson 1977; Flenniken 1981; J. Clark 1982; Callahan 1985; Ohnuma and Bergman 1988; Pelegrin 1991a, 1991b; Wilke and Quintero 1994, 1996; Wilke 1996). Particular emphasis was placed on the nature of the PPNB naviform core-and-blade industry at ‘Ain Ghazal and the technological constraints that structured the production of naviform cores and tool blanks. These data were contrasted with those concerning the production of cores and tool blanks during the PPNC and during the Yarmoukian phase of the Pottery Neolithic period. The major topics and the rationale for their consideration are outlined below.

Resource-Selection Strategies

Tool-stone is chosen to accommodate, among other things, the requirements of a technology and its inherent constraints. Therefore, the attributes of the resources chosen by the flint-knappers at ‘Ain Ghazal were assessed in order to understand the needs and constraints of the technology. Resource-selection options also were considered in an effort to determine the effects of dissimilar resources on modifications in reduction strategies, and how these in turn affected patterns of artifact variability, or standardization in form.

---

[1] Generally speaking, the products of core reduction are blanks that are used for tool production, even though further modification may be only minimal or unnecessary.

Core-and-Blank Production

A technological analysis of core-and-blank production techniques was conducted in the course of this study to examine their basic structures, including, for instance, how cores were produced and reduced, how tool blanks were configured and produced, and causes of variation or standardization in the morphology of the products and in the debitage that was created during the course of production. The technical constraints of the technologies and the level of expertise that they required were also important concerns. All of these factors bear on general modes of production and the necessity, or lack thereof, of special technical skills that the various core-reduction technologies may have entailed.

Tool Production

Tool-production *per se* also may reflect several important aspects of lithic economies, since the tool requirements of the community structured its tool-production endeavors. Consequently, tool assemblages were studied for clues to industrial organization. Technical demands of tool production are also important factors that reflect not only individual production techniques and resulting causes of variation in tool morphology, but more importantly, technical constraints of tool production and degrees of production difficulty. These latter factors relate to the need for specialists to produce tools and reflect the economic organization of tool production.

RESEARCH PROCEDURES

The analysis outlined above involved three general procedures:

1. Technological and economic analyses of tool-stone acquisition techniques;
2. Technological and economic analyses of core production and tool-blank production; and
3. Assessment of technological behaviors at loci of lithic debitage concentrations.

Procedure 1: Resource-Acquisition Analysis

The study of tool-stone acquisition tactics used during ‘Ain Ghazal’s occupation entailed a resource inventory, a geological field survey, and experimentation to determine if heat-treatment of flint was used to process tool-stone during the PPNB.

The first stage of this research was an inventory of the archaeological collection to determine the various types of tool-stone that were selected for use during the several periods of occupation. Next, a field survey was conducted to locate sources of flint that were used at ‘Ain Ghazal, and to understand the underlying organizational efforts that were needed to exploit the resources. At issue was whether flint was locally procured during all or some of the periods of site occupation, or whether it was transported or imported to the site from some distance.

Likewise, it was not clear whether any or all of the lithic economies were locally autonomous, or whether they were part of a larger, regional economic structure. For example, if only local sources of tool-stone were used, and stone was reduced into cores and tools at or near the townsite, then data would support locally-organized, autonomous lithic economies at ‘Ain Ghazal (*e.g.*, J. Clark 1981; Lech 1981, 1987; Fedick 1991; Taute 1994). Conversely, if data support the use of nonlocal raw material, then travel or trade outside of the local area may have been an important part of the lithic economy. In such a case, village economic autonomy during that period of occupation would need to be reconsidered (Hodder and Orton 1976; Renfrew 1977; *e.g.*, Becker 1951; Ginter 1974; Bosch 1979; Budziszewski 1990; Borkowski *et al.* 1991).

Local quarrying of stone would have entailed less complicated organization, less time, and less effort than obtaining stone from a great distance (*e.g.*, Ericson 1982) or extracting flint by mining (*e.g.*, Bosch 1979; Lech 1987; Holgate 1995).[1] Indeed, locally quarried stone could have been acquired by individual stone-knappers for their own use. The degree of task specialization that prevailed, then, is also an issue. For instance, if blade-core flint was not procured locally, or if it required extensive mining, specialized task groups or individuals may have been a necessary part of the Neolithic economy (Bosch 1979; Balcer 1980; Lech 1981; Quintero and Wilke 1995; Quintero 1996). In either case, tool-stone acquisition has bearing on regional economic organizations, as well as on local structures. In addition, understanding changes in the tactics used to procure stone and in the selection of stone resources leads to a broad, diachronic view of the evolving structure of lithic economy at ‘Ain Ghazal and, potentially, at comparable early settlements, such as Jericho, Wadi Shu‘eib, Abu Suwwan, or LPPNB Basta.

Resource Survey

A geologic survey and subsequent analysis of flint acquisition sites were conducted and are discussed in detail in a following chapter. Briefly, preparatory archival and field analyses of the local lithology were conducted in 1992 and 1993, and a final field analysis was undertaken in 1996. Geologic maps and site reports, and initial studies disclosed appropriate geologic deposits (Cretaceous limestone) potentially containing flint in the vicinity of ‘Ain Ghazal. The immediate terrain contained wadi-rolled flints and bedded chert deposits that were suitable for the production of flake-based industries and comparable to stone that was used for flake-core reductions in assemblages from ‘Ain Ghazal. However, since the high-quality flint that was used during the PPN at ‘Ain Ghazal for the production of naviform cores was not located, further field surveying was conducted to search for its sources.

Laboratory Analyses

Flint raw material located during field surveys was compared visually to archaeological lithic samples to evaluate potential sources of ‘Ain Ghazal tool-stone. Ultraviolet light fluorescence (Hofman *et al.* 1991) and visual inspection of stone attributes in normal light were used for lithic sourcing.

A separate laboratory analysis was conducted to determine whether Pre-Pottery Neolithic stone-workers thermally altered their flint to enhance its knapping characteristics. Heat-treatment was a common stone-processing procedure in prehistory (Rick and Chappell 1983) and its use during the Pre-Pottery Neolithic has been posited but not confirmed by others (*e.g.*, Nadel 1989; Bar-Yosef 1991b). This analysis was important for a clear understanding of tool-production processes at ‘Ain Ghazal. In order to test whether flint from PPN contexts at ‘Ain Ghazal was thermally altered, heat-treatment experiments were conducted on archaeological cores and blades, and on freshly quarried flint to determine if such a procedure was used in prehistory, and if so, at what stage of the manufacturing process heat-treatment occurred. Flint for naviform core-

[1] While there is some ambiguity in the use of these terms, the following basic definitions are generally accepted. “Quarrying” refers to obtaining stone that largely is visible as surface exposures or that is readily exposed with little excavation.“Mining” stone requires extensive excavation to expose material that is buried and not easily accessible.

and-blade production could have been thermally altered at various times during the reduction sequence, for instance, at the nodule stage or at the precore stage. It is sometimes feasible to discern heat-treatment that occurred at diverse production stages by the presence of heat-affected surfaces on artifacts (*e.g.*, Johnson 1979: 27), but more accurate determinations generally are possible via reheating tests, as used here. This research is discussed in Chapter 5.

Procedure 2: Technological Analysis of Core-and-Blank Production

Lithic replication experiments were used to ascertain the techniques used for naviform core-and-blade production, for production and reduction of other blade cores, and for flake cores. As discussed above, replication analyses were based on technological and behavioral analogies, and followed longstanding practices used by New World and Old World archaeologists, particularly those of Crabtree (1968, 1972, 1982; see also Bordes and Crabtree 1969).[1]

The analysis involved identification of technologically meaningful artifacts and attributes (such as cores, production and reduction debitage, and manufacturing attributes on tool blanks and tools) in the archaeological collection, and flint-knapping experimentation structured to replicate these data. Using the archaeological data base from ‘Ain Ghazal as a reference, replication of the various stages of lithic manufacturing proceeded until a technologically correct duplicate of the archaeological assemblage was produced, alternative procedures were rejected, and a reasonable analogue of the behavior of Neolithic knappers was established. In this manner, probable production and reduction processes of the various forms of Neolithic blade and flake cores and their products were defined.

Experimental replication was concerned with evaluating past technological behaviors at ‘Ain Ghazal, such as: (1) knappers’ decisions concerning appropriate raw material; (2) various core preparation and reduction tactics; (3) desirable tool-blank characteristics; and, (4) the degree of difficulty of the knapping process. Knowledge of the processes of core-and-blade production allowed recognition of technological byproducts of reduction as a meaningful class of artifacts associated with real human behaviors. Technological and economic constraints of the industries were also made more apparent. A preliminary study of the PPNB naviform-core technology was conducted from 1992 to 1994 (Wilke and Quintero 1994; Quintero and Wilke 1995) and was augmented with data presented below. This research is presented in Chapter 6.

Procedure 3: Analysis of Lithic Debitage Loci

Technological analysis of a sample of lithic debitage loci representing the various periods of ‘Ain Ghazal’s occupational history was undertaken in order to determined their character, that is, whether they were discreet, intact, core-production or core-reduction localities, tool-production loci, or dumping areas for lithic waste. While such loci have commonly been interpreted as flint-knapping areas, their technological origin is rarely assessed. These assemblages have the capacity to disclose the reduction strategies that were used during ‘Ain Ghazal’s occupation. Equally important, their attributes may reveal the nature of the lithic-processing activities that occurred at the townsite, and whether or not core reduction and/or tool production were normal household activities or, possibly, the activities of specialized craftpersons (*e.g.*, Healan *et al.* 1983; J. Clark 1990; Michaels 1989). Chapter 7 details this study.

[1] For a brief history and modern evaluation of this approach, see Johnson (1978) and Yerkes and Kardulias (1993).

DATA BASE

The primary collections for this study were selected portions of the PPN and PN assemblages excavated at the site of ‘Ain Ghazal from 1982 to 1996. Ancillary material assessed for comparative purposes were portions of the Neolithic collections from the sites of Wadi Shu‘eib, Wadi Jilat, ‘Ain Jammam, and Basta (all in Jordan), and a small collection of naviform cores and related debitage from Douara Cave II in the Palmyra Basin in Syria.

This study also profited from very brief examinations of portions of Neolithic collections from PPNA ‘Ain Darat, Netiv Hagdud, and Gilgal I, PPNB Mujahia and Horvat Galil, and Late PN Nahal Zehora II (all in Israel). Additional materials of Epipaleolithic origin were observed in order to assess the technological origins of the naviform core and the technological character of Epipaleolithic industries. These data sets included the extensive Epipaleolithic surface collection of Kharanah IV, in Jordan, portions of Epipaleolithic collections from Poleg 18 and Nahal Hadera V on the coast of Israel, and a variety of small Epipaleolithic sites of various periods in the Negev. Preliminary analyses of the Jordanian and Syrian data were conducted in 1988, 1989, 1992, and 1993. The final stage of this research has been ongoing since 1993.

Study of the ‘Ain Ghazal collection entailed a technological assessment of the core-preparation and reduction approaches used during both Neolithic periods, and an analysis of the manufacturing strategies employed for tool production. These data sets constitute a problem-oriented, nonprobabilistic sample (*e.g.,* Asch 1979) of the technologies and periods in question, and consisted of the following:

1. The collection of cores and formed tools excavated from PPN and PN contexts from the excavation seasons of 1982, 1984 through 1989, 1995, and 1996;
2. A representative sample of LPPNB, PPNC, and PN flaked-stone technology consisting of the debitage, cores, and tools excavated in 1993, 1995, and 1996;
3. A representative sample of MPPNB flaked-stone technology consisting of the debitage, cores, and tools excavated in 1983;
4. A sample of lithic debitage loci that span the PPN and PN occupational sequence at ‘Ain Ghazal; and,
5. A cache of 82 blades recovered from a single MPPNB locus.

The following chapters are comprehensive assessments of these materials.

Chapter 5

‘AIN GHAZAL FLINT RESOURCES AND THE WADI HUWEIJIR FLINT MINES

This chapter reports on flint resources that were used at ‘Ain Ghazal during its lengthy occupation, and details the discovery of Neolithic flint mines near the townsite that were exploited by community members for the production of naviform cores and blades. Results of laboratory examinations of the resource also are presented. These tests include the lithic sourcing techniques that were used to verify the exploitation of the resource for the ‘Ain Ghazal blade industry and heat-treatment experiments to determine whether the archaeological flint had been thermally altered prior to its use. Technological and economic implications of this discovery are addressed in an effort to understand some of the organizational aspects of this portion of the lithic economy during the PPNB occupation of ‘Ain Ghazal.

ARCHAEOLOGICAL BACKGROUND

Pottery Neolithic

The lithic assemblage from ‘Ain Ghazal is typical of the Neolithic pattern in the Southern Levant in that its Pottery Neolithic component is essentially flake-based, that is, there is a decreasing representation of large blade-tools as opposed to tools made on blade segments and flakes, and the debitage is dominated by flake-production debris and flake cores (Gopher 1989; Crowfoot Payne 1983; Gopher and Gophna 1993; Rollefson 1993).[1] These patterns are addressed below, but it is important to note them here, and that stone for flake-core and flake-tool production was obtained from readily accessible local sources. At ‘Ain Ghazal, most of the PN tool-stone is essentially a moderate- to low-quality “flint,” or bedded chert, and is identical to that which underlies portions of the site and forms much of the lithology of the area. In addition, the highly impacted, incipient-cone cortex on many of the better-quality flints that were used as cores and tools suggests that wadi-rolled flint cobbles also were a minor source of PN tool-stone, and that the gravels of the Wadi Zarqa drainage were exploited for resources during this period as well. In keeping with current tendencies in lithic analysis, some would suggest, perhaps, that the PN technology was an expedient core-and-flake-production technology (Binford 1977a; Parry and Kelly 1987) because of the ubiquitous use of local material to produce the characteristically uncomplicated, but varied flake-tool assemblages. These perceptions are discussed at length below, but for the present it is important to contrast these general characteristics of the PN lithic assemblage with those of the PPNB assemblage from ‘Ain Ghazal, which are also typical of many Levantine sites.

[1] It is not the concern of the present discussion to consider regional or phase variations in this pattern, but rather to characterize Pottery Neolithic stone assemblages in a general fashion and to note the trend toward flake-core reduction.

PPNB flint-knappers, on the other hand, were confronted with an additional task, the production of blades for tool blanks, a task that complemented the flake-based industry that also occurred during the PPNB. Production of blades was accomplished largely by the reduction of naviform blade cores. The archaeological record attests to the fact that choosing blade-core flint was a highly selective endeavor; not any flint would do. PPNB blade assemblages throughout the Levant contain a predominance of high-quality flint for the production of naviform cores.[1] It is not surprising, therefore, that replicative experiments have demonstrated that the production of blades from naviform cores required the use of superior stone (Wilke and Quintero 1994). In the southern Levant, PPNB flint-knappers often used an exceptional, highly siliceous, lustrous flint that generally was light brown, but sometimes was red, pink, or purple in color. Most importantly, this flint had excellent knapping qualities, and produced cores and blades of extraordinary quality. What had been most frustrating for technological and economic studies was that the sources of this stone had not been discovered, even though stone of this type was apparently widely used during the PPNB and earlier.[2] Consequently, the methods used for stone acquisition and the organization of tool-stone procurement had remained unknown.

The conspicuous presence of this resource in archaeological collections combined with its unknown origin had prompted two divergent interpretations of techno-economic events that might account for this situation. One proposal was that nonlocal, exotic flint from an unknown source was obtained by PPNB stone-workers for naviform-core production, possibly via trade networks (Bar-Yosef and Belfer-Cohen 1989b; Gopher 1994). The second view was that local flints of a less siliceous nature were heat-treated to improve their quality and alter their color, thereby making them more desirable for core-and-blade production, and tool production (Bar-Yosef 1981; Crowfoot Payne 1983; Gopher 1989). These alternative resource-procurement schemes suggested the presence of the following two opposed economic strategies:

1. Nonlocal flint of exceptional quality was obtained either by direct procurement by members of the PPNB communities, or indirectly by participation in exchange networks. Both possibilities imply a dependence on exotic resources that would have required extensive transportation of large quantities of stone and complicated pragmatic considerations, possibly entailing complex organizational schemes and economic interdependency among communities (Bar-Yosef and Belfer-Cohen 1989b).
2. Local flint was obtained by community stone-workers and technically altered by systematic heat-treatment. This stratagem implied that stone procurement and manipulation were managed within the context of uncomplicated, autonomous, community-based economic systems.

[1] For example, in Israel at Munhata (Gopher 1989), Abu Gosh (Lechevallier 1978), and Jericho (Crowfoot Payne 1983); in Jordan at Beidha (Mortensen 1970), and Wadi Shu‘eib and Abu as-Suwwan (personal observation of author); in Syria at Qdeir 1 (Calley 1986b), Tell Halula (Molist *et al.* 1994), and Dja‘de el Mughara (Coqueugniot 1994). A similar pattern is noted in Anatolia, as at Çayönü (Redman 1982; Caneva *et al.* 1994) and at Aşıklı Höyük (Balkan-Atlı 1994) where obsidian was exploited for the production of naviform cores and blades.

[2] As at Abu Gosh (Lechevallier 1978), Munhata (Gopher 1989; personal observation of author), Jericho (Crowfoot Payne 1983), Abu as-Suwwan (personal observation of author), and Wadi Shu‘eib (Rollefson 1987a; personal observation of author). Such flint has also been observed at PPNA sites, as at Gilgal (Noy *et al.* 1980; and personal observation of author). Pink/purple flint also occasionally was noted in the Acheulian lithic assemblage from Tabun Cave, Israel (personal observation of author).

A research program was devised to explore how these alternative economic behaviors might relate to the PPNB occupations of ‘Ain Ghazal. Comprehensive analysis of the lithic inventory from ‘Ain Ghazal revealed the following basic attributes.

‘AIN GHAZAL DATA

The PPNB assemblage from ‘Ain Ghazal exemplifies the selective exploitation of fine-textured, nodular flint for naviform-core production. This behavior occurred in spite of the fact that no local source of such stone was apparent, and that abundant quantities of lesser-quality flints and bedded cherts were readily available in the local lithic environment. At ‘Ain Ghazal, the bedded chert that underlies the town site was exploited for tough blanks for adzes and axes, bifaces, and for flake-core production during both the Pre-Pottery and the Pottery Neolithic periods. However, it was used only rarely for the production of blade cores, and these generally were single-platform cores of poor quality. It was not used during the PPNB for naviform-core production.

The principal tool-stone for this industry was a fine-grained, nodular flint ranging in color from tan to golden brown, to greens banded with red, to reddish-purple, and pink. The exceptional quality of the flint is evident by its visual characteristics (smooth, waxy texture) and by the high caliber of the cores, blades, and blade-tools that it yielded. Reduction of naviform cores at ‘Ain Ghazal frequently yielded fine, delicate blades with minute platforms. Blade-tool blanks over 14 cm in length are not uncommon.

In addition to the superior quality and unusual color variations of the blade-core flint, the following assemblage characteristics are also noteworthy:

1. Nodular flint was the dominant resource selected for naviform core production.
2. The cortex of the nodules was pristine and smooth, without incipient-cone fractures, suggesting that they were obtained from the parent matrix rather than from wadi gravels.
3. Small, flat nodules constituted the major choice for core production, although larger nodules were used as well.
4. The substantial amount of core-production debitage, spent cores, partially reduced rejects, and lithic waste in the site assemblage suggested that nodules were reduced at the townsite, and were therefore transported from their geologic source to the townsite for reduction.
5. Most expended cores are still quite large, in fact many are still reducible and do not give evidence for extensive “desperation reduction,” implying that an abundant supply of flint was readily available.
6. The luster, texture, and color of the flint suggested, according to existing literature, that thermal alteration may have been used to enhance the quality of the stone.

The above observations implied that nodular flint was quarried, or perhaps mined, from the parent limestone matrix, and that probably there was a large, primary deposit that was sufficiently exposed at one time to allow selective exploitation of nodules by size. The source was thought to be somewhat close to ‘Ain Ghazal and easily accessible in order to allow the easy transportation of large numbers of unreduced nodules to the site. Consequently, a systematic field survey was organized to locate possible sources of this resource in the terrain surrounding the townsite. In addition, because of the possibility that heat had been used to alter the characteristics of the flint, heat-treatment experiments were designed to determine if the archaeological flint had been heat-treated. The procedures that were used and results of the field surveys and of the laboratory research are presented below.

GEOLOGICAL FIELD RESEARCH

As in most areas of the southern Levant, flint of widely varying quality is pervasive in central Jordan. The Jordan rift valley bisects massive, flint-bearing, limestone deposits that must have exposed an abundance of tool-quality stone during the Neolithic.

Wadi-cut terrain on both sides of the Jordan River contains tabular and nodular flints, as well as bedded cherts. These drainages and their associated gravels were particularly fruitful, potential sources of tool-stone during prehistoric times (Bender 1974; Taute 1994), although modern exposures generally reveal only moderate- to poor-quality flints.

Geological Environment

The uplifted Cretaceous limestone of the Jordanian highlands typifies the geologic environment surrounding ‘Ain Ghazal. The site is bisected by the north-south trending Wadi Zarqa and there are also several secondary, neighboring drainages. The wadi topography is marked by steep limestone escarpments that rise *ca.* 75 m above the Zarqa stream channel, and by extensive erosional features, such as carved chalky marls, limestone benches, caverns, and solution caves.

The Upper Cretaceous sediments that underlie the site belong to the Belqa Group that characteristically contains limestone, chalk, and chert deposits (Quennell 1954; Bender 1968, 1974).[1] Erosion of the steep topography has exposed these resources in the immediate vicinity of ‘Ain Ghazal. Based on the carbonate morphology of surface soils, geologic assessment of the Zarqa drainage indicates that the present topographic environment has remained essentially unchanged for at least the past 20,000 years (Mandel and Simmons 1988).

Field Survey

Prior to this research, an archaeological field survey (Simmons and Kafafi 1988) documented an extensive Neolithic presence in an area 8.4 km^2 surrounding the site, principally along the nearby drainages. Additional observations[2] suggested that wadi-rolled cobbles of good-quality flint might be located in the drainages north of the site. These data indicated that a thorough survey for in situ nodular flint in the wadi exposures surrounding ‘Ain Ghazal might be fruitful. Therefore, the initial phase of the survey considered the northern portions of the Wadi Zarqa and a small tributary, Wadi Huweijir, that drains eastward into the Zarqa.

Vehicle and foot surveys were conducted along the wadis Zarqa and Huweijir and their adjacent uplands. Nodular flint deposits were discovered north of the townsite, on the east end of Wadi Huweijir, or “Little Stone Wadi,” where it intersects the Wadi Zarqa (Fig. 5.1) approximately 2 km from ‘Ain Ghazal. Here, seasonal water flows have exposed an extensive section (*ca.* 40 m deep) of the Amman Silicified Limestone (ASL) Formation of the Belqa Group, apparently of Late Cretaceous (Santonian to Campanian) age (Bender 1975). Flat nodules of

---

[1] Modern geological maps for the Amman area are planned by the Natural Resources Authority of Jordan, but these are not yet available.

[2] By D. Olszewski, a member of the survey crew.

remarkably lustrous, high-quality flint of many colors, including pink, reddish-purple, red and green, golden brown, grey, and tan were visible on the talus slopes. In addition, horizontal strata of nodules laced the walls of Wadi Huweijir and its small tributaries, as well as portions of the Wadi Zarqa both north and south of the Wadi Huweijir intersection. The modern exposure of the deposit extends approximately 500 m along the west side of Wadi Zarqa, and on both sides of the Wadi Huweijir and its side channels for nearly 1.5 km (Plate 5.1). Altogether, the currently observable flint deposit encompasses approximately 1.5 km^2 and is the first known source of such stone in the southern Levant (Quintero 1996).

WADI HUWEIJIR MINES

Neolithic exploitation of the deposit was considerable and appears to have involved several strategies.

Seam Mines

The most extensive evidences of flint acquisition are excavations that occur in the sides of Wadi Huweijir that exposed broad strata of flint nodules in a series of linear features exploited as "seam mines", that follow the horizontal layers of flint (Plate 5.2). This strategy created a number of small and large grottos, or rock shelters, that follow distinct flint strata creating shelves or large terraces along the face of the wadi (Plate 5.3).

Mapping and characterization of the northern face of the wadi revealed 10 seam mines along one 100-m section of the drainage. These range in size from 1 m deep by 4 m in length, to over 4 m deep and 30 m in length. Many of these mines still contain nodules in situ and occasional mining detritus (Plate 5.4), and extraction cavities where nodules were removed from the matrix (Plate 5.5).

Exploitation of flint resources by mining seams of nodules in this manner is a common, logical strategy. In steeply cut terrain, such as Wadi Huweijir, this tactic results in linear exposures of flint that are readily accessible along a vertical working face (Fig. 5.2). Such features have been noted in several areas in the Old World; for instance, seam mines frequently were used during the Neolithic in Europe (Schmid 1973) and are well documented in the Neolithic mines at Spiennes in Belgium (Hubert 1978) and at Harrow Hill in Britain (Holgate 1995).

It is significant that numerous barren grottos are also present among the Huweijir mines, and appear to have been either completely exhausted by Neolithic stone-workers, or mined to the point where further exploration was not feasible. Superficially, all of these mines may be confused with natural rock-shelters, and close examination is necessary to determine their cultural origin. Characteristics that aid in their identification are their nearly horizontal ceilings and excavated interiors that cut deeply into the rock creating a rather low, linear morphology that is unlikely to occur naturally. There are also numerous more ambiguous features that appear to be relic seam mines with ceilings that collapsed, apparently in antiquity, and that are now open terraced benches exposed to the vagaries of erosion (Plate 5.6). In addition, overlying rock has fallen into some of the intact excavated mines. Both of these situations suggest that the limestone matrix containing the nodular strata may have been somewhat unstable and dangerous, and that timbers or other shoring may have been used to support the ceilings of the larger excavations.

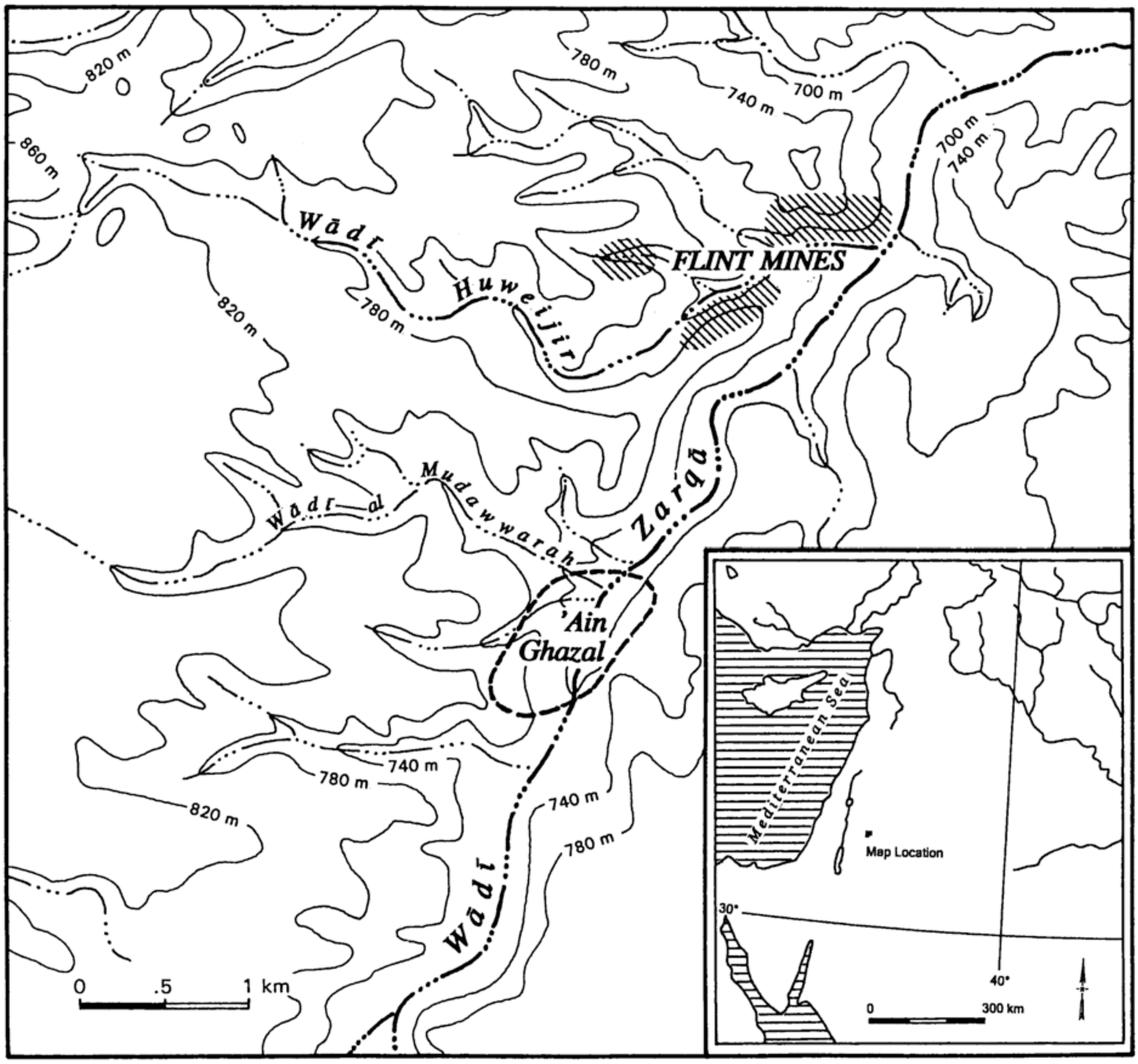


Fig. 5.1. PPNB flint mines located in wadis Huweijir and Zarqa, and their position relative to the site of ‘Ain Ghazal. Note the proximity and easy access to the mines from the Neolithic community.

Plate 5.1. View of the lower course of Wadi Huweijir just above its confluence with Wadi Zarqa, looking southwest. ‘Ain Ghazal is *ca*. 2.5 km south, and is obscured by the hill in the upper left of the photo. Major mined portions of Wadi Huweijir are on south-facing slope at the right edge of the photo.

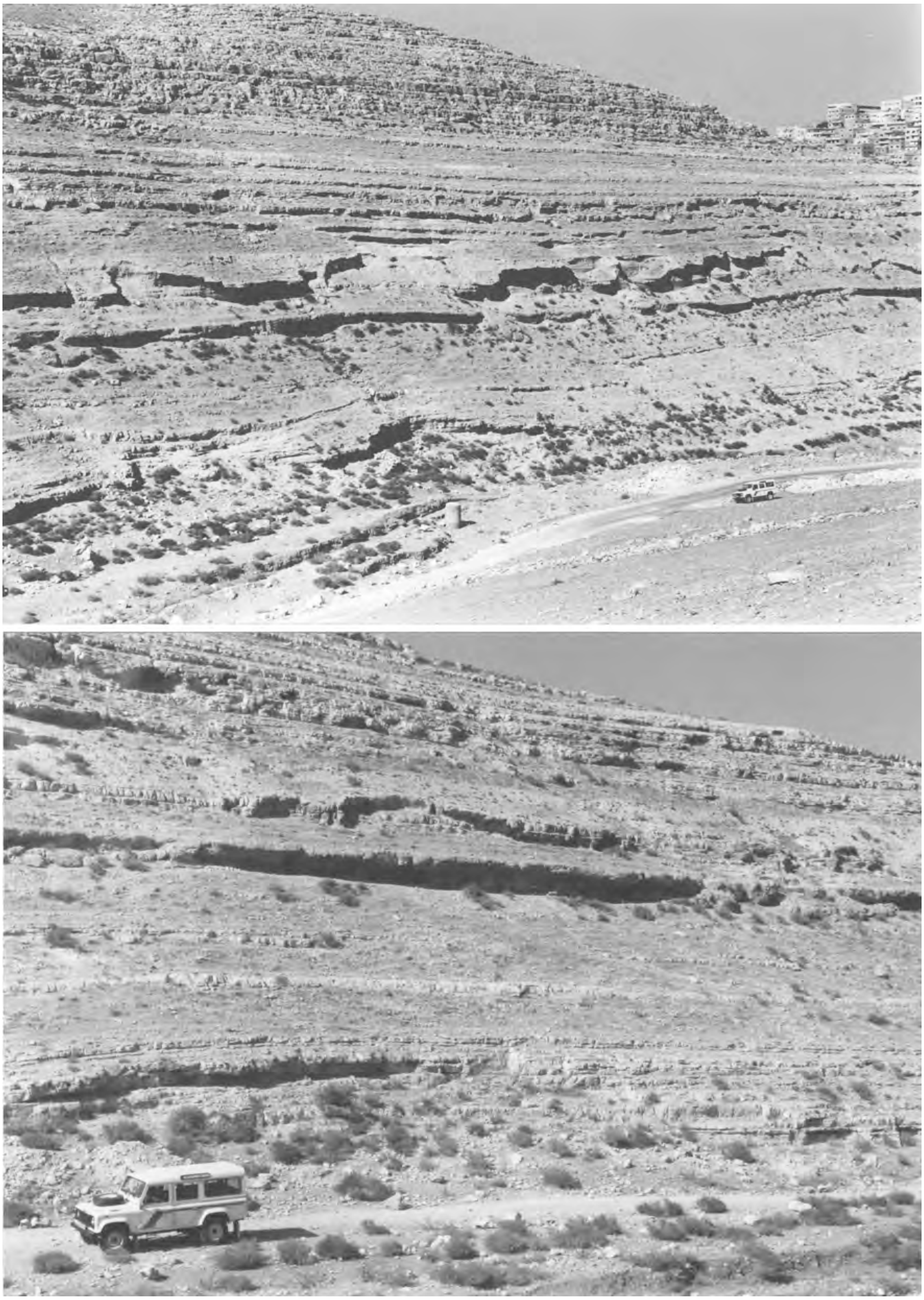


Plate 5.2. View of flint seam mines on the north side of Wadi Huweijir.
upper steep limestone escarpment with numerous horizontal seams of flint and linear mining features.
lower long excavated exposures where Neolithic seam mining occurred.

Plate 5.3. Horizontal seams of flint nodules in limestone matrix.
upper naturally occurring nodules. *lower* seams of flint exposed by Neolithic mining.

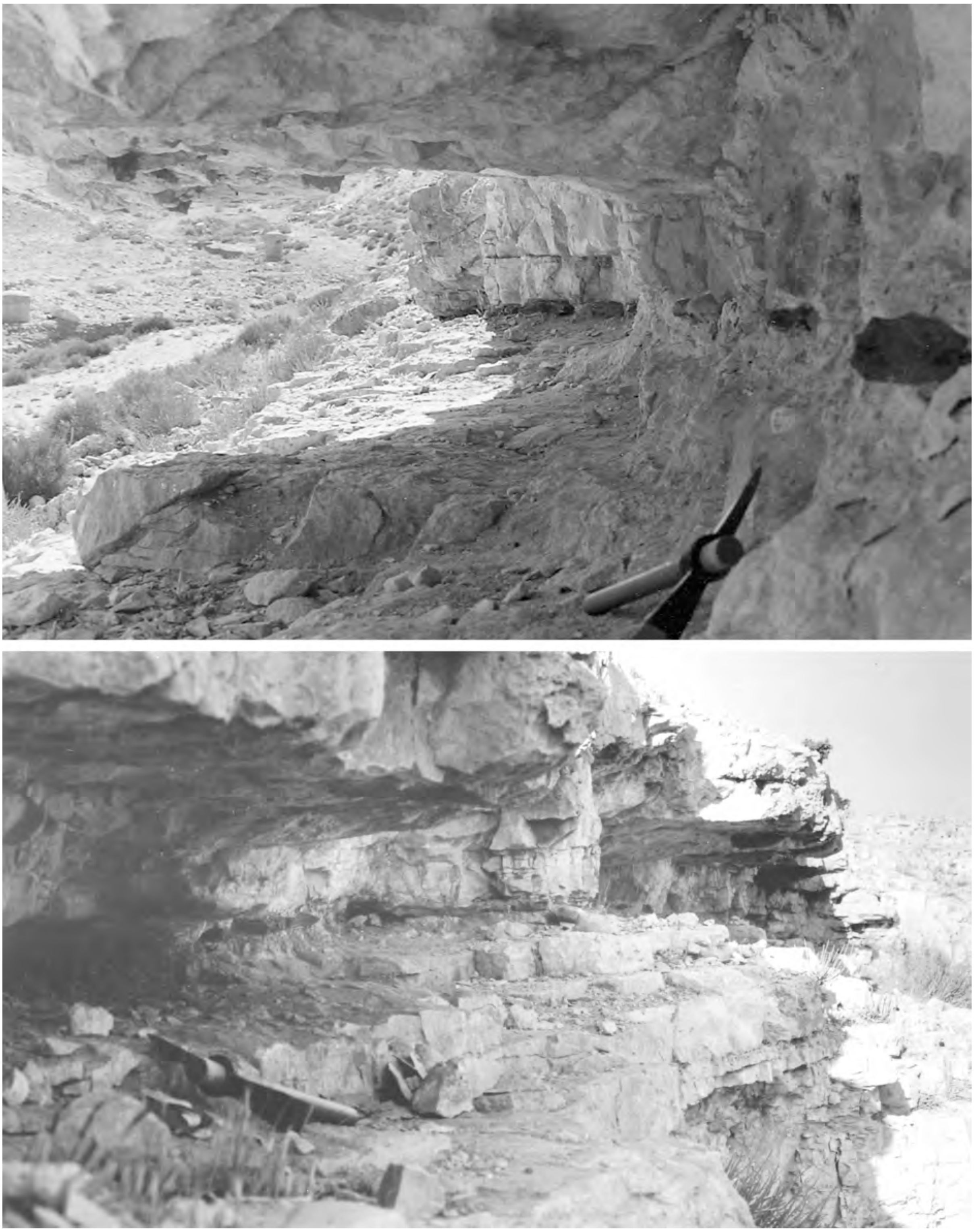


Plate 5.4. Views of seam mines.
upper "grotto" where limestone was removed to expose flint nodules, some of which remain in the back wall. Note the flat ceiling and floor resulting from excavation.
lower long, linear excavation typical of seam mines, with flint nodules in situ in back wall of mine.

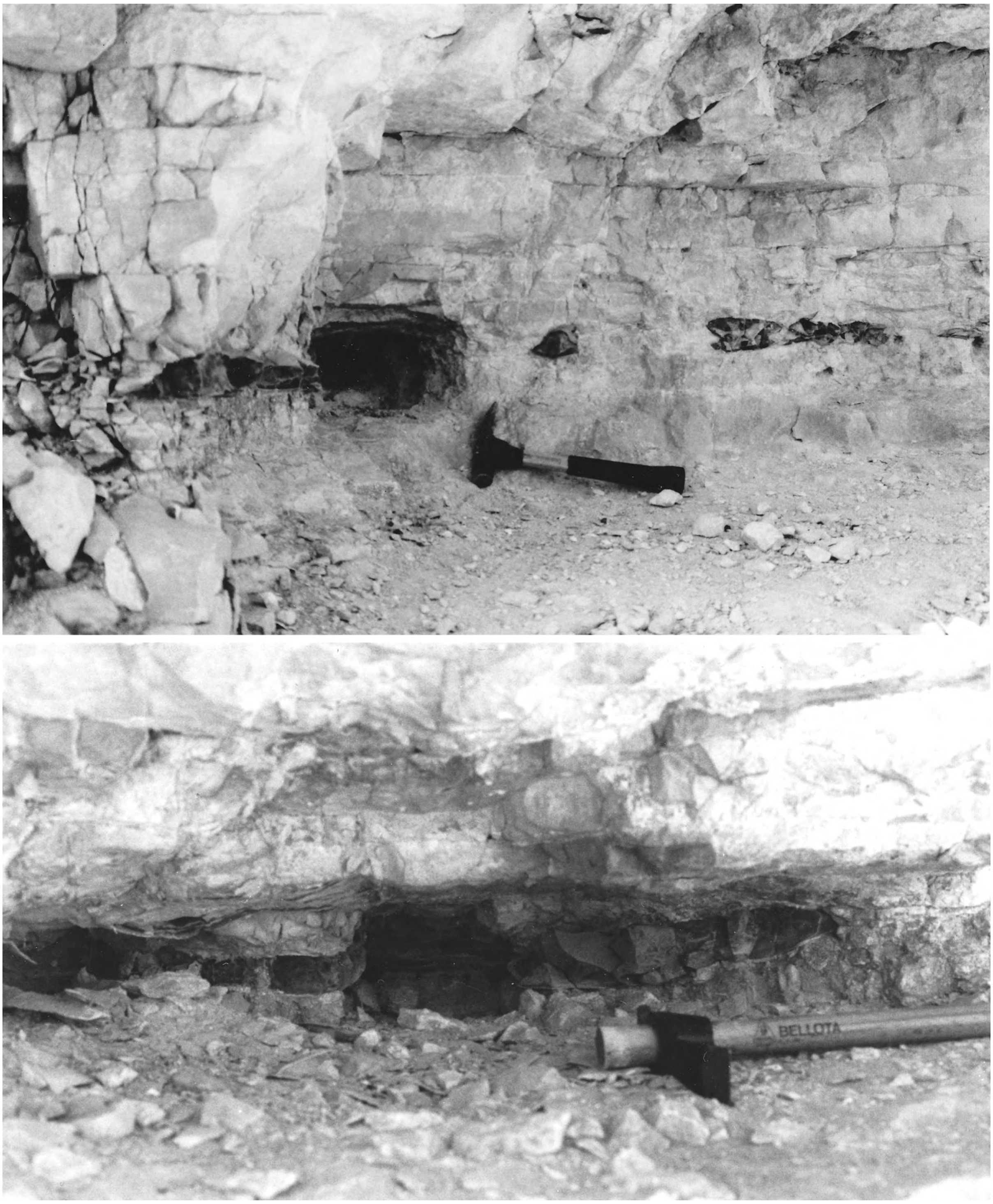


Plate 5.5. Excavated cavities formed by extraction of flint nodules.
upper deep, rectangular hole resulting from successful extraction of nodule.
Marks from chipping away limestone are clearly visible in rim of cavity.
lower unsuccessful attempt to remove nodule from deeply undercut, limestone wall.
Note flint flakes and debris in front of fractured nodule.

Mining Activities

Flint debris both within the grottos and on the talus slopes immediately below the terraces includes archaeological debitage, such as tested nodules, cortical flakes, a small amount of core-production debris, and an occasional aborted, partially formed naviform precore (Plate 5.7). Similar debitage is scattered along the west slope of the Wadi Zarqa, in the bottom of Wadi Huweijir from its confluence with the Wadi Zarqa westward approximately 1.5 km, and along numerous narrow terraces that step up both sides of the wadi. However, there is no evidence of lithic workshop activities, such as extensive core production or reduction, or of living sites at the mining area. This circumstance correlates well with previous observations of obvious preparation and reduction of cores at ‘Ain Ghazal, and supports the interpretation that nodules were mined and tested for quality at the mine site, then transported to the town site for use. Resource procurement without production at a quarry or mine site is not an anomaly, but is an expected behavior when resources are small nodules that are easily transported (Sappington 1984), and when the reduction locality is nearby, as in this case.

While the actual mining practices are implied by the grotto exposures, there is only limited evidence of the process of extraction that was used. Mining tools have not been located at the site. Nonetheless, the lithic assemblage from ‘Ain Ghazal contains bifacially flaked, pick-like artifacts, numerous, heavily battered, spherical flint hammerstones that may have been suitable for mining. Artifacts of this sort are commonly thought to be flint-mining tools and have been found in association with many mines for lithic resources, as at Neolithic mines in the Carpathian Mountains (Valde-Nowak 1995) and various Danubian sites in Poland (Lech 1981), in Italy (Di Lernia *et al.* 1995), and at Grimes Graves in Britian (Holgate 1995) where thousands of antler picks were used for mining flint. At one Neolithic flint mine in the Netherlands, Bosch (1979) and others recovered large quantities of hammerstones and over 15,000 flint-mining axe-heads broken and abandoned in ancient galleries. Antler picks also were found but these were few in number, and were judged to be too weak to mine the tough chalk matrix. Perhaps the lack of bone or antler mining implements in the faunal collection from ‘Ain Ghazal results from similar circumstances. Certainly, wooden gads, or pry bars, and wedges could have been used and would have been particularly useful in extracting nodules from exposed seams and from shallow terrace exposures.

Quarry Terraces

On the north side of Wadi Huweijir, narrow quarrying terraces are very conspicuous and numerous (Plate 5.8), and rest immediately on top of seams of flint that are covered with shallow layers of limestone. The abrupt, sequential terracing and ample debitage argue for the exploitation of these strata of flint by shallow quarrying methods whereby the thin layers of limestone were flaked or pried off of the underlying flint nodules. Several nodules of flint on these terraces were left partially exposed by Neolithic stone-workers who careful chipped away portions of the surrounding limestone matrix (Plate 5.9). Evidence for extensive quarrying in this fashion is circumstantial at present, however, and will have to be evaluated in light of future assessments of natural, geomorphological processes. Extraction of flint in this manner is not well documented, but one terraced quarry with an associated flint pick was located in Italy (Boschian 1995).

Circumstantial data also suggest that nodules were quarried from flint that was naturally exposed in the wadi, since tested nodules, flakes and other debitage are strewn throughout the area on both sides of Wadi Huweijir and in the Wadi Zarqa where there is no evidence of associated mining activities. However, it seems unlikely that blade-core flint would have been systematically obtained in this manner, since such flint undoubtedly would be dry and weather-fractured, and poorly suited for blade production. It is more probable that these residues are detritus left from prospecting for potential mining sites.

Discussion

Following the discovery of the seam mines, additional surveys were conducted of the remaining drainages near ʻAin Ghazal to look for other local sources of blade-core flint, but none were found. While certainly it is possible that other sources of such flint were used in addition to that which was discovered in the Huweijir locality, it is still the case that all of the above data attest to the exploitation of the Wadi Huweijir resource during PPNB times. It is also evident that the archaeological lithic debris and the natural, unaltered flint at the Huweijir mines are identical in luster and color to the flint used by Neolithic stone-workers at ʻAin Ghazal. These data argue that natural, thermally unaltered flint from the Huweijir mines was used by stone-workers from the ʻAin Ghazal community for manufacture of naviform cores and blades.

LABORATORY EXPERIMENTS

The following laboratory analyses provide further data that support the conclusion above, and attest to the common origin of the archaeological flints from PPNB contexts at ʻAin Ghazal and those from the Wadi Huweijir mines.

Ultraviolet Fluorescence Analysis

While accurate sourcing of cherts and flints is generally recognized as a difficult task (Sieveking *et al.* 1972; Aspinall *et al.* 1981; Bar-Yosef 1991a), researchers in the North American Plains currently are having success sourcing widely distributed, Paleoindian artifacts by matching them to voucher specimens of chert and flint using ultraviolet light fluorescence (UVLF). The use of UVLF is a common geological technique for differentiating minerals, and has had extensive modern usage in geochemical explorations for the petroleum industry (Waychunas 1988; Goldberg and Weiner 1989; Brittain 1990). However, its application to archaeological sourcing problems is new and has had remarkable results (Banks 1990). The straightforward and inexpensive procedure uses ultraviolet light to compare the fluorescent properties of cherts and other lithic material from known sources with the fluorescent characteristics of lithic artifacts made of material from unknown sources (Hofman *et al.* 1991). Cherts from identical sources fluoresce identically when exposed to both longwave and shortwave ultraviolet light.

This work is preliminary, but it appears, nonetheless, to offer a reliable, convenient, and economical means of identifying sources of flints when a standard of potential sources is available for comparison. The method relies on variations in fluorescent responses of chert, or flint, to both wave lengths, and requires multiple samples of the resource in order to compensate for inherent variation within a given source or outcrop. This latter constraint is especially important when several sources are known to yield flints with a common set of characteristics. In such cases, sourcing small collections of samples can be difficult (*e.g.*, Hillsman 1991).

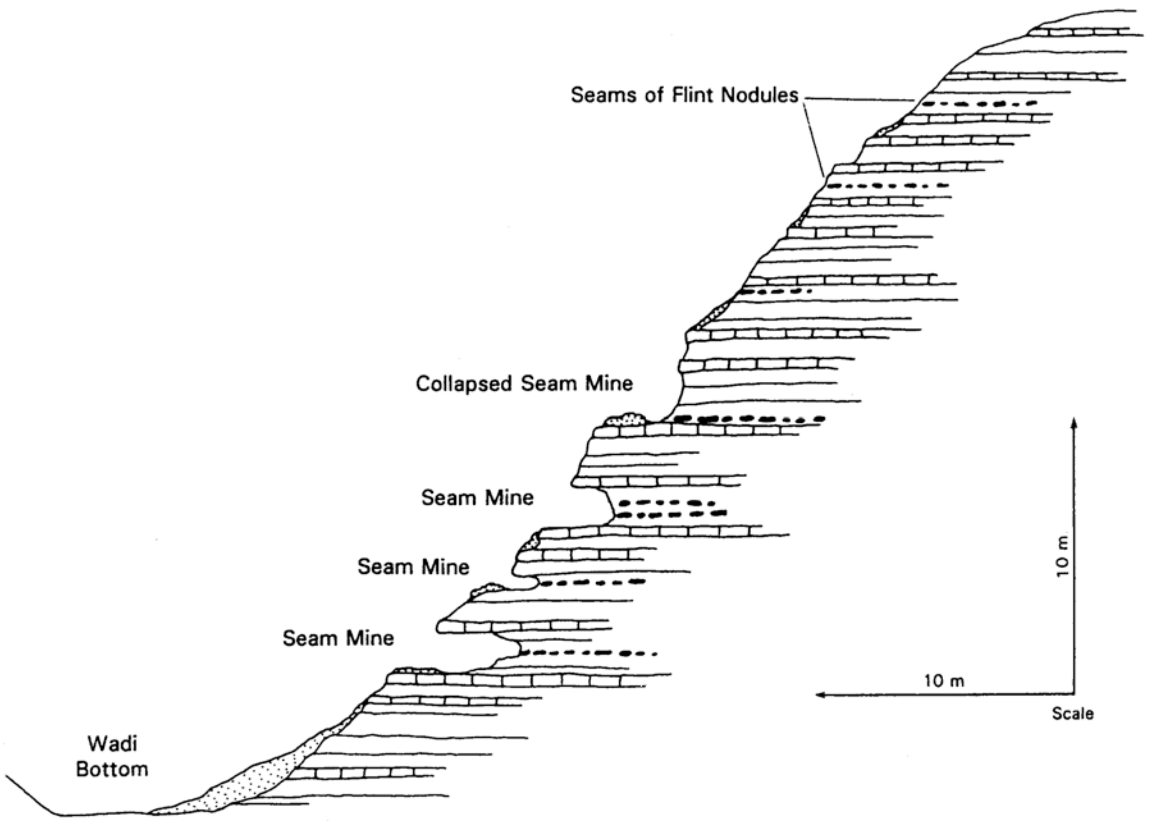


Fig. 5.2. Schematic representation of cross section of wadi showing typical mining exposures.

Plate 5.6. Linear features in Wadi Huweijir that appear to be collapsed seam mines. In some cases, ceilings have collapsed onto floors that are still apparent (*center, right*); in other cases, erosion has obliterated most of the remnant features (*left of center*).

Plate 5.7. Archaeological mining debris.
upper section of tested flint nodule. *lower* aborted naviform precore in mining debris.

Plate 5.8. Quarried terraces on north side of Wadi Huweijir.
upper flint was removed from beneath shallow cap of limestone along narrow, natural (?) terraces.
lower quarried terrace with tested nodules.

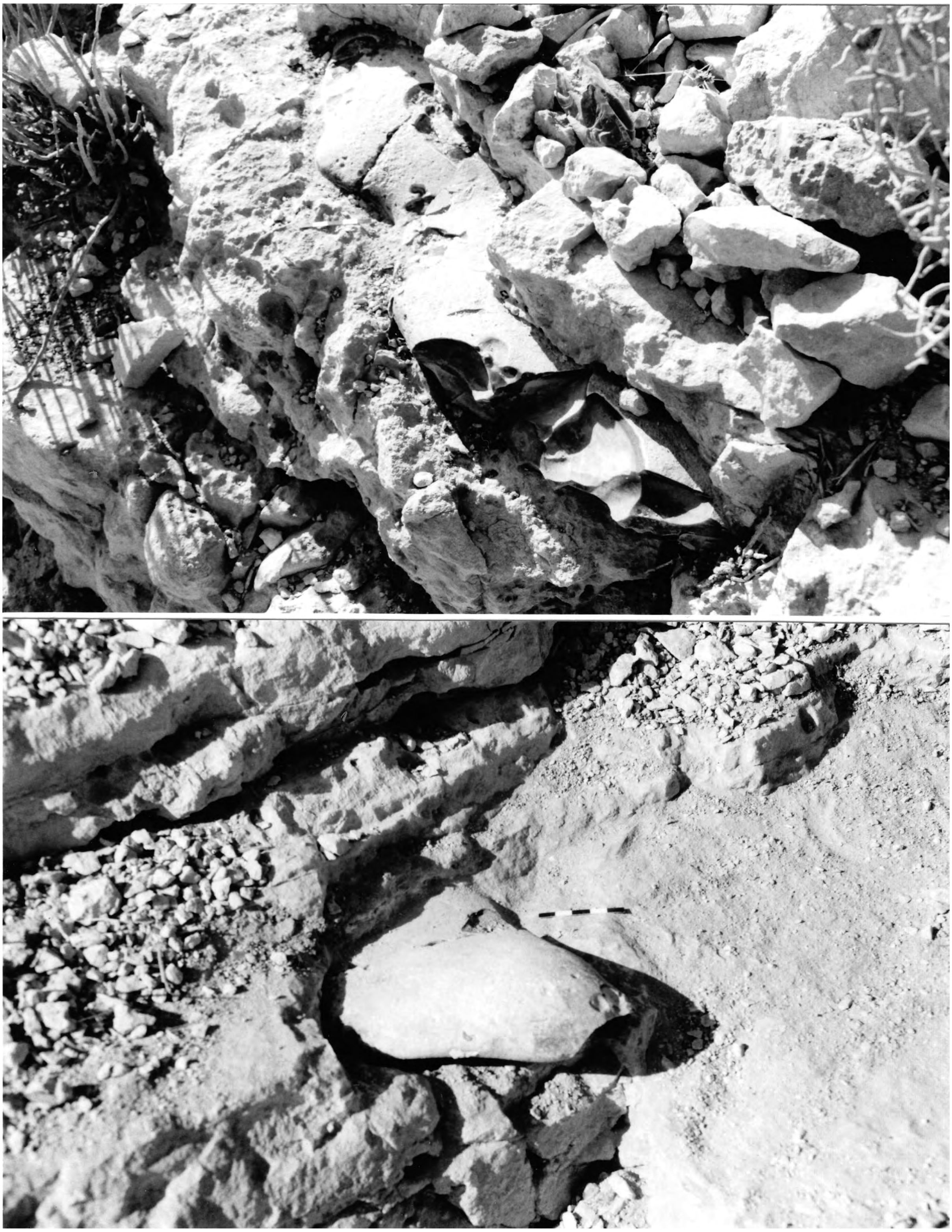


Plate 5.9. Tested and partially excavated flint nodules in north wall terrace features.
upper nodule tested for quality, partially exposed, and rejected.
lower nodule partially exposed by chipping away limestone matrix
(note flake scars in limestone), and ultimately rejected. Centimeter scale.

Fluorescent properties of flints and cherts are divided into three discreet color divisions, those that fluoresce within the warm-tone ranges of yellow, those that fluoresce within the cool-tone ranges of green, and those that have little or no fluorescent properties that appear as variations of purple (Wain 1965). Differences within these ranges, as well as between the larger groups, are assessed under both wave-lengths in order to make comparisons, and ultimately matches, with specimens of known origin. Large sample populations are needed to account for slight differences in reactions that may be due to natural variety within a single formation, diverse fracture planes or textures of samples, and variable degrees of patination (Hofman *et al.* 1991; Hillsman 1991). Nonetheless, current research has demonstrated that in many cases ultraviolet fluorescence produces reliable and valid matches between archaeological cherts, or flints, and their parent sources.

Consequently, flint samples from the Huweijir mines and from ‘Ain Ghazal were inspected in normal light, and under both longwave and shortwave ultraviolet light in order to compare pertinent characteristics.[1] Specimens were selected that represented the range of variation in color, texture, and luster apparent in the flints from both the Wadi Huweijir formation and from the ‘Ain Ghazal collection. Archaeological flints and cherts from ‘Ain Ghazal that did not appear in normal light to derive from the Huweijir mines were also tested. In order to avoid misinterpretations that might derive from variable patination layers, only freshly knapped, noncortical flakes were compared.

The lithic material from the Huweijir mines and comparable flint from the ‘Ain Ghazal collection responded in an identical manner under both shortwave and longwave ultraviolet illumination. These results are outlined in Table 5.1. Both groups fluoresced with the same dull, yellow/brown range of hues under each wavelength. Variations in secondary field characteristics, such as mottling and banding, that appeared in the archaeological specimens also appeared in the resource samples and reflected a second range of fluorescent responses that also matched one another. The ‘Ain Ghazal specimens that did not appear to originate from the Wadi Huweijir source exhibited entirely different responses; either they fluoresced as dark green, or they had no fluorescent properties and reflected dull purple light.

These results argue that the fine-quality, multicolored flint used by ‘Ain Ghazal stone-workers was obtained at the nearby Wadi Huweijir mines. The results support the same conclusion based on visible flint attributes that are apparent in normal light and strengthens its validity.

Heat-Treatment Experiments

Intentional heat-treatment of flint has been difficult to document in most archaeological contexts. This problem is due, in part, to a number of variables that affect not only how any given type of stone will respond to heat, but also how a particular sample of stone will react. Numerous researchers have noted that detection of heat-altered stone by means of changes in luster, color, and fracture character, for instance, depends minimally on: (1) the temperature reached in the heating; (2) the chemical properties of the stone; and (3) the grain quality and degree of silicification of the stone (Mandeville 1973; Purdy 1974; Rick and Chappell 1983). These difficulties are compounded when archaeological specimens are few, and when source deposits

[1] I used a Mineralight Lamp, model UVGL-48 Multi-band UV with sensors for measurements at 254/356 nm, manufactured by UVP, San Gabriel, California.

are unknown and therefore unavailable for comparative analyses. Moreover, natural weathering processes such as wind-glossing can effect a "greasy" sheen on flint (Stapert 1976) that may be mistaken for luster caused by heat-alteration.

Table 5.1. Primary ultraviolet fluorescence responses.

Normal Light	Munsell Code[a]	Short Wave	Long Wave
Pale red (pink)	(10R 6/3)	yellow-brown	yellow-brown
Weak red and green	(5R 4/2, 10YR 6/2)	yellow-brown	yellow-brown
Weak reddish-purple	(10R 5/3)	medium brown	medium brown
Reddish brown	(5YR 3/3)	dark brown	dark brown
Very pale brown (tan)	(10YR 8/2)	light yellow-brown	light yellow-brown
Grey	(10YR 6/1)	medium yellow-brown	medium yellow-brown

[a] Since Munsell soil and rock color charts are reliable standards of comparison for color variations between populations, in most circumstances their use is encouraged and they are used here for color references in normal light. However, use of these charts is unwarranted with ultraviolet illumination because it renders the color chips unreadable.

Because of these complexities, most of the southern Levantine cases where intentional heat-treatment of flint has been suspected have proven to be equivocal, such as at PPN Jericho (Robins *et al.* 1981; Miller 1983) and Netiv Hagdud (Nadel 1989), and at the Natufian occupation at Wadi Hammeh 27 (Edwards and Edwards 1990). Nonetheless, it is a commonly held view that heat-treatment of flint was practiced during the Neolithic in the southern Levant (*e.g.*, Bar-Yosef 1981, 1991b; Edwards and Edwards 1990; Goring-Morris 1994), and that heat-alteration of local flints transformed them into the highly siliceous, often pink, flint in question.

'Ain Ghazal Heat-Treatment Study

Preparatory to this study, lengthy series of heat-treatment tests were conducted on a wide range of nonarchaeological flints and cherts of varying qualities in order to establish a standard for changes in their characteristics and ranges of temperatures that induced such changes. These tests were necessary because of the numerous variables that affect how any given sample of stone will react to heat-treatment, as mentioned above.

Three major properties often are used to detect heat-treatment in archaeological specimens: improved fracture quality, alteration of natural colors to reddish hues, and increased luster (Rick 1978; Luedtke 1992). All are problematic. While many flints become increasingly easy to flake as they are subjected to increasing temperatures (up to that point when they suffer thermal shock and are ruined), detecting "improvement" in fracture quality may be quite difficult and subjective. Stone may be insufficiently heated so that improvements in flaking quality are nil, or minuscule, and undetectable. Red- or pink-colored flints in archaeological collections are equally troublesome. Not only do a variety of red hues appear naturally, but most flints will not become red or pink with heat-treatment (Mandeville 1973; Purdy 1974; Rick and Chappell 1983; Dunnell *et al.* 1994). Also, if red or pink hues are heat-induced, they may appear at very low temperatures (Purdy 1974; Rick and Chappell 1983), or at high ones (Nelson 1968; Inizan *et al.* 1975-1976), so the unpredictability of their occurrence is compounded. In sum, reddish colors in flints (and other stones) are not necessarily reliable evidence of heat-treatment.

However, most researchers agree that change in luster is a reliable indicator of heat-alteration (Collins 1973; Rick and Chapell 1983), although this too is a variable response, and is dependent on the quality of the stone and the temperature achieved. It also may be imitated by the effects of natural agencies such as wind abrasion (Stapert 1976). Nonetheless, it is considered the best trait for detecting heat-alteration because it is pervasive in most heat-treated flints, may be induced at relatively low temperatures, and, consequently, has a high degree of predictability. In general, fine grained, highly siliceous flint will become lustrous at much lower temperatures than will coarser-grained flints, some of which will never attain any luster.

In preparation for this research, several hundred controlled, heat-treatment experiments were conducted to investigate these differences. Many of these exercises were carried out over several years in conjunction with tests on the performance of two heat-treatment kilns, and with heat-treatment of many varieties of tool-stone used for flint-knapping. These tests established a low temperature threshold for heat-induced luster. Fine-grained, highly siliceous flint, comparable to that used at ‘Ain Ghazal, was altered with very low temperatures (175-205 degrees C), whereupon it displayed extremely lustrous fresh flake scars. This temperature standard was used to structure heat-treatment studies of archaeological flint from ‘Ain Ghazal.

Samples of archaeological cores, blades, and core-production debitage of various colors from ‘Ain Ghazal’s PPNB collection were subjected to systematic, incremental heating in order to determine if their high degree of luster was a natural trait or the result of prior heat-alteration. It was assumed that natural, unaltered flint of this quality would exhibit increased luster with exposure to only modest increases in temperatures, but that flint that was already heat-altered would not be visibly affected. The samples were buried in sand to reduce thermal shock, and heat-treated in a ceramic kiln fitted with a thermocouple and temperature gauge. The kiln temperature was controlled with a variable autotransformer, and increased from the ambient temperature in 10-degree increments each hour. The samples were checked at every 10-degree rise in temperature, after reaching 120 degrees C, for heat-affected changes in luster.[1] All of the samples became noticeably more lustrous at *ca.* 180 degrees C, comparable to earlier tests on like-quality stone.[2] In all cases, marked increases in luster occurred in a very low temperature range (180-205 degrees C), strongly implying that the stone had not been previously heat-treated. Moreover, the natural colors of all of the samples remained unaltered.

With the discovery of the Wadi Huweijir flint mines, similar tests were conducted on freshly quarried stone samples that included the full color range of flints from various individual mine sources. This raw flint reacted in an identical manner as the archaeological samples; an obvious increase in luster occurred within the same low temperature range. However, these and subsequent heatings (up to 300 degrees C) did not cause any of the samples of flints to become pink, although, in the very high temperature ranges, from 290 to 300 degrees, flints that were naturally in the red color range became darker reddish-brown, and the cortex was reddened. These attributes are not characteristic of the lithic industry from ‘Ain Ghazal. At 300 degrees C, most of the samples suffered severe thermal shock and were ruined.

---

[1] At these intervals, the kiln was slowly cooled at *ca.* 30 degrees C/hr, and fresh flakes were knapped from the cooled samples.

[2] This reaction also compares favorably to tests conducted by Nelson (1968) on flint from the Edwards Plateau of Texas.

Summary

These tests argue strongly that the highly siliceous, fine-grained flint used for naviform core-and-blade production during the PPNB at ‘Ain Ghazal was not heat-altered stone but was, in fact, raw, freshly mined stone from nearby Wadi Huweijir, and possibly from other mines exploiting the same geological formation. Extensive construction of houses in the area around ‘Ain Ghazal may have destroyed other evidence of prehistoric flint mining.

In related research reported elsewhere (Wilke and Quintero 1994), naviform core-and-blade production was replicated using good-quality, raw flint from Cretaceous-age deposits in Texas. When the Wadi Huweijir mines were discovered, similar replications were conducted using Huweijir flint. Not surprisingly, the knapping qualities of the superior Huweijir flint far surpassed those of even the Texas stone, allowing production of exceptional blades that were strong, sharp, and easily pressure-flaked. Significantly, experiments by others have shown that heat-treatment reduces the strength of flint-tool edges making them more likely to fracture and wear quickly (Olausson 1983; Dunnell *et al.* 1994). It seems reasonable to conclude that at ‘Ain Ghazal heat-treatment was not necessary for blade production, and that it probably was not desirable for blade-tool efficiency.

In sum, there can be no doubt that flint reduced at ‘Ain Ghazal was mined from the Wadi Huweijir mines, and that nodules were transported to the site for use in their natural, unaltered state. Results of heat-treatment studies and replicative knapping experiments support the conclusion that heat-treatment was not used to create the highly lustrous, pink and red properties found in artifactual flint at ‘Ain Ghazal. Therefore, thermal pretreatment of flint was not a normal part of the manufacturing process for naviform core-and-blade production.

DISCUSSION

Proximity of the Wadi Huweijir mines, sourcing analyses, and heat-treatment tests all argue strongly that blade-core flint used at ‘Ain Ghazal for the standard production of naviform cores was a local resource that was obtained by the community from mines in nearby Wadi Huweijir and possibly from other local exposures. Since the resource is still viable, that is, it was not extinguished in prehistory, it is likely that flint obtained in this manner was the mainstay of the lithic economy for the production of naviform cores and blades for a significant portion of the PPNB, nearly 1,300 years. Given this situation, extensive exchange networks or direct procurement of stone outside of the area probably were not necessary, so that naviform core-and-blade production at ‘Ain Ghazal was supported by a locally-autonomous economy. Nevertheless, the structure of this economy requires further consideration.

It is evident from the scale of the excavations at the Wadi Huweijir mines that the long exposures of flint nodules within the limestone matrix were extracted with considerable effort, very likely entailed a significant degree of risk, and involved the removal of substantial amounts of flint. Excavated flint nodules then would have been transported 2 km to the townsite for reduction. While it is tempting to envision a bustling, expansive industry to account for the mining data, this vision is moderated by the 1300 years of PPNB use of these resources. Unfortunately, extensive erosion and weathering of the drainage, and the enigmatic nature of the terrace quarrying make obtaining accurate, quantifiable data for the intensity of the exploitation problematic. Nevertheless, based on the pervasiveness of the resource in the archaeological assemblage and the nature and size of many of the mining exposures, it seems reasonable to conclude that the seam mines reflect more than casual quarrying activities.

While local procurement of tool-stone clearly was an economically viable choice, in some cases (i.e., where seam mines were cut several meters horizontally into the limestone escarpment) flint appears to have been obtained with difficulty. In such cases, procurement of tool-stone most likely required a coordinated mining effort and the organization of stone-workers, possibly with the assistance of other community members, to expose the stone, select nodules of appropriate quality and configuration from the resulting exposures, and arrange for nodules to be transported to the town where they were transformed into naviform cores and tool blanks by local flint-knappers.[1] The exploitation enterprise apparent at the more extensive seam mines in Wadi Huweijir, coupled with the expertise and organization needed to mine, select, and transport whole, unreduced nodules to the townsite for reduction suggest that this aspect of the lithic economy was not a simple venture, in spite of the fact that local resources were used.

It is also noteworthy that proximity to the resource may have been an important factor in the selection of the initial town location during Neolithic times. It seems logical that easy accessibility to this highly desirable resource would have prompted the earliest settlement at ‘Ain Ghazal in the middle PPNB. Certainly, corroboration of the patterns seen at ‘Ain Ghazal is needed. It would be profitable to investigate other Cretaceous limestone deposits similar to those discussed here for evidence of mining. It is quite likely that seam mines such as these are common occurrences near many other Neolithic townsites. It is just as likely that there are many other sources in the southern Levant of highly siliceous flint, often pink or red in color, that were sought out and exploited during the PPNB.[2]

[1] Such organizational complexity in similar types of flint-mining ventures has been thoroughly explored in literature, for example by Lech (1981, 1987).

[2] Subsequent to the research reported here, we discovered several other deposits of pink and purple flint throughout Jordan, especially within the Upper Cretaceous Amman Silicified Limestone (ASL) and Wadi as-Sir Limestone (WSL) formations (Rollefson *et al.* 2007). Also, fieldwork by Gebel (Muheisen *et al.* 2004) located several flint sources and an associated knapping station that are thought to have been used by LPPNB occupants of Basta.

Chapter 6

NAVIFORM CORE TECHNOLOGY

This chapter is, in essence, a study of flint-knapping behavior. And, while it may be argued by some that such technical studies are not within the anthropological domain, I agree with others who maintain that “flint-knapping is just as much a cultural activity as making pots, or building a temple, or marrying a very ‘cross’ cousin” (MacNeish *et al.* 1967: 96). The analyses that follow document both the character of naviform core-and-blade technology and its inherent technical requirements, and the behaviors that were used to create naviform-core industries. Replication experiments give evidence for core-production and core-reduction processes, as exemplified by the naviform core-and-blade collection from ‘Ain Ghazal. Further, they disclose certain necessary preconditions that allowed its success.

BACKGROUND

Aspects of Technology

Technological analyses, such as this one, are intrinsically processual in character because they deal with behavioral sequences. On a large scale, one considers resource selection, modification of raw material to fashion products, and continual manipulation of a product through its use and maintenance. But, each of these behaviors is also an amalgam of choices and decisions that accommodate individual situations, as well as the intended goal of the behavior. The outcome is considerable behavioral flexibility within each of these actions, so that the resulting technology is a dynamic one.

Variation in lithic technological processes derives from many sources. While on the one hand it is bounded by cultural constraints, on the other hand it results from a variety of culturally determined concepts of acceptable patterns. Mental templates allow for ranges in permissible designs, for instance, and diverse views on usefulness, the appropriateness of recycling, and the final point at which items are deemed useless and are discarded. Variation also may be quite technical in origin. Since lithic technology is material-dependent, that is, both reliant upon manipulation of certain resources for its successful creation and responsive to differences in materials, it is affected by diverse choices of raw material and approaches to its use. It also is affected by, even constrained by, the skill levels of flint-knappers, and incorporates their varying decisions and strategies, their success and their failures.

It seems clear that the archaeological record, at least that portion of it that is technological in nature, reflects a collage of variable behaviors, and that technological processes are, to a degree, flexible. At the same time, the dynamic activity of creating stone tools is predictable and explainable because variability also is controlled by (1) the mechanical properties of lithic reduction, (2) physical and chemical properties of stone, and by (3) physical attributes of human anatomy, as discussed in Chapter 3. Given these conditions, an analysis of naviform core-and-blade technology must be processual in nature, rather than purely descriptive or typological, in order to understand both the causes of variation and the constraints that shaped the technology. The replicative analysis that follows has such a goal.

Technological History and Analytical Issues

The Near Eastern Neolithic core-and-blade traditions and Upper Paleolithic blade traditions of northern Europe are, in some aspects, quite similar. Lithic technologies of both traditions include a conspicuous presence of bidirectional, opposed-platform, blade cores (see Rust 1943; Demars and Laurent 1989). Opposed-platform blade cores of naviform configuration are well documented also in the Upper Paleolithic Swiderian Culture of Poland (Kobusiewics 1967; Kozlowski and Sachse-Kozlowska 1976; Schild 1980a; Jasnosz 1982). However, the affinities of the broadly defined Levantine naviform core-and-blade technology and its technological origins remain somewhat obscure. Core-reduction approaches similar to those described for European Upper Paleolithic sites probably were used for opposed-platform cores of the Levantine Upper Paleolithic, like those at Ksar Akil, Lebanon (Ohnuma 1988: 156).

Bidirectional, opposed-platform, blade(let) cores that may be considered as naviform core precursors are apparent in some Epipaleolithic deposits, such as those at Nahal Hadera on the Levantine coast (Ronen and Kaufman 1976), Mureybet in Syria (Calley 1984, 1986a), Kharaneh IV and Wadi el-Jilat in Jordan (*e.g.*, Garrard and Stanley Price 1975-77: Fig. 1: 4; personal observations of the author). During early Neolithic times, however, naviform core technology appears in the archaeological record of the Southern Levant quite fully developed. Some data suggest the development of the naviform reduction strategy may have occurred initially in the northern Levant, at the end of the PPNA and concurrent with the early appearance of Helwan projectile points (*e.g.*, Bar-Yosef 1996).[1] And while early site data are scanty, the reduction strategy appears to have become widespread and dominant throughout a large portion of the Near East (particularly in the Levant, extending to the western portion of the Tigris-Euphrates Basin and into Anatolia) in a relatively short period. It is not clear what cultural mechanisms allowed these latter events to occur. But it is clear that the naviform core is one member of a long line of opposed-platform, bidirectional blade cores with a clear local foundation in Upper Paleolithic and Epipaleolithic traditions.

As previously noted, characterization of the morphology of naviform cores and blades is not lacking in Levantine research. One of the earliest depictions of unreduced naviform cores appears in Rhotert's accounting of the Kilwa culture of Transjordan (1938: 142-145). Many of these early works provided detailed descriptions of assemblage attributes (*e.g.*, Mortensen 1970, 1988; Crowfoot Payne 1983). These studies and later research on naviform cores were mainly typological in nature and documented the distribution of the technology in various portions of the Levant, and noted its chronological associations. Some early works (Suzuki and Akazawa 1971), and more recent projects (Calley 1986a, 1986b; Nishiaki 1993) sought to understand the origins of morphological attributes of naviform cores in local industries. Such studies revealed important general aspects of naviform core reduction sequences by considering the abandoned archaeological remains of the technology, and were able to describe essential artifacts and their attributes. They were less able to address the technological behaviors that created the industries and technological causes of assemblage variations.

[1] See Abbès (2007) for recent research supporting this view.

The prevailing perception of naviform core-and-blade technology, therefore, was incomplete and lacking basic information on technological processes and restrictions that structured the overall technology. There was no clear understanding of how or why cores were configured as they were, or how blades were produced. For example, a commonly held view was that blades with punctiform platforms, the intended products of naviform core reductions, were detached by indirect percussion or the use of billets (*cf.* Suzuki and Akazawa 1971; Inizan 1980; Valla 1984; Calley 1984, 1986b; Cauvin and Coqueugniot 1988; Rollefson 1990a). However, the validity of this assessment had not been tested by experimental replication.

Certainly, without a basic understanding of the dynamics of naviform blade-core technology, and of the constraints and sources of variability within it, questions of cultural and temporal variation could not be resolved. Nor were we likely to know the technological and economic implications of the technology and why it had such a prominent place in the adaptations of PPNB communities.

REPLICATIVE ANALYSIS

‘Ain Ghazal Database and the Experimental Process

The following understanding of the procedures involved in creating the naviform core technology was derived from an analysis of archaeological collections and a lengthy program of replicative experimentation. The Pre-Pottery and Pottery Neolithic assemblages from ‘Ain Ghazal comprised the primary archaeological data base, although appropriate portions of other collections also were examined. The ‘Ain Ghazal data consisted of over 1,500 blade cores and flake cores, 339 of which are naviform blade cores. The comparative assemblages also included several hundred loci of lithic debitage, 21 loci of lithic production debris, an MPPNB blade cache, and several thousand blades, formed tools, and pieces of core-production and core-reduction debitage. Attributes of all of these materials were studied for technological information regarding their significance to the reduction process, their technological function, and methods of their production.

Data gleaned from these studies provided a technological standard that guided the experimental reduction of over 300 naviform cores during a period of three years.[1] In the course of this experimental study, the archaeological data were constantly evaluated and referred to as the process of replication progressed and alternative procedures and knapping strategies were tested. Successful replication of the processes of core production and reduction, and their accompanying technological behaviors, required that all of the products and by-products of reduction be duplicated, that is, that the entire debitage assemblage as well as the full array of products match the archaeological material. Since there was little previous technological information concerning the character of naviform core technology, such as the shape of the initial preformed core, how platform spalls were removed, or the method of blade detachment, the entire production and reduction process had to be reconstructed from the experiments undertaken here. Moreover, because no one else had mastered replication of this technology, there was no one to teach the techniques of core production and reduction; everything had to be learned from trial and error, with constant reference to the ‘Ain Ghazal data set.

[1] The archaeological material was evaluated by the author. Flint-knapping for the naviform core-and-blade reduction experiments was carried out by the author and by Philip J. Wilke, and entailed intensive technical evaluation and comparisons with the archaeological data.

During the course of the study new observations gleaned from ongoing analyses of the ‘Ain Ghazal collection led to new replicative experiments and expanded conclusions regarding the production and use-life history of the cores, variations in certain aspects of core production and reduction, and the evolution of the technology at ‘Ain Ghazal. In addition, flint-knapping skills and technological expertise needed for successful core production and core reduction were constantly evaluated in order to assess the importance of these constraints to the evolving technology at ‘Ain Ghazal.

This study led to the conclusions detailed in the following pages regarding basic characteristics and constraints of naviform core-and-blade technology. Table 6.1 presents a typology of technological debitage that results from reduction of naviform cores, as attested by the replicative and archaeological data.

Resource Selection and Core Production

The choice of raw material was an important element of the technology. It is clear from both the archaeological record and from replicative experiments that successful production of blades from naviform cores depended on the availability and selection of excellent-quality stone. This prerequisite has been noted for other sophisticated blade technologies, such as Neolithic pressure-blade production in Iran and Iraq (Wilke 1996) and Upper Paleolithic percussion-blade industries in France (Bordes and Crabtree 1969; Morala and Turq 1991). Nonetheless, the archaeological signature of naviform core technology varied, depending on the resource that was used for core production. In Levantine archaeological contexts, the material selected for use generally was very fine-grained, highly siliceous flint, including tabular and nodular stone. Obsidian was used primarily in Anatolia (*e.g.*, Calley 1985; Balkan-Atlı 1994; Caneva *et al.* 1994)[1] where abundant sources occur, and to a much lesser extent in the Northern and Southern Levant where obsidian arrived as an import. Because each of these materials required somewhat different reduction approaches to create naviform cores and blades, the reduction residues, and, hence, the archaeological assemblages, differ.

Occasionally at ‘Ain Ghazal, and at some sites such as those at Wadi el-Jilat (Baird 1995) and Basta (H.G.K. Gebel, personal communication 1993)[2] where high-quality, tabular flint was available, that material was selected for naviform core production. Nonetheless, the stone of choice at ‘Ain Ghazal was very fine, nodular flint from the Huweijir source. Cores were configured on both thick and thin nodules, but thin nodules are clearly dominant in the collection and probably were preferentially selected. The archaeological data from these and other sites confirm that Neolithic flint-knappers chose tool-stone with naturally occurring fortuitous shapes (i.e., thin, flat-sided nodules or tabular stone) whenever possible, because these materials required only minimal modification to fashion naviform cores. At Mureybet and Qdeir 1 (Calley 1986a, 1986b) in Syria, and at Jericho in the West Bank (Crowfoot Payne 1983) thick flint nodules sometimes were used that needed extensive bifacial reduction in order to fashion the preliminary shapes of cores. Obsidian blocks were used for naviform core production in Anatolia, as at Aşıklı Höyük (Balkan-Atlı 1994) and no doubt required intensive shaping.

[1] Useful research on obsidian exploitation, Neolithic obsidian industries, and obsidian exchange networks include, for example, Balkan-Atlı *et al.* 1999; Binder and Balkan-Atlı (2001), and the several papers *in Technical Systems and Near Eastern PPN Communities* (Astruc *et al.* 2007).

[2] See recent reporting of the LPPNB Basta lithic assemblages and their raw material sources (Muheisen *et al.* 2004).

Table 6.1. Naviform core-production and core-reduction debitage.

FINAL CORE PRODUCTION. The following are technological debitage types that result from final core preparation, and do not include debitage generated from initial configuration of a preformed core from raw material.

- **Initial platform spalls:** removed to create striking platforms at opposite ends of the core.
  - **unprepared:** usually have a natural cortical ridge (especially when cores are made from flat nodules), or may have a flat dorsal surface (as from a squared edge of tabular material).
  - **faceted:** flat dorsal surface usually created by unidirectional faceting; typically occur with use of tabular material or nodules with broken edges that do not require bifacial shaping.
  - **crested:** bifacially prepared ridge, usually a result of core shaping; may also be unifacially crested; "boat spalls."
  - **combination:** has attributes of two or more of the above.
- **Noninitial platform spalls:** removed subsequent to, or spontaneous with, the initial platform spall; usually correct a defective platform.
  - **flat:** dorsal and ventral surfaces are flat; typically increase width of striking platform or eliminate irregular surface; "ski spalls," also "tablets."
  - **crested:** bifacially or unifacially crested dorsal ridges; may or may not be distinguishable from crested initial platform spalls; "boat spalls."
  - **faceted:** flat dorsal surface created by faceting; may correct platform angle if canted laterally.
  - **combination:** has attributes of two or more of the above.
  - **spontaneous:** flat platform spalls that can occur with any of the above; dorsal and ventral surfaces may be parallel and of similar width; result from double contact with hammerstone; noncorrective.
- **Back core-trimming flakes:** generally, faceting or alternate flakes that flatten the back of the core; also may establish platforms for detachment of lateral core-trimming flakes from the back of the core.
- **Lateral core-trimming flakes:** usually flat, broad flakes that regularize lateral topography of the core; detached from lateral margins of core platforms, from the back of the core, or from a lateral margin of the working face of the core.
- **Faceting flakes:** flatten platforms; typically detached from tabular material.

CORE REDUCTION AND MAINTENANCE. The following products and by-products are created during core reduction, which involves blade production and core maintenance.

- **Initial blades:** first blades removed from cores; establish additional ridges.
  - **crested:** bifacially or unifacially prepared ridge; "lames à crête."
  - **unprepared:** often a natural, cortical "ridge," especially when cores are made from flat nodules; or, a natural squared edge if core is made on tabular material.
- **Noninitial blades:** all subsequent blades.
  - **intended blades:** intended products of core reduction.
  - **ridge-straightening blades:** core maintenance blades and small "bladelets"detached to straighten and define ridges and align blade platform for detachment of blade products; includes so-called "upsilon" blades.
    - **crested blades:** usually partially crested, corrective blades that improve the core profile or direction of an existing ridge.
    - **noncrested blades:** irregular maintenance blades, usually lack carefully prepared platforms; includes so called "upsilon" blades.
  - **hinge- and step-removal blades:** remove hinge and step terminations from the working face of the core; "clean-up" blades.
  - **profile-correction blades:** straighten the profile of the face of the core; thick, short blades usually with broad platforms, often strongly curved. Often necessary following a series of short blade detachments from one or both platforms.
  - **overshot blades:** blades that remove a portion of the opposite platform; may be unintentional detachments that may destroy the core; or, may be detached intentionally to remove a defective platform margin at the opposite end of the core. Also called "plunging" or outrepassé blades.

Table 6.1 continued. Naviform core-production and core-reduction debitage.

- **Platform-isolation elements:** small, curved flakes and bladelets that adjust, align, and isolate the platform and ridge of the intended blade.
- **Edge-preparation flakes and blades:** small, generally broad flakes and short blades detached to strengthen the core platform margin by removing overhangs and negative bulbs; also help narrow, isolate, and align the platform area of the intended blade; can include so-called "upsilon" blades.
- **Back core-trimming flakes:** generally, faceting or alternate flakes that flatten the back of the core; also may establish platforms for detachment of lateral core-trimming flakes from the back of the core.
- **Lateral core-trimming flakes:** usually flat, broad flakes that regularize lateral topography of the core; detached from lateral margins of core platforms, from the back of the core, or from a lateral margin of the working face of the core.
- **Corrective platform spalls:** reestablish advantageous platform; most often faceted or flat; platform area may include a damaged remnant of the working face of the core.
- **Faceting flakes:** flatten platforms prior to rejuvenation.
- **Industrial waste:** small fragments of the above.

Each form of raw material required a different set of knapping strategies to achieve the common goal of production of a bidirectional, opposed-platform, naviform blade core (Plate 6.1). And, each of these reductions created slightly different debitage assemblages. The reduction of large, thick nodules to produce preformed, or unreduced, cores resulted in large quantities of partially cortical and noncortical core-production debitage. Since a preformed core was essentially a triangular-shaped biface, the resulting debitage emphasized biface production. Small, flat nodules required only minimal modification to acquire the proper form. Bifacial shaping and platform preparation usually were modest, and the small quantity of resulting debitage was largely cortical. Tabular material also required only minor preparation, since its naturally flat, parallel surfaces were ideally suited for naviform cores.

The form and quality of available stone that was selected for use required a compatible array of knapping procedures, knapping options that were chosen from several strategies at the knappers' disposal. These procedures resulted in slight variations in the final forms of naviform cores and in concomitant assemblages of production debitage. Consequently, one should be cautious when assessing the "cultural" significance of different core forms in regional archaeological assemblages, since assemblage variation may simply reflect local resource constraints.[1]

Replication Strategies

The following discussion summarizes the results of replicative experiments conducted for this research. In essence, these studies demonstrate that the production of naviform cores and blades was very sophisticated technologically. At its best, at 'Ain Ghazal, essentially during the MPPNB, it was certainly as difficult as the production of Mesoamerican pressure-blade cores and blades, and entailed precise manipulations of the cores to create the refined blades that were produced. The technological details presented below illustrate this conclusion, and also account for some of the variability seen in the archaeological record of naviform core industries.

[1] Rigid views of core "types" that do not take into account technological variation such as described here, and the alterations of core forms that result from diverse reduction and reuse episodes, add confusion, not clarity, to the archaeological record.

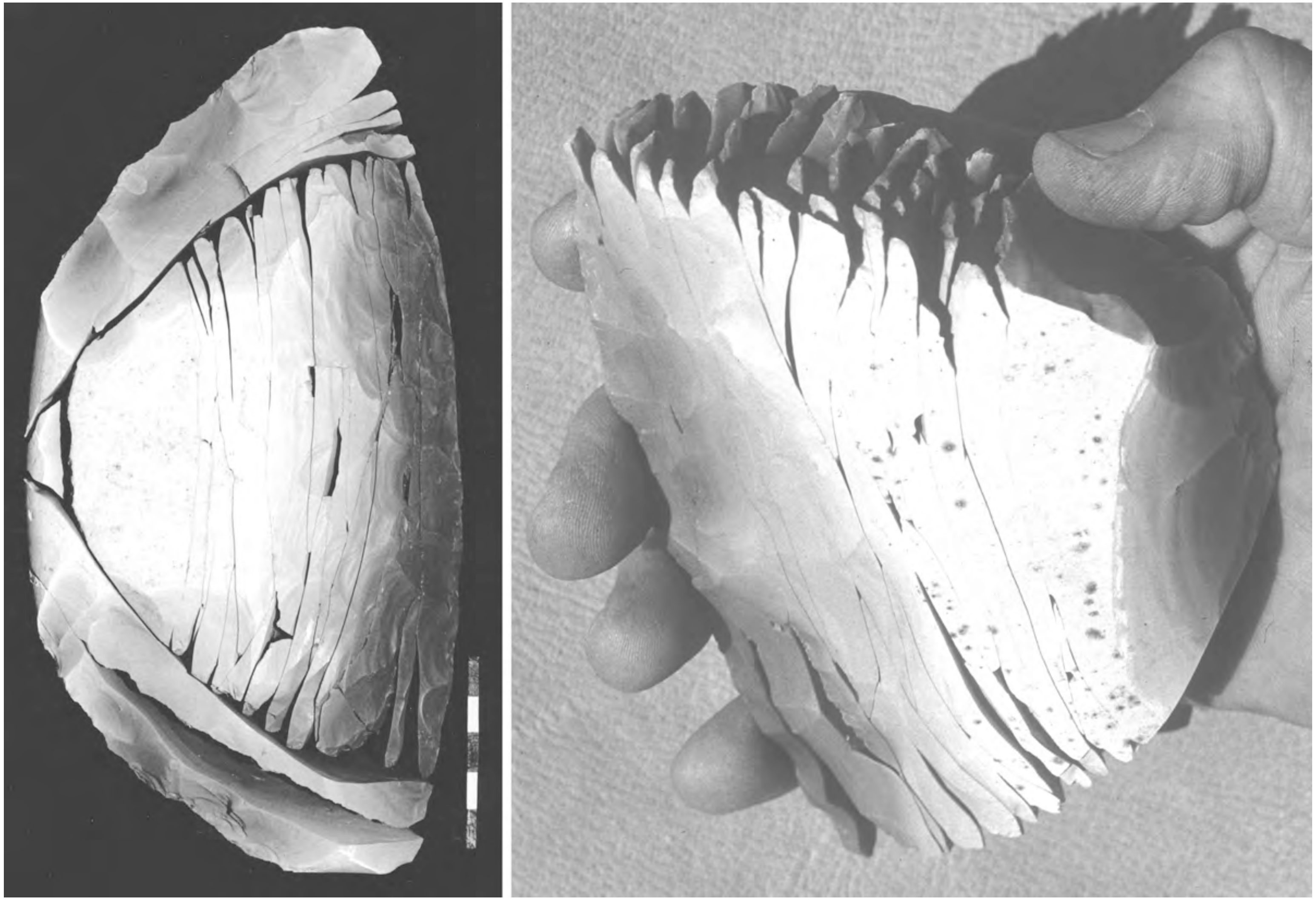


Plate 6.1. Refitted replication of naviform core reduction. *left* note opposed platforms (created by platform spall removals), common working face, blade detachments from both the upper and lower platforms, and the exhausted core. *right* refitted blades from same reduction showing isolation of blade platforms. Scale here and elsewhere in centimeters.

Core Production

In spite of resource variability, the basic core design was remarkably consistent. Many researchers (*e.g.*, Mortensen 1970; Suzuki and Akazawa 1971; Calley 1986b) have noted its triangular, or "boat-shaped" configuration (especially in its exhausted state), the opposed platforms with a common working face, and the acuteness (roughly 50 degrees) of the platform angles to the face of the core (Plate 6.1). In addition to these features, the core had to be relatively narrow, of a consistent width (ca., 2.5-4.0 cm), and length (ca., 12-15 cm), and with parallel sides that framed a narrow, rectangular working face. Control of the width of the core face in this manner regulated the width of the blades that would be produced from the core, thereby standardizing the shape and size of the blades. These constraints were quite rigid and were faithfully adhered to by MPPNB flint-knappers at ‘Ain Ghazal as they shaped core preforms and maintained them during reduction. All of these attributes are clearly evident on reduced archaeological specimens, such as the cores in Plate 6.2 in this chapter. Core production proceeded in a series of broad stages. These necessary tasks followed one another in a natural sequence of events, from thinning and configuring the body of the core, to shaping the core margins, to detaching the platform spalls. Unlike blade production, which is a dynamic mixture of various actions, core production consists of fairly predictable, technological stages.[1]

The first stage consisted of configuring the basic, flat-sided, triangular precore from various forms of lithic material, and was discussed above (Plate 6.3, upper left and upper right). The final stages of the naviform core-production sequence are discussed below. Table 6.1 summarizes all italicized terms used for products and by-products of core production and reduction. Table 6.2 presents naviform precore-production stages and some of the related debitage categories, and compares these stages to the dynamic character of the core-reduction process.

1. Shaping the core preform: final production of the core preform entailed preparation of the front (or intended working face) of the core, preparing the striking platforms, and shaping the back of the core. During each of these activities, knapping decisions were governed by the form of the raw material. Preparation of the intended face of the core entailed the following:
    - When thick nodular flint was used that required bifacial thinning, the front of a preform was generally straightened bifacially by creating a crested ridge in preparation for detachment of the *initial blade* (Plate 6.3, lower left). This procedure was also useful when thick tabular flint was shaped.
    - Thinner nodular and tabular flint with suitably straight, natural ridges on the front of the core preform required little preparation prior to the detachment of the initial blades.
    - Tabular material generally was faceted to create a straight, flat, working face and corner ridges. A corner ridge would then become the initial blade.[2]

2. *Initial platform spalls* were prepared on both ends of the core preform prior to their detachment. Spalls were shaped in much the same manner as the working face of the core

[1] There are diverse views among lithic analysts regarding the applicability of "reduction stages" in models of technological processes, as opposed to the more flexible conceptualization of a reduction "continuum" (*cf.* Callahan 1979; Shott 1994; Bradley and Giria 1996).

[2] These knapping strategies were described in Polish literature some years ago for assemblages of the Upper Paleolithic Swiderian Culture (*e.g.*, Schild 1980a).

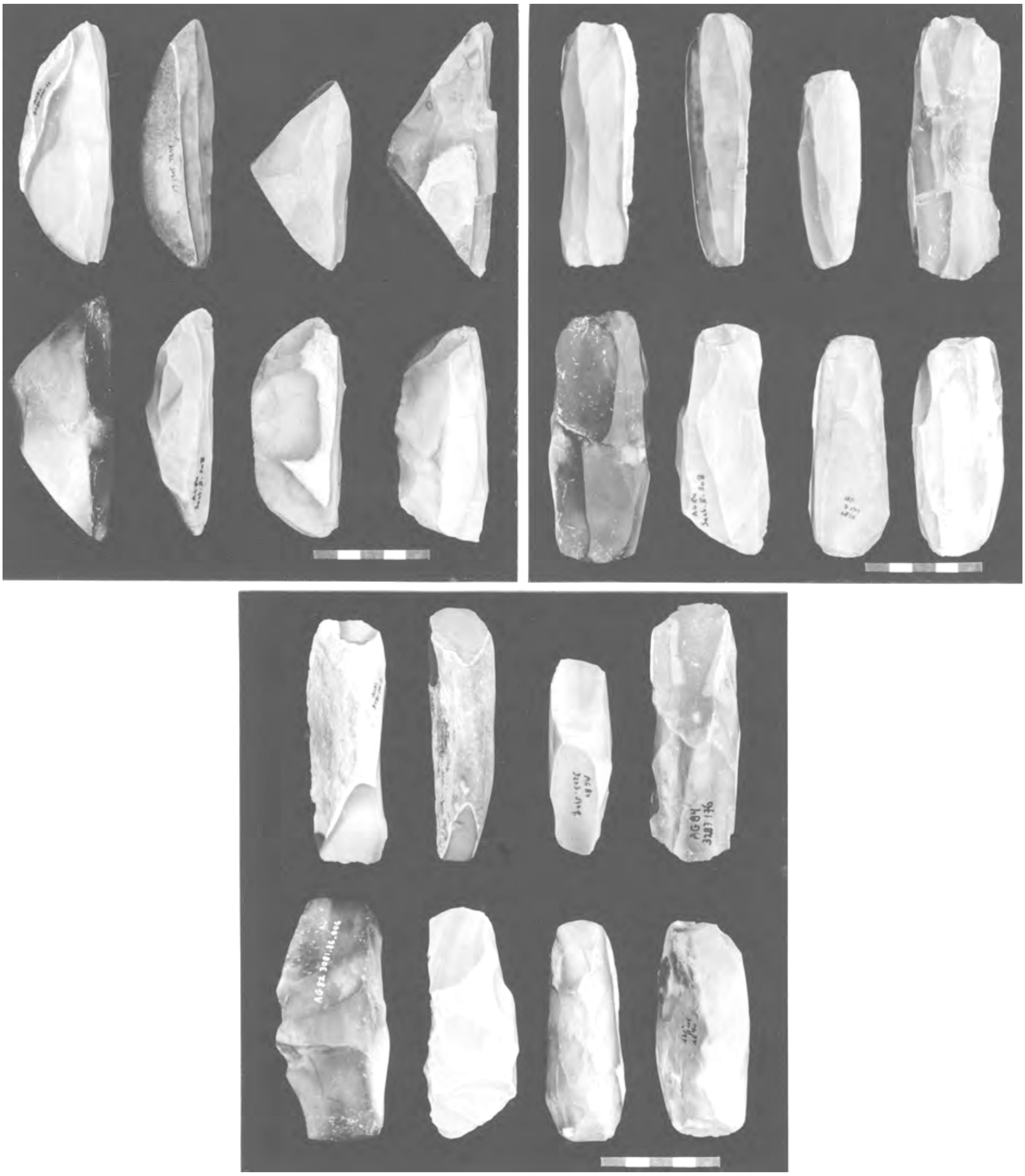


Plate 6.2.   MPPNB naviform cores.
upper left profile views of exhausted cores of typical size.
Note their straight working faces and acute platform angles.
upper right working faces of the same cores. Note their flat sides and generally common widths.
lower back view of the same cores showing typical features that facilitated holding during reduction.
Natural cortical back, intersecting spalls, back cresting.

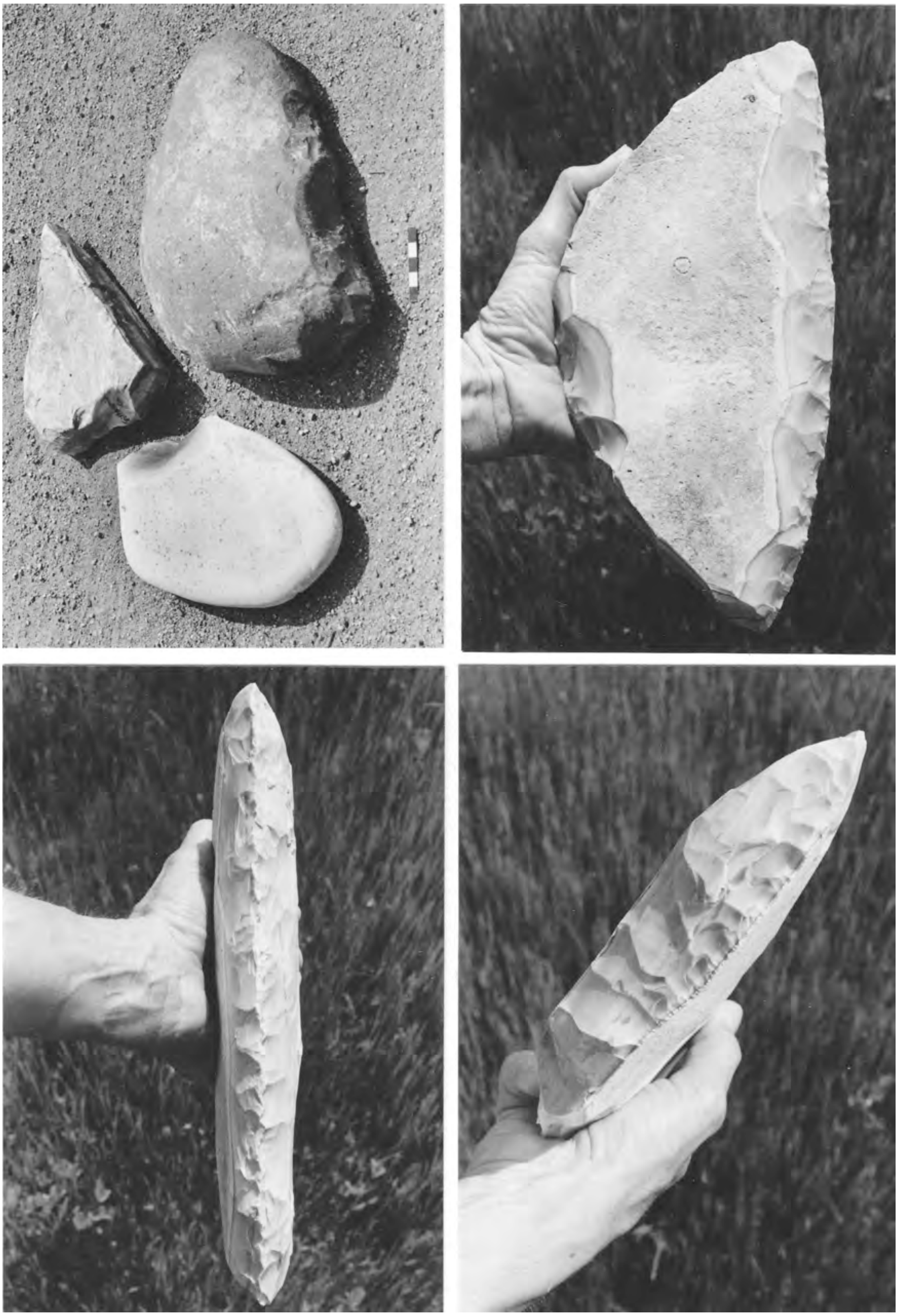


Plate 6.3. Preparation of naviform precore. *upper left* typical forms of raw flint. *upper right* replicated preformed core of tabular flint with crested front margin and faceted platform areas. *lower left* same core, front view of crested margin where initial blade will be detached. *lower right* same core, view of faceted platform area.

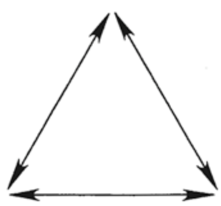
Table 6.2. Naviform core-production and core-reduction strategies.

PRE-CORE PRODUCTION SEQUENCE

THIN NODULE	THICK NODULE	TABULAR STONE
Stage One Regularize morphology (alternate flakes)	**Stage One** Regularize morphology (biface-thinning flakes)	**Stage One** Regularize morphology (faceting flakes)
Stage Two Shape core margins Shape core front (cortical or crested) Shape platform spall areas (cortical or crested)	**Stage Two** Shape core margins Shape core front (crested) Shape platform spall areas (crested)	**Stage Two** Shape core margins Shape core front (natural or faceted) Shape platform spall areas (natural of faceted)
Stage Three Remove platform spalls (cortical, crested, etc.)	**Stage Three** Remove platform spalls (crested)	**Stage Three** Remove platform spalls (ski spall, faceted)
Stage Four Trim core back (nothing/alternate flakes)	**Stage Four** Trim core back (core-trimming flakes)	**Stage Four** Trim core back (faceting flakes)

CORE REDUCTION PROCESS

Blade Production
initial blade
intended blades
ridge-straightening blades
platform isolation elements
edge-preparation flakes and blades



Core Maintenance
lateral core-trimming elements
back core-trimming flakes
corrective platform spalls

Error Correction
hinge- and step-removal blades
profile-correction blades
overshot blades

preform, and their configuration was governed by the same constraints. They were fashioned of either essentially unmodified, natural surfaces, or of shaped margins of the core preform. Their morphology was determined by both the type of raw material being altered, and the discretion of the knapper.

- *Unprepared platform spalls* (Plate 6.4, upper left) most often were created from natural, cortical ridges of thin, flat nodules, or, from naturally flat edges of tabular material. These spalls were essentially unaltered since they were fortuitously shaped and needed no further adjustment.

Often it was necessary to shape the margins of the preformed core in order to detach a spall. In such cases, platform areas were either crested or faceted to create desirable topography. Shaping allowed the spall to detach easily, and at the correct plane and angle, so that the resulting platform was not canted from side to side, and so that it had an acute angle to the working face of the core.

- *Crested platform spalls* (Plate 6.4, upper right) normally were generated from thick nodules and tabular material that required bifacial preparation. Spalls of this type are commonly called "boat spalls."[1]
- *Faceted platform spalls* (Plate 6.3, lower right; Plate 6.4 lower left) usually were produced from flat tabular or nodular stone that required little or no bifacial shaping. In some cases such stone was faceted on the margins to adjust the topography, and the shape of the precore, prior to spall detachment. Faceting usually was unidirectional and served to flatten the surface of the intended platform area.

Flint-knappers used the most logical strategy to shape the spall area, selecting what was easiest, most likely to be successful, and what was the most judicious use of the stone. Partial cresting or faceting and combinations of strategies were common.

3. Platform spalls almost always were detached before the initial blade was removed (Plate 6.5). Spalls were removed either by direct percussion with a hammerstone, or by a burin blow. During replication experiments, percussion blows were most successful when the force was directed into the mass of the stone in line with the arc of the spall. When using a burin blow, the prepared platform end of the intended spall was struck on an anvil stone and the spall was detached in the same manner as a large burin spall.

4. *Noninitial platform spalls*: platform spalls sometimes were detached to correct a defect in an imperfectly created platform, or as a maintenance tactic during the course of core reduction.
   - *Corrective platform spalls* were either flat ("ski spalls" or "core tablets") (Plate 6.4, lower right), crested ("boat spalls"), faceted, or a combination of these forms, as the situation dictated. Evidence of prior platform spall removals usually remains on dorsal surfaces of corrective spalls, and their corrective role generally is apparent. Corrective platform spalls often were removed to widen a platform; in such cases their ventral surfaces are wider than their dorsal surfaces. Or, they commonly were detached to correct a canted core platform, and, consequently, they have a slanted dorsal surface. Corrective spalls were detached in the same manner as initial spalls.
   - *Spontaneous spalls* (Plate 6.4, lower right) are noninitial spalls that occasionally were detached unintentionally with the removal of other spalls. These detachments possibly were the result of a broad contact point or double contacts between the

[1] "Boat spall," or "boat-shaped" piece, also refers to crested platform spalls from bifacially prepared Yubetsu cores of the Upper Paleolithic and Neolithic of Eastern Asia. "Ski spall" also derives from the same industries.

anvil or hammerstone and the spall platform. Spontaneous spalls may be recognized in archaeological deposits by their flat, parallel dorsal and ventral surfaces, and by the fact that they have no obvious corrective attributes; they merely mirror the ventral surface of the intentionally removed spall.

5. Modification of the back of the core was usual when cores were bifacially prepared, or when spall scars met in a sharp edge. This adjustment in core morphology was intentionally executed to facilitate holding the core in the hand during blade production. When spall scars were separated by a smooth cortical area, the back of the core often was left unaltered. When core backs were shaped, this was done in a variety of ways that complimented core-production strategies, that is, by bifacial cresting, by faceting, or by the removal of back core-trimming flakes (see Plate 6.2).
   - *Back core-trimming flakes* (Plate 6.6) are expanding, faceting flakes that flatten and smooth the back of the core. Usually they were removed unifacially. Sometimes the negative scars from these removals created favorable topography for trimming and shaping the sides of the core.

   An important point is that the procedures chosen to trim the back of the core were determined by the same constraints that governed other aspects of core production. Ultimately, these choices depended on the form of the stone being used, the easiest strategy for core preparation, and the skill and inclination of the knapper. It is important to note that naviform cores in the ‘Ain Ghazal PPN collection were configured with most of the above variations that resulted from use of nodular flint (as tabular material was rarely used).

Blade Production

Unlike core production, the blade-production process is best conceived as a reduction continuum rather than a series of sequential stages (see Table 6.2). While it is the case that certain tasks must be completed, these tasks generally are situationally dependent rather than strictly sequential. Thus, the three actions, or tasks, of blade production, core maintenance, and error correction occur as the process dictates at any point during core reduction. Of course, there is a single goal, the production of blades for tool blanks. Nonetheless, successful blade production from naviform cores, or from any other type of blade core, must be maintained with continual core-maintenance and error-correction tactics during the course of production.

The naviform core is remarkable technologically, however, because it permitted a higher degree of control over all three of these aspects of the blade-production process than any other type of core. Use of the two opposed platforms provided the knapper ease of access to the core face and the body of the core, thereby increasing the number of knapping options available for successful core reduction. Hence, the blade-production process could be tightly controlled and the morphology of the blades could be configured in a predictable fashion. Because of these assets, the naviform core is an exceedingly efficient and sophisticated design.

Naviform cores were reduced by direct percussion with a hammerstone in these experiments, not by indirect percussion or by pressure, although both of these methods were tested. There is no doubt that PPN naviform cores were also reduced by direct percussion.[1] Alternative methods of

[1] I agree with those who maintain that indirect percussion was little used in prehistory (*e.g.*, Tixier *et al.* 1980: 96: “malgré sa mention très fréquente, nous n’avons pas encore de preuve absolue de l’utilisation de cette technique en Préhistoire”).

Plate 6.4. Platform spall types: archaeological.
upper left natural, cortical, initial spalls removed from thin nodules.
upper right crested, initial or noninitial spalls, dorsal view.
lower left faceted, initial or noninitial spalls, dorsal view.
lower right ski spalls and spontaneous spalls, initial and noninitial, dorsal view.

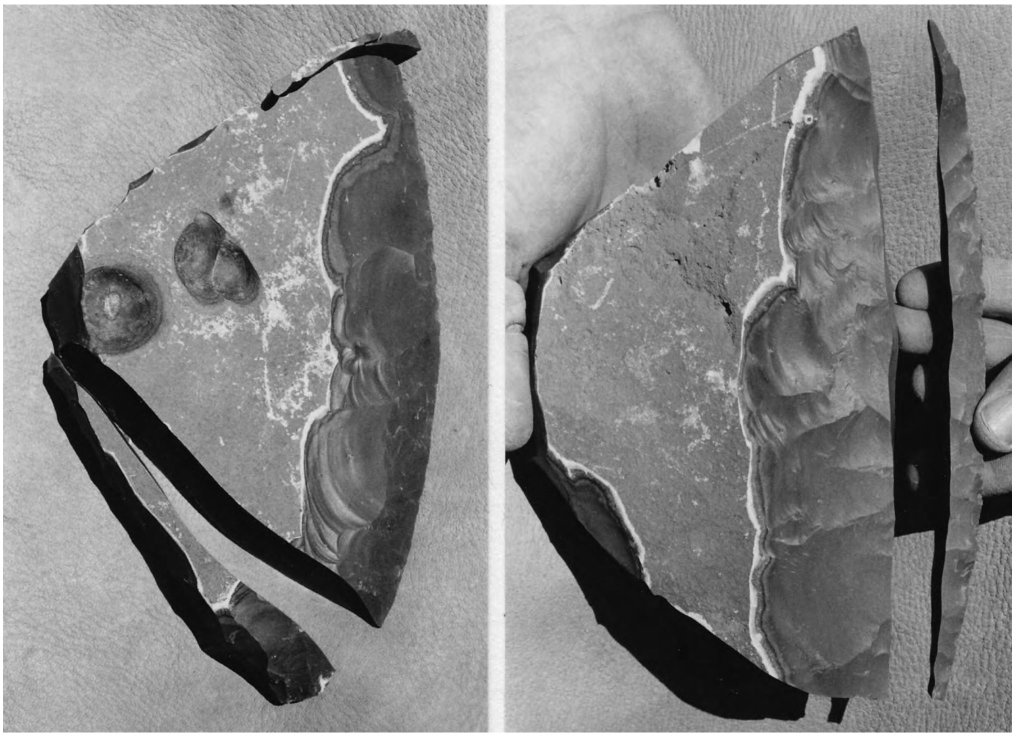


Plate 6.5. Reduction series: removal of platform spalls and initial blade.
left replicated preformed core with platform spalls detached, in correct orientation.
right same core with initial blade detached, in correct orientation.

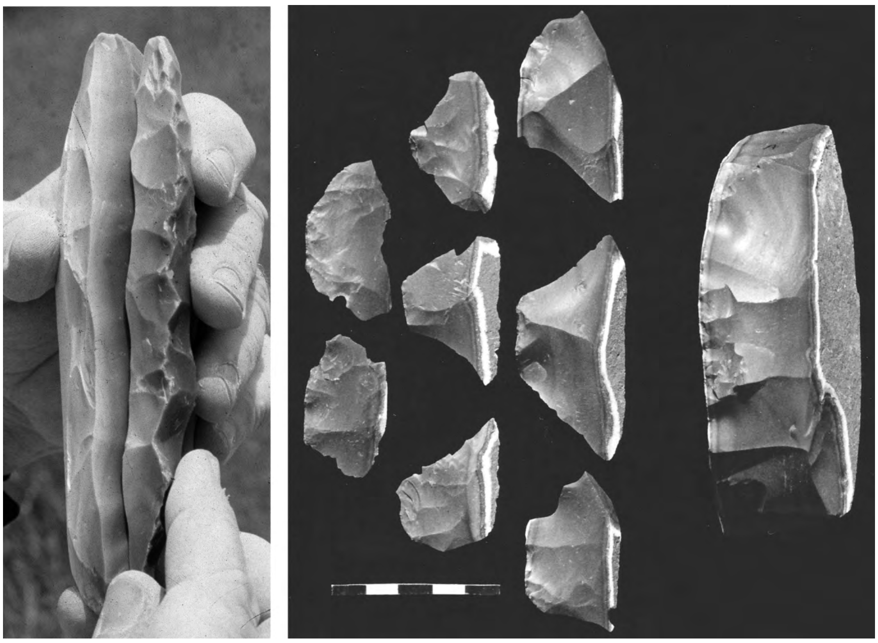


Plate 6.6. Reduction series: replicated cores, front and back preparation.
left detached initial crested blade in correct position.
right back view of faceted core in Plate 6.5 showing back core-trimming scars, and various forms of back core-trimming flakes in their correct orientations.

blade production were tested during the course of replicative experimentation; neither produced adequate results. Use of indirect percussion, or the "punch" method, did not produce straight blades with punctiform platforms. Also, the cores were difficult to immobilize, and the force of the blow was too strong, so that platforms were shattered and blades consistently overshot the opposite end of the core. In addition, indirect percussion did not allow the high degree of control of the blade detachment process that direct percussion with a hammerstone affords. Detachment of blades by pressure produced blades that were too thin and too regularized; the dorsal morphology and overall form of pressure blades was too straight and uniform, and did not match the archaeological examples.

Replicative experiments show that cores were held in the hand during reduction, not in any type of device. Supportive archaeological evidence for this conclusion is the presence of trimmed core backs that were purposefully created to allow cores to be held without discomfort, and the absence of patterned abrasion marks on the sides of cores, which are likely to be present when devices such as vises are used to immobilize blade cores. It also is likely that cores were not placed on a hard rest, or anvil, while they were reduced, but instead were held firmly on the thigh. Use of this position is supported archaeologically by the occasional presence of blades that overshot the ends of their cores, an expected occurrence when cores are not supported on a hard rest. However, the straight profiles of most of the blade products suggest that a "soft" rest, such as the thigh, was used to focus the force of the blow (Bordes and Crabtree 1969). Using this strategy, in most cases, blade detachments stop near the opposite end of the core, thereby creating straight blades that do not curve or hook on the distal end. Replicative experiments demonstrate, therefore, that holding naviform cores in the hand during reduction, resting the core on the thigh, and using direct percussion with a hammerstone produce assemblage characteristics that are, in all respects, identical to those in the archaeological collections that were studied.

In every regard, the process of blade production was structured to provide straight, rather than curved, blades with regularized widths, acceptable conventional lengths, standardized general topography, and that also were free from defects (Plate 6.7). In order to achieve this end, certain tactics and actions were used, many of which produced diagnostic debitage. The following generalizations are noteworthy. The ridge system on the face of the core was set up, or "preconfigured," to structure the shape of the intended blade. This ridge configuration and the amount of force used to detach the blade from the core determined the shape of the blade: (a) areas with accentuated parallel ridges that were detached with a firm stroke of the hammerstone tended to yield long, parallel-sided, trapezoidal blades; (b) areas with single, distally-placed ridges that were detached with a light blow tended to produce pointed blades with triangular cross sections; (c) the sides of the core face generally yielded sturdy, backed blades with one good cutting edge; and, (d) the central plane of the core face was useful for configuring symmetrical blanks for tools such as projectile points. Thus, preconfigured blade blanks were structured to meet the varied tool needs of a developing agrarian village, providing for subsistence activities (hunting, gathering, reaping, etc.), and other tasks (cutting, grooving, scraping, boring, etc.).

It also is evident in archaeological collections that these desired tool-blank forms were kept in mind during the course of blade production, but that these forms were ideal types. Parallel-sided blades with basically trapezoidal cross sections were desired for appropriate tools that required sharp, acute edge angles, such as sickle blades and some knives; and, generally pointed blanks with sturdy, triangular cross sections were preferred for projectile points, boring tools, etc. (Plate 6.7, upper right and lower). However, it is clear from the published literature of many major sites (*e.g.,* Cauvin 1968; Mortensen 1970, 1988; Crowfoot Payne 1983; Gopher 1989, 1994), and from

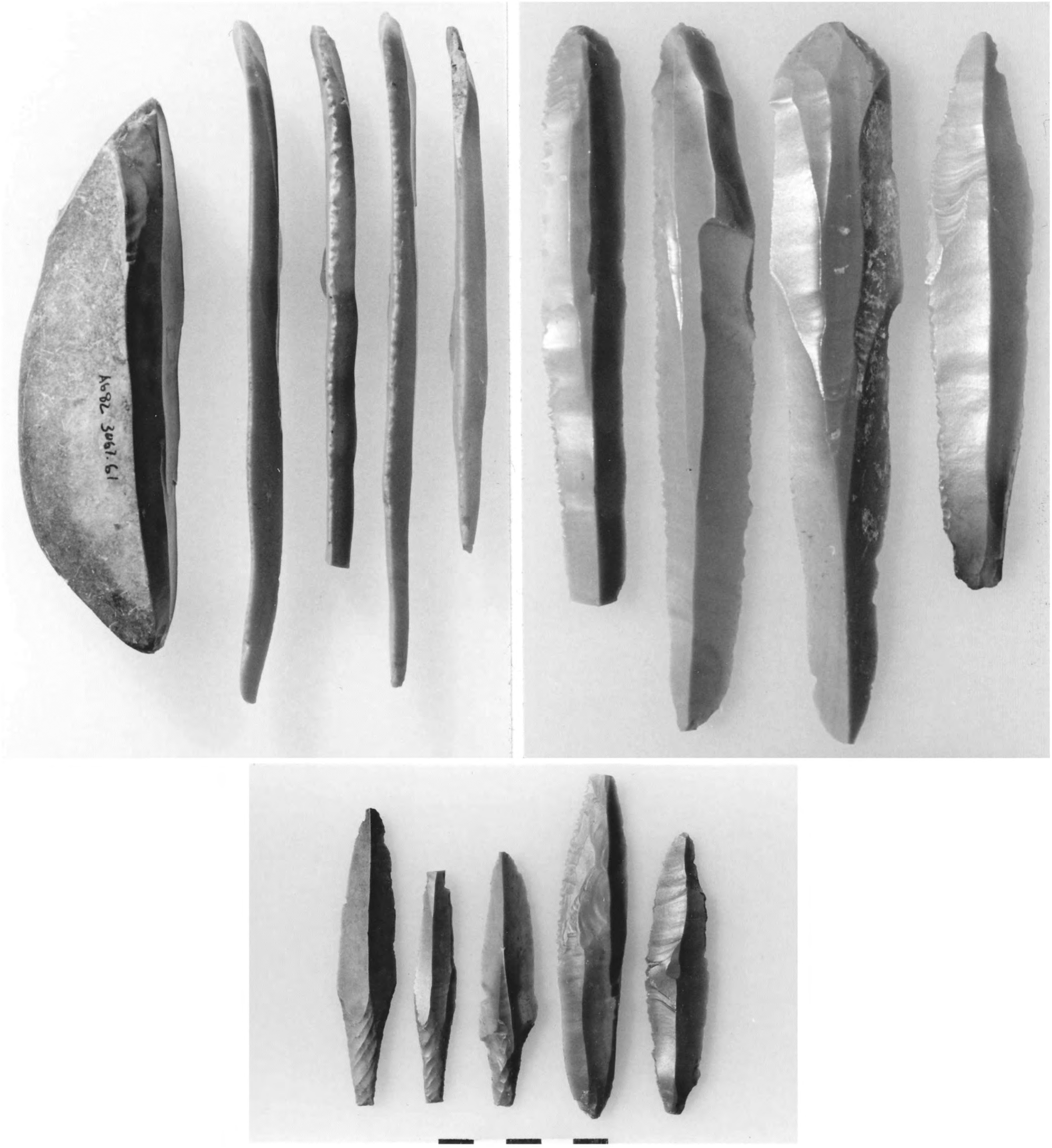


Plate 6.7. MPPNB naviform core and blade tools.
upper left profile views of naviform core and typical blade tools showing flat working face of core and straightness of blades. Core is 10.6 cm long.
upper right same tools (sickle blades) showing typical features of blades. Note the platform isolation, punctiform platforms, bidirectional blade scars, and standardized widths.
lower projectile points and edge-modified blades. Note straight edges and standardized widths.

consideration of the PPNB tool assemblages and the cache of blade blanks from ‘Ain Ghazal (see Chapter 7, Pls. 7.14-7.17), and the cache of blades from Beidha (Mortensen 1988), that there was considerable acceptable variety in the dorsal morphology and overall configuration of tool-blank forms. In addition, blades normally were trimmed to some degree to fashion most appropriate tool shapes. It appears to be the case, then, that standardization of the overall shape and size of blades created a versatile blank, such that almost any good blade would do to fashion several different types of tools. Any given reduction provided a number of standardized blade blanks with various ridge configurations that were all considered appropriate tool blanks.

Important aspects of the blade-production process and technologically diagnostic debitage types are discussed below. Only a general outline of this process is presented here.[1] It is important to recall that the process is variable, and that this outline should not be construed as a strict sequence of actions. Table 6.1 summarizes the blade-production products and by-products that appear in italics.

1. Platform selection: appropriate core platforms were chosen for removal of the first and subsequent blades. This choice was determined by pragmatic considerations of the moment, not by rigid, preconceived patterns of sequential blade removals. The best choice of platforms gave the easiest access to the ridge that was “set up” on the face of the core, and had the best angle (*ca.* 50 degrees) in relation to the face of the core.

2. Blade configuration: to a degree, blades were configured on the face of the core prior to their detachment (Plates 6.8, 6.9). A prominent ridge (or ridge system) that would become the dorsal surface of the blade was selected or produced on the face of the core.
    - Ridges were straightened, aligned with a potential platform area, and accentuated by detaching *ridge-straightening blades and “bladelets”* (Fig. 6.1; Plate 6.10). Removal of ridge-straightening blades also was necessary to create a desirable ridge pattern for a particular type of tool blank, such as parallel ridges for sickle blades. A common form of ridge-straightening blade is the so-called *“upsilon” blade“* (Plate 6.9), a short bi-pointed blade that served several functions in the reduction process. Often it was detached from the opposing platform after a pointed blank (*e.g.*, for projectile points, borers, knives) was removed from the center of the core. Here, it served to reestablish straight, parallel ridges, and thus it set up, or preconfigured, a parallel-sided tool blank (*e.g.*, for sickle blades).[2]
    - Sometimes, ridge-straightening blades were crested, usually unifacially, prior to their removal to straighten and strengthen their form. Either or both platforms could be used for these blade detachments. Ridge-straightening blades are recognizable by their irregular shape and dorsal topography, and by platforms that usually are broad and unprepared.

3. Preparation of the core platform margin prior to blade production entailed subtle adjustment as well. For instance, the margins of both of the core platforms were set back from the face of the core to cause a slight curvature of the core face, and to strengthen the platform margins. This curvature helped reduce the likelihood that a blade would fail, break, or fall short during detachment. It also increased the probability that the blade would

[1] See Wilke and Quintero (1994) for an expanded discussion.

[2] See Wilke and Quintero (1994) for illustrations of this process. “Upsilon” blades are a common form of debitage in naviform core-reduction assemblages, and it has sometimes been suggested erroneously that they were hafted as projectile point forms.

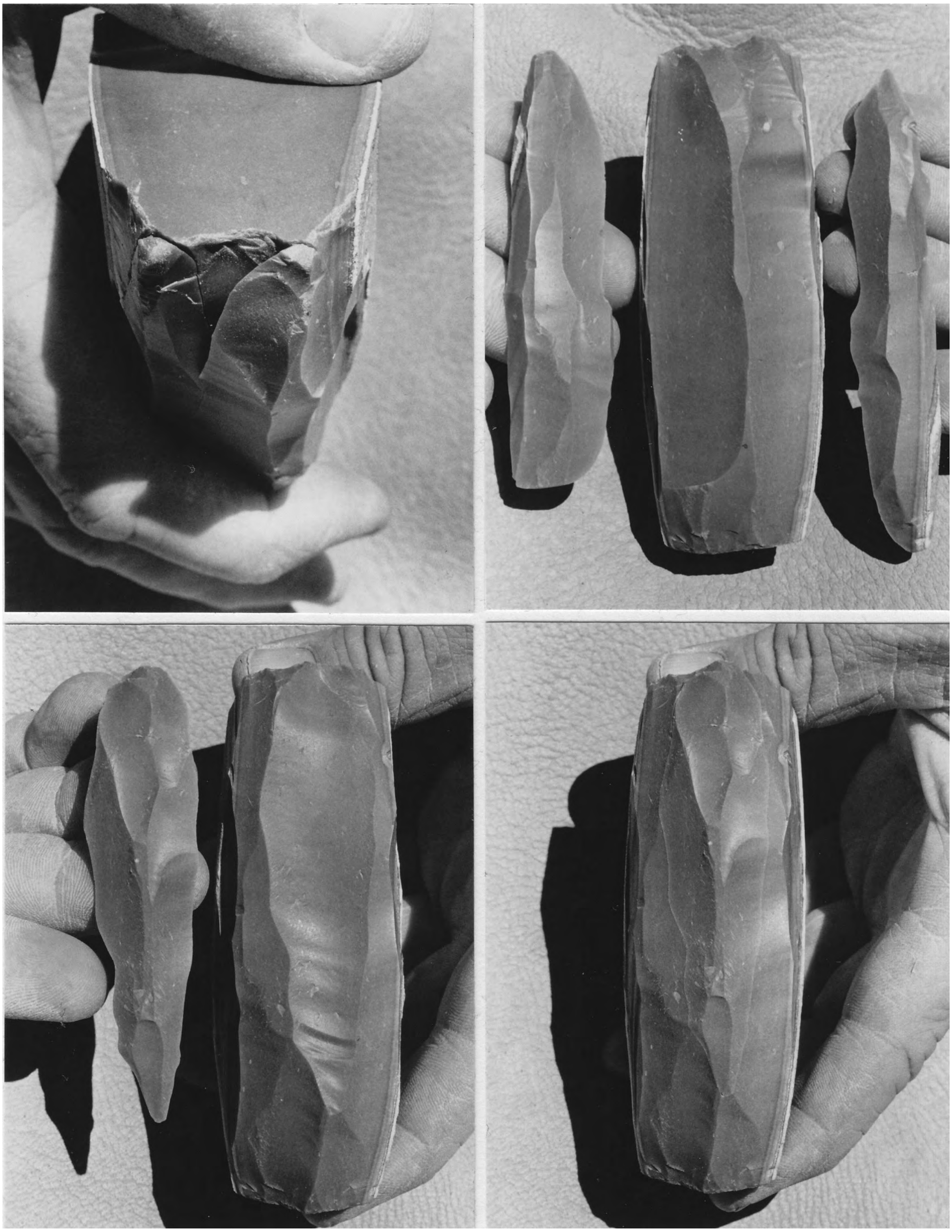


Plate 6.8. Reduction series: replication of blade production.
upper left isolation of blade platforms.
upper right two straight blade blanks taken from the lateral edges of core, from opposite platforms.
lower left blade (projectile point blank) detached from the core.
lower right blade repositioned on the face of the core to show how it had been configured prior to detachment.

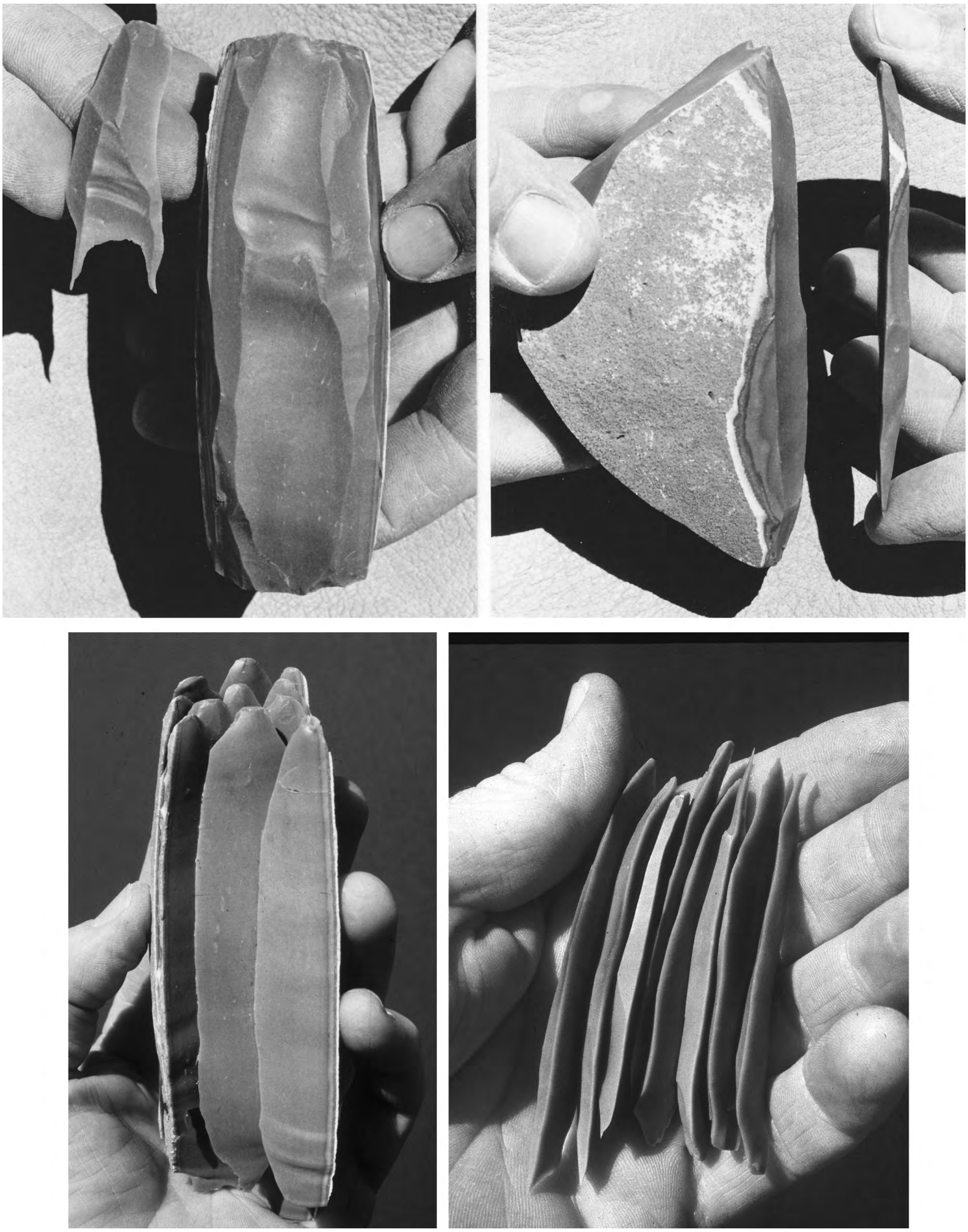


Plate 6.9. Reduction series: replication of core maintenance and blade production.
upper left ridge-straightening ("upsilon") blade removed from face of core to realign ridges following detachment of projectile point blank, as shown in Plate 6.8, lower left.
upper right blade detached in Plate 6.8, upper right, next to profile view of core face.
lower left refitted blades, same reduction. *lower right* replicated blades.

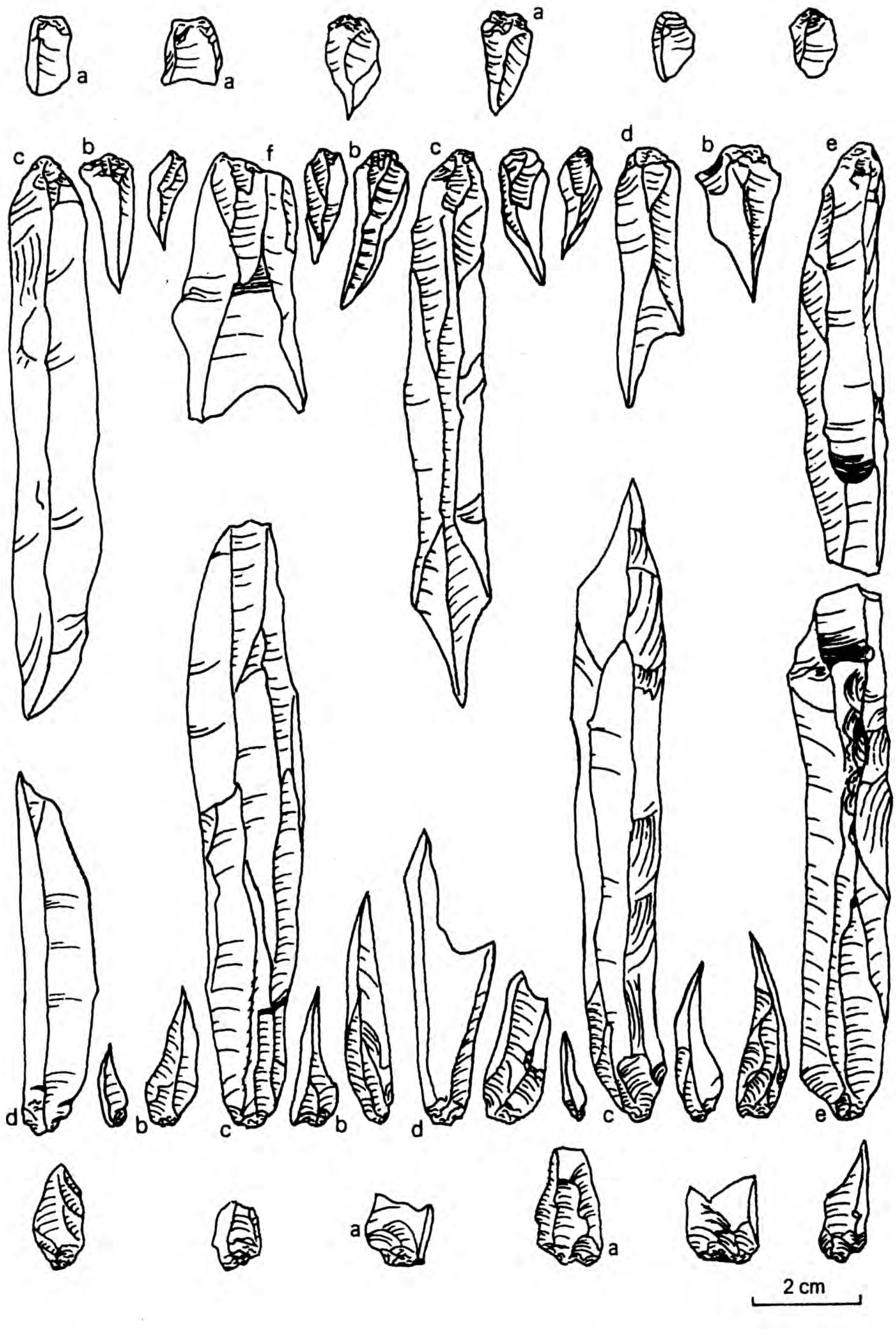


Fig. 6.1. Blade-production debitage: schematic view. Products and by-products of core reduction and maintenance in their approximate technological orientations as they would appear on the face of a core. *a* edge-preparation flakes; *b* platform-isolation elements; *c* blade products; *d* ridge-straightening blades; *e* hinge- or step-removal blades; *f* profile-correction blade. Compare to Table 6.1.

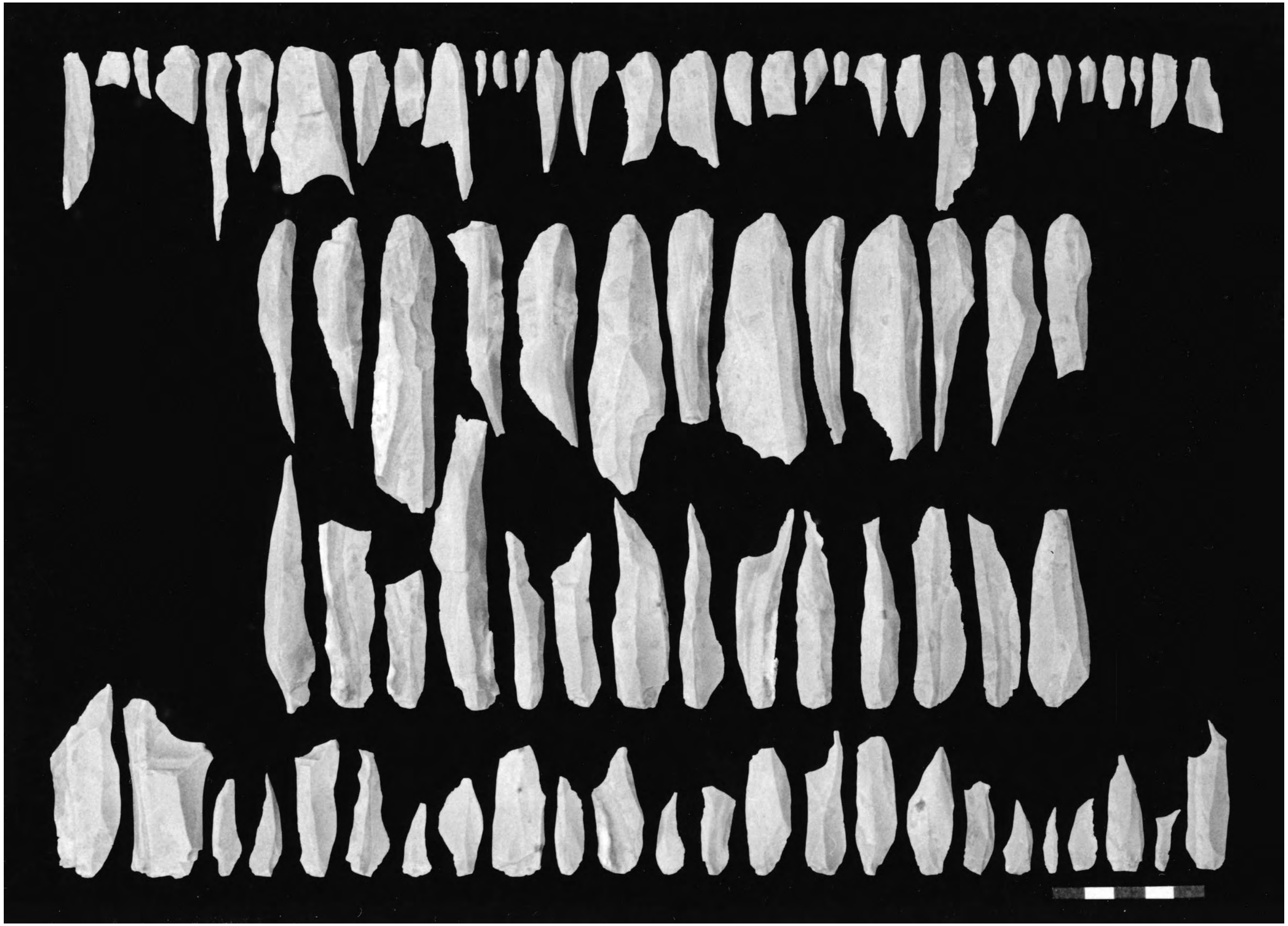


Plate 6.10. Typical blade-production debitage: replications. Technological types of debitage discussed in the text. Compare to Fig. 6.1 and Table 6.1. *upper and lower rows* edge-preparation flakes, platform-isolation elements. *center rows* ridge-straightening blade.

carry to the end of the core, but stop before overshooting, or plunging, at the opposite platform.

- Preparation of core platform margin was accomplished by removal of *edge-preparation flakes and bladelets* (Fig. 6.1; Plate 6.10),[1] small, short flakes and blades with broad, unprepared platforms.

4. One of the most important procedures for ensuring successful blade production was isolation of the platform of the intended blade. Such isolation enabled the blade to be detached with a very small amount of force, and resulted in the minute "punctiform" platforms that typify blades produced from naviform cores.
   - A series of *platform-isolation elements* (Fig. 6.1; Plate 6.10), or small, curved, blades and bladelets, were removed from both sides of the intended blade platform. These removals aligned the platform with the chosen ridge or ridges, and decreased the mass of the stone adjacent to the blade platform, thereby decreasing the width of the fracture that was necessary to release the blade from the core. Platform-isolation elements usually are recognizable by their wide, unprepared platforms and their strong lateral curvature.

5. In most cases, the platform area of the intended blade was abraded, thereby strengthening it to withstand the force of the hammerstone blow. Abrasion was particularly necessary because isolated platforms were very small and otherwise would tend to collapse. It is not uncommon on archaeological specimens, therefore, for abrasion to extend onto a small portion of the dorsal surface of the blade, thereby providing extra strength to the platform of the blade. Abrasion of the platform also roughened it, thus providing better contact for the hammerstone.

6. Blades were detached from the core with a downward and outward, glancing blow of the hammerstone, so that on contact the prepared platform of the intended blade was raked lightly with a flat face of the hammerstone. Very little force or shock to the stone was necessary. For the replication experiments described here, relatively soft limestone or very finely consolidated sandstone hammerstones were used for core preparation and for blade production. Limestone hammerstones of nearly identical configuration were discovered in archaeological material excavated from ‘Ain Ghazal after these experiments were conducted.

7. *Initial blades*, the first blades detached from the core, may have a variety of forms, depending on the configuration of the stone that was used to form the core (Plate 6.11; Fig. 6.2). Sometimes combinations of these forms were used.
   - *Crested blades* were produced by detaching a bifacially prepared front margin of a core. This margin became the dorsal ridge of the initial blade. Crested blades reflect the preparation that was used in forming the initial margin of the core, so that they may be finely structured, even pressure-flaked, or only partly or unifacially crested. They may be detached entirely from one end of the core, or both platforms may be

[1] Small blades, or "bladelets," are common in the ‘Ain Ghazal collections. Most of these are byproducts of preparing the edge, or margin, of the core, or result from isolating blade platforms. They generally are identifiable by their irregular, curved morphology, and by platforms that usually are unprepared. A small number of bladelet cores specifically intended for production of bladelets are present in the PPNB assemblage from ‘Ain Ghazal (see Chapter 7), although true microblade cores are all but absent.

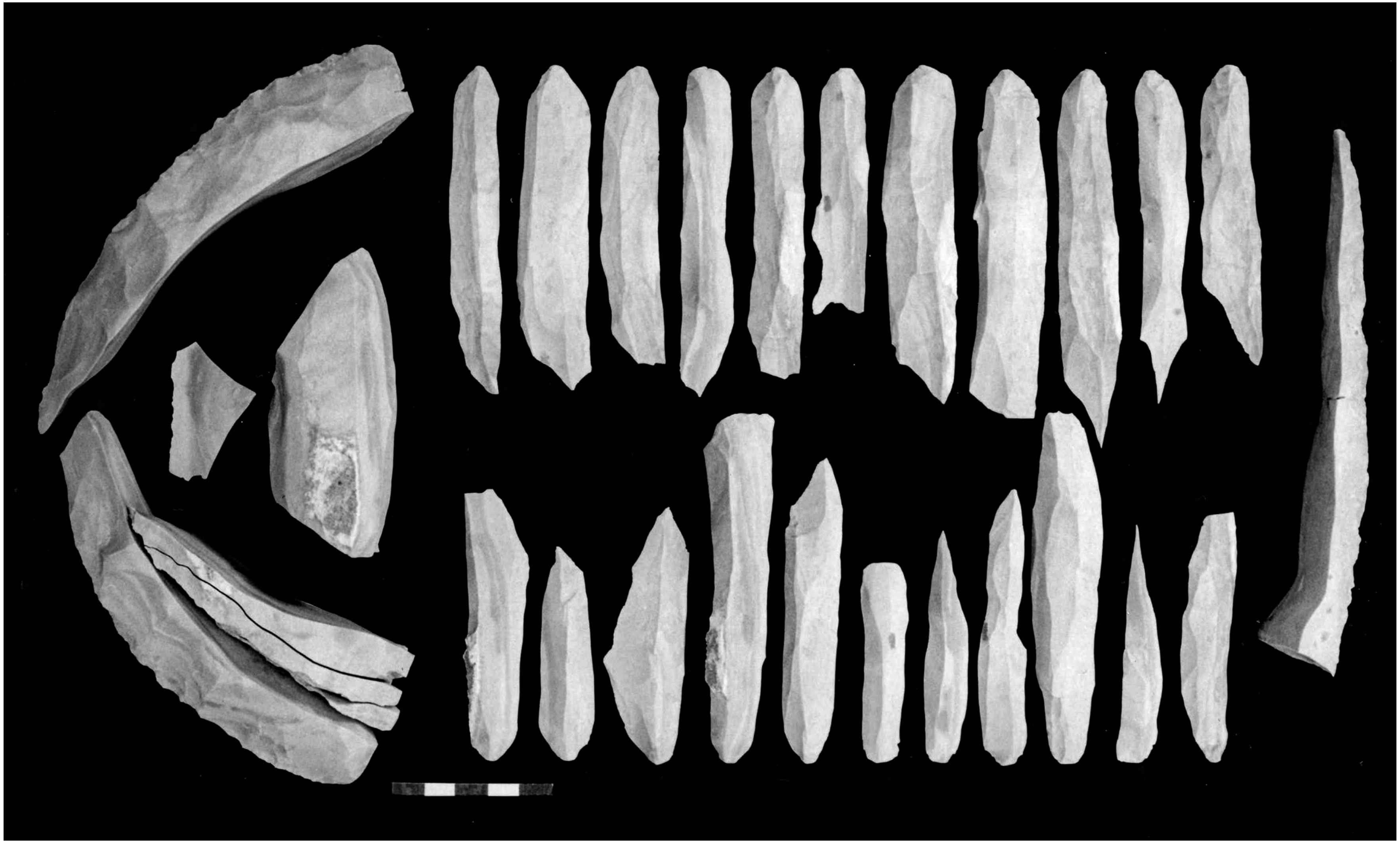


Plate 6.11. Naviform core reduction: exploded view. Blade products, platform spalls, initial blade, and exhausted core that go with the debitage in Plate 6.10, all in their technologically correct orientations.

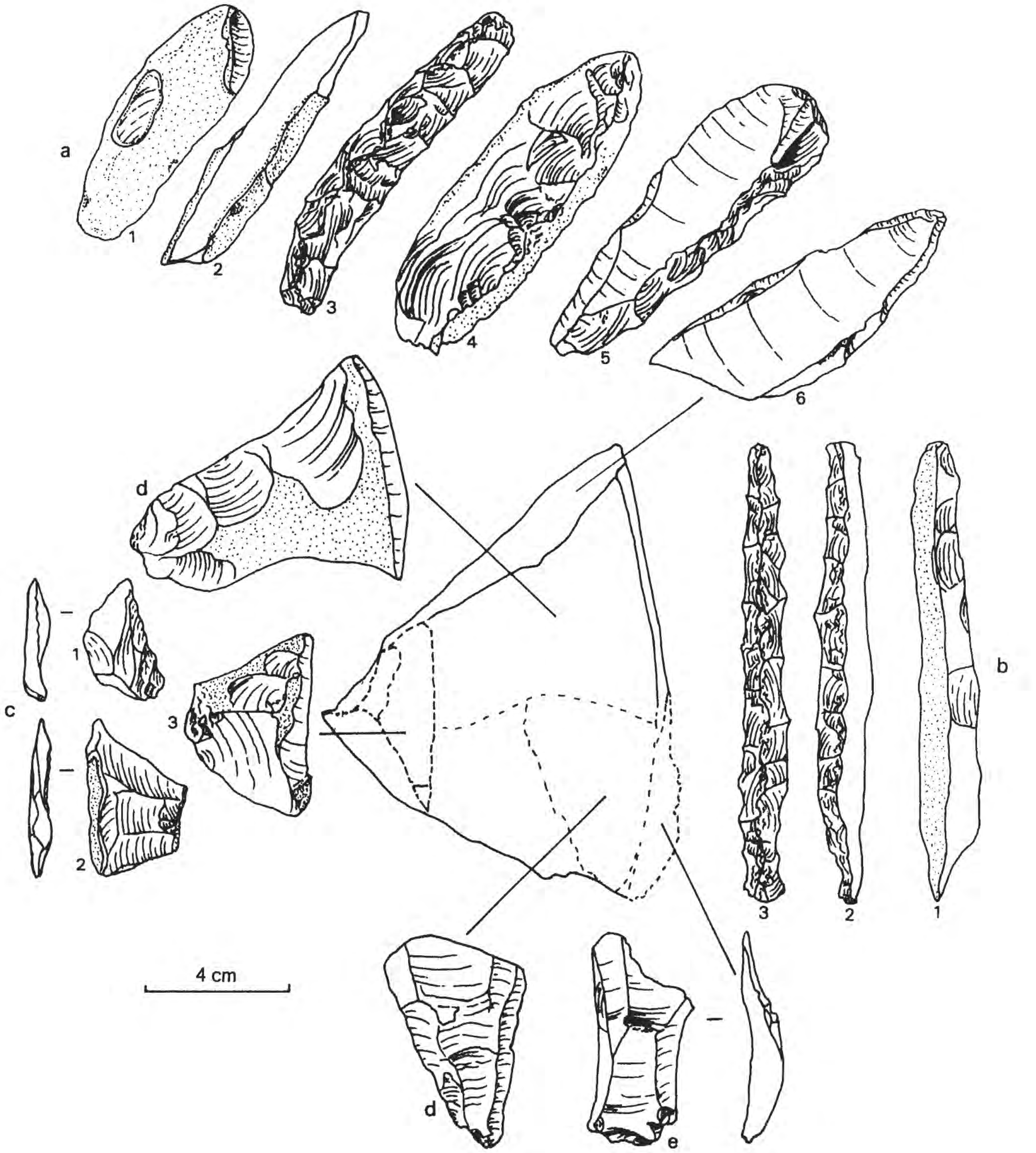


Fig. 6.2. Schematic view of idealized representations of core-preparation and core-maintenance debitage. By-products are shown both detached and refitted on the core. *a* platform spalls (1, natural, nodular flint; 2, natural, tabular flint; 3, bifacially crested; 4, faceted; 5, corrective, flat); *b* initial blades (1, natural ridge; 2, unifacial ridge; 3, bifacially crested); *c* back core-trimming flakes (1, alternate flake; 2, faceting flake; 3, back-trimming flake); *d* lateral core-trimming flakes; *e* profile-correction blade.

used to remove a portion of the crest. Their function is to initiate blade production by establishing the first ridges on the face of the core. In the 'Ain Ghazal collection, crested blades are the most common form of initial blade.
    - *Unprepared*, or natural initial *blades*, may be detached from an unprepared margin of a core, such as a natural cortical edge of a narrow nodule or the right-angle margin of tabular flint.

8. *Noninitial blades* are all blades subsequently detached from the core, both blade products and by-products of blade production and core maintenance.
    - *Intended blades* are the "products" of the reduction (Plate 6.11). During blade production, intended blades were carefully prepared on the face of the core, as discussed above. This careful preparation was not as common for maintenance blades.

9. During core reduction, both platforms normally were used for blade production, so that both the blades and working faces of the cores may display bidirectional scars of previous blade removals (Plate 6.11). Both core platforms usually were exploited for blade production to the same general degree, although not sequentially, as mentioned previously. This pattern of use is a natural result of the dynamics of the reduction process that typically affords each platform a favorable position for blade production, core maintenance, and error correction at some point during the reduction. Use of both platforms preserved the symmetry of the core thereby encouraging continuation of the blade-production process. Vagaries in the reduction process sometimes resulted in the preferential use of one platform, especially towards the end of the reduction process. In these cases, the resulting blades would tend not to display bidirectionality and they may not be recognizable as products of such a core configuration.

Core Maintenance

As with all types of blade-core technologies, maintaining the core during reduction was a major concern. Both the face of the core and the general shape of the core required adjustments and repair during core reduction to ensure continuation of the blade-production process. The face of the core was shaped and kept free of defects during the course of blade-production and core maintenance. Occasionally, it also was necessary to adjust the morphology of other portions of the core in order to regain the proper flat-sided, triangular form.

1. Sometimes blades failed during detachment, or failed to carry to the opposite end of the core, and marred the face of the core.
    - *Hinge- and step-removal blades* ("clean-up blades") were detached to removed irregularities caused by hinge terminations or step terminations.[1] They were detached from the opposite end of the core (Fig. 6.1; Plate 6.12, upper). Such blades are common in archaeological collections, and exhibit the problem that they removed on their dorsal surface. They exemplify the advantage of using two opposed platforms for blade production and core maintenance. "Upsilon" blades

---

[1] Hinge terminations result when the fracture that is detaching a blade stops prematurely. The fracture loses energy and rolls away from the face of the core. Step terminations are the result of angular fractures that cause a portion of the blade to break away from the core, thereby halting detachment. Both types of blade terminations disfigure the core face and impede the reduction process, until maintenance measures are invoked.

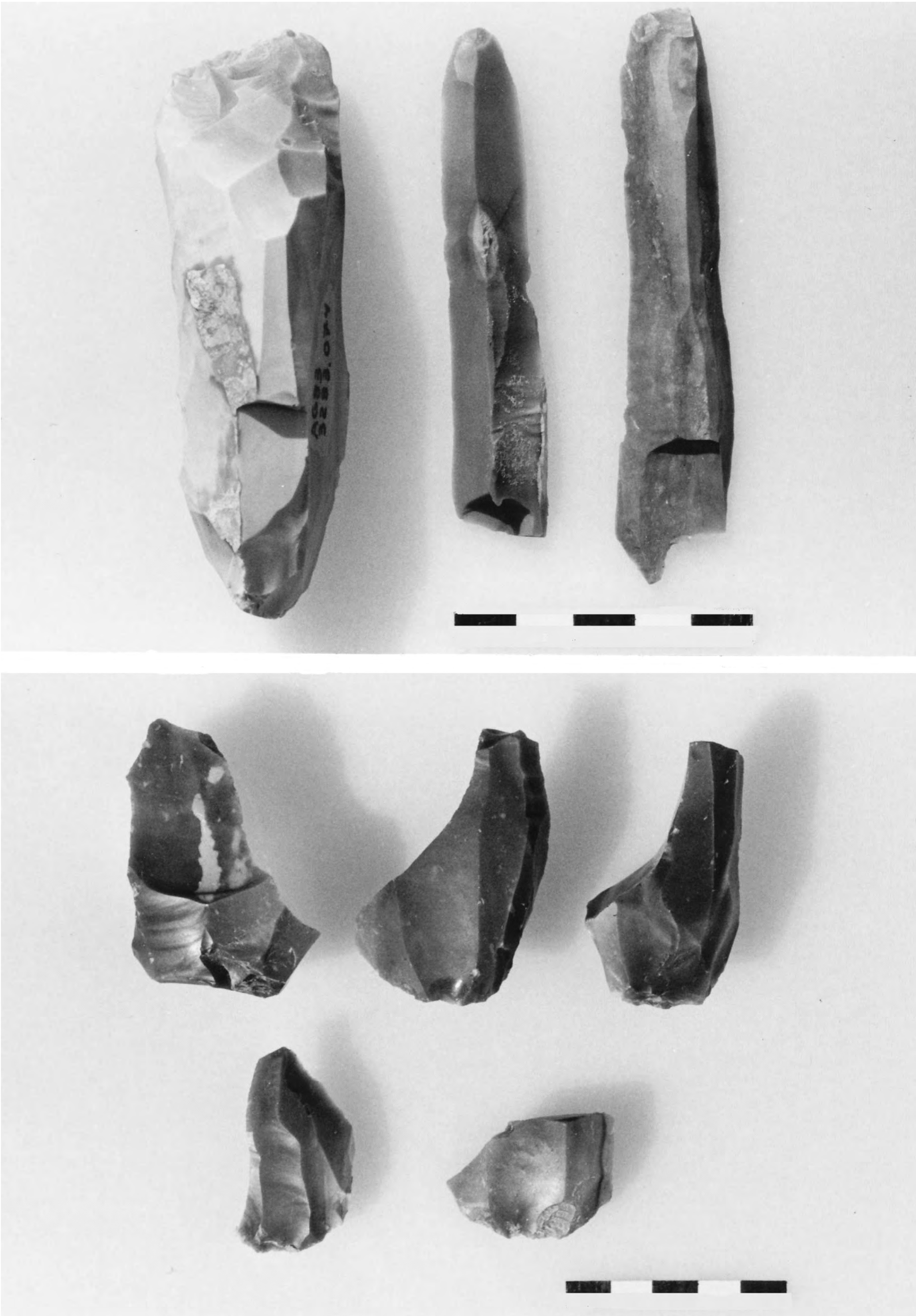


Plate 6.12. Error-correction debitage and errors: “clean-up” blades and overshots.
upper archaeological “clean-up” blades that successfully removed step-termination blemishes from the core face.
lower archaeological overshot blades (distal fragments). The upper left blade in the lower photo successfully removed a defective core platform margin and a step termination from the face of the core. The others were errors that removed large portions of the opposite platform of the core.

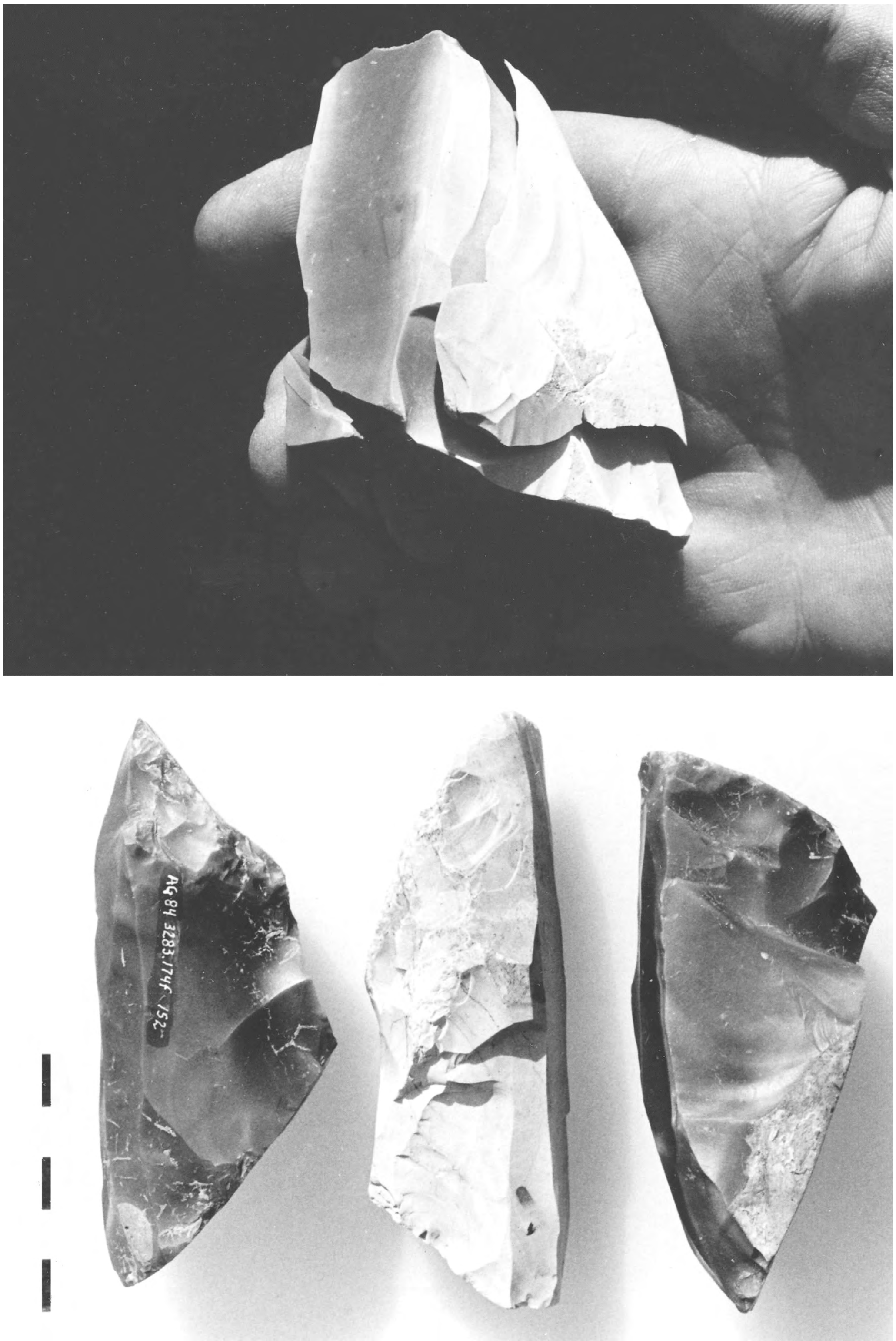


Plate 6.13. Lateral core-trimming elements.
upper replicated core with lateral core-trimming flake removed following detachment of a back-trimming flake (*lower left*) to prepare a striking platform.
lower archaeological cores with maintenance scars from the removal of lateral core-trimming flakes.

also were used for this purpose. Successful detachment of hinge- and step-removal blades is a very skillful flint-knapping maneuver.

- *Profile-correction blades* (Fig. 6.2) are short, thick blades that were removed from one end of the core face to eliminate a bulge and flatten (straighten) the face of the core. Detachment of profile-correction blades was necessary when one platform was used to produce several blades that ended short of the opposite platform, thereby creating a bump in the core face near the opposite platform.

2. In some cases, blades were produced with such force that they removed a portion of the opposing platform of the core.
    - *Overshot blades* were either accidentally produced, the result of excessive force that was directed along a prominent ridge line, or, they were intentionally produced to remove a portion of a defective platform at the opposite end of the core. Accidental overshot blades are not uncommon in the archaeological record, and both initial blades and noninitial blades were created in this fashion (see Plate 6.12). In extreme cases, overshot blades were detached with sufficient force to sever a major portion of the opposite platform and effectively destroy the core (Plate 6.12, lower). Often these "death-of-core" blades were initiated by detaching a blade down one side of the core face along the strong ridge that configures the lateral margin. Such detachments then turn abruptly clipping off the margin of the core platform, with catastrophic results. The intentional detachment of an overshot blade to remove a defective platform margin is present, but not common, in the archaeological assemblage from ʻAin Ghazal. Use of overshot blades in this fashion as a maintenance maneuver requires very high levels of flint-knapping expertise.

3. Core maintenance also was necessary to retain the parallel-sided form of the core, and to adjust the width of the core during reduction.
    - *Lateral core-trimming flakes* (Plate 6.13) flattened the sides of cores and were detached from the margins of the platforms, from the backs of cores, or even from lateral margins of flat, core faces. Evidence for these maneuvers are negative flake scars of lateral core-trimming flakes that emanate from core platforms, core backs, and core faces. Lateral core-trimming flakes characteristically are broad, flat, and expanding, and may carry the remnant scars of a core face or platform on their lateral or distal edges.
    - *Back core-trimming flakes* sometimes were detached in order to create platforms for removal of lateral core-trimming flakes. Consequently, core-trimming flakes resulted from both core preparation and core maintenance.

4. Platform "rejuvenation" spalls are quite common in archaeological collections, but experience has shown that most of these spalls resulted from reconfiguring the core platform during core preparation, rather than from core maintenance actions. Nonetheless, it sometimes was necessary to create a new platform on one end of a core when the existing platform became defective.
    - *Corrective platform spalls* were detached to fashion new platforms, and usually were detached from the face of the core. Most corrective platform spalls were either faceted or, more commonly, flat spalls that retained a defect on their dorsal surfaces (see Fig. 6.2).

Termination of the Production Process

Blade detachment generally continued until cores became too small to produce blades of adequate length, or until cores became too short or lost too much mass to be held effectively, and ceased to be productive. At this point most cores were discarded, although some cores were recycled as tools (or as other types of cores) (see Chapter 7). In the course of the replication experiments described here, a normal yield of blade products from a standard-sized, MPPNB core was 20-25 good-quality blades (see Plate 6.11, for example).

NAVIFORM CORE-AND-BLADE TECHNOLOGY: CONSTRAINTS AND BENEFITS

The PPNB naviform core-and-blade technology resulted both from the tool needs of the Neolithic economy, and from the character and technological requirements of the raw materials that were available in the lithic landscape. The influence of both of these constraints on the structure of the technology has been explored and several important aspects of the technology are evident. Naviform core technology was a sophisticated method of producing blanks for the very specific requirements of Neolithic tools. Both archaeological tool assemblages and blade products from naviform core reductions attest to the need for versatile tool blanks of regularized form. The naviform core reduction strategy was selected and used nearly exclusively, supplanting all other types of core reduction approaches, because it satisfied these needs better than any other strategy.

Use of naviform cores allowed better control over blade morphology than was possible with previous percussion-blade technologies used in the Levant. Most importantly, it produced standardized tool blanks consistently, in a predictable and reliable fashion. Various configurations and types of stone[1] were manipulated to create carefully structured, equivalent core morphologies, with parallel sides, flat working faces, and standardized lengths and widths. The unique design of the core allowed blades to be shaped on the face of the core prior to detachment. A select repertoire of flint-knapping tactics and equivalent core forms produced blade products of specific size and configuration. The focus on one or another blade-blank type (*e.g.*, projectile point, sickle blade, etc.) would have been dictated by the tool needs at a particular time, whether on a daily basis at ‘Ain Ghazal, for instance, or during different phases of the evolution of the PPNB. These shifts in blank selection would reflect changes in subsistence and other cultural needs.

It is also evident that naviform core reduction and blade production, as exemplified by the MPPNB collection from ‘Ain Ghazal, entailed a sophisticated sequence of manipulations, all of which required skillful flint-knapping. Technological control and skill, and the exceptional tool blanks that were created all attest to this fact. Blades were “set up,” or preconfigured, on the core face, platforms were isolated to an extreme degree, and blades were detached with high levels of expertise. In essence, blades were “peeled” from the face of the core. The resulting archaeological blades are thin and well formed, and have distinctive, punctiform platforms that are so characteristic of the technology. The replicative experiments described above and the blade-manufacturing experiences of others (*e.g.*, J. Clark 1987) have demonstrated that the production of high-quality blades, such as those described here, required constant knapping in

[1] In addition to flint and obsidian, we now have evidence that orthoquartzite was used in some contexts during the PPNB in Jordan to create naviform cores and blades (Wilke *et al.* 2007).

order to maintain the requisite skill level to create the industries. This fact mitigates against the casual production of blades within the context of a generalized, subsistence-level, lithic economy.

In reference to prehistoric Mesoamerican peasant economies, some researchers (Santley 1984; Mallory 1986; also see Santley *et al.* 1985) estimated household blade consumption of a typical agricultural family to be quite low, perhaps 20-50 blades per year for a family of five individuals. While there have been no equivalent studies or estimates for the Neolithic Near East, these levels may well be realistic approximations for requirements of Near Eastern Neolithic peasant families, such as those at ‘Ain Ghazal as it flourished during the MPPNB. Recall that an average experimental reduction of a naviform core produced about 20-25 good blades. Even discounting the fact that flint blades are more durable than the obsidian blades used by Mesoamerican families, the average family at ‘Ain Ghazal might have required the reduction of only one or two cores per year, if all of their blades needed to be replaced annually. Such a task would have required roughly 40 minutes of blade-production time. These extremely low consumption rates and concomitant brief manufacturing episodes are strong arguments that blades were not made by individual farmer/flint-knappers for their own needs, but by craft specialists who made blades in a consistent fashion for other members of the community. As J. Clark noted for Neolithic economies of Mesoamerica,

> Quite simply, a craftsman could not maintain any degree of skill at this low production rate. Each annual knapping session would be analogous to learning the technique anew, a self-defeating exercise since it would result in a higher number of knapping errors and inferior blades. The minimal skill requirements alone dictate that production be undertaken by a few for many. (1987: 272)[1]

In sum, the development of the naviform core-and-blade technology resulted from the fortuitous combination of tool requirements of the Neolithic lifestyle, the availability of appropriate raw materials in the nearby lithic environment, and an economic situation that fostered diversification of industrial activities. The coincidence of necessary lithic resources, technological necessities, and economic demands of settled village life appears to have initiated selection and subsequent development of the technology, a technology that required, in turn, the specialized expertise of a few individuals who provided essential products for the rest of the community.

[1] This argument was first proposed by Clark in reference to obsidian pressure-blade production in the Middle Formative period in Mesoamerica (*ca.* 600 B.C.). Nonetheless, this period is essentially the “Neolithic” of Mesoamerica, and economic demands of ordinary peasant families are likely to be comparable to those of the Neolithic Near East.

Chapter 7

DEBITAGE ANALYSIS

In spite of technological and temporal variations in assemblages, PPNB lithic technology is characterized in a general fashion by a reliance on naviform blade cores for the production of blade-tool blanks. And while naviform cores and blades are not unknown from these periods, the PPNC and PN are typified by the reduction of flake cores. These patterns are well recognized in regional studies (*e.g.*, Moore 1982; Crowfoot Payne 1983; Gopher 1989; Rollefson 1990a; Gopher and Gophna 1993), but there remains much ambiguity regarding both the nature of technological variability within these broad periods and the technical and economic implications of these strategies of tool-blank production. A particularly vexing problem is the difficulty in assessing the role that naviform core technology held in the evolving lithic economy of ‘Ain Ghazal, since naviform core-and-blade debitage and blade products from naviform core reductions persist throughout the occupational sequence of the town, although in varying frequencies.

These concerns are addressed here with a comprehensive technological analysis of the by-products of tool-blank manufacturing, and the individual character and intrasite distribution of production loci. Specifically, loci of core-production and core-reduction debitage were studied to document when and in what contexts naviform cores were actually produced and reduced at ‘Ain Ghazal. In addition, debitage assemblages, including individual debitage loci of core production, core reduction, and tool production from the MPPNB, Late PPNB, PPNC, and the Yarmoukian, or Early Pottery Neolithic,[1] periods were analyzed to understand what these lithic manufacturing data reveal about the organization of tool production at the townsite.

ANALYTICAL PROCEDURES AND RATIONALE

Since in-depth debitage analyses are infrequent in Near Eastern lithic studies, loci of lithic debitage are essentially unstudied, and, perhaps, unappreciated for the extensive behavioral information that they contain.[2] It is often the case, for example, that debitage data are assigned collectively to uninformative “chips and chunks” debris categories. Consequently, there are few comparative technological data from other Neolithic sites that would be useful for evaluating the patterns observed in this study and for making regional comparisons. It is worth considering that researchers working in other geographic areas have found technological analyses of debitage to be invaluable aids for interpreting lithic economic behaviors. For example, it is possible in many instances to differentiate primary reduction loci from secondary debris deposits, core-reduction loci from tool-production loci, and workshop localities of specialists from generalized production areas, and so on (*e.g.*, Healan *et al.* 1983; Shafer and Hester 1983, 1986; but see Mallory 1986; J.

[1] MPPNB, *ca.* 9,250 - 8,500 B.P.; LPPNB, *ca.* 8,500 - 8,000 B.P.; PPNC, *ca.* 8,000 - 7,700 B.P.; Yarmoukian PN, *ca.* 7,700 - 7,100 B.P.

[2] Analysis of a debitage locus at PPNB Kfar HaHoresh in Israel is a notable recent exception (Goring-Morris 1991, 1994).

Clark 1986a; Michaels 1989; J. Clark and Bryant 1991). Analyses of this type are useful for addressing several current analytical difficulties regarding Neolithic assemblages.

A significant issue for the current study is whether naviform core-and-blade assemblages resulted from the work of a few specialists, flint-knappers who produced tool blanks for use by other people in the community, or whether household members tended to produced their own cores and blanks for tools. Tool data are not particularly useful for this analysis since many Neolithic tools are very informal and resulted from only minimal alteration of a wide variety of tool blanks (*e.g.*, cores, core-production flakes and spalls, and diverse forms of blades and blade-production debitage). Consequently, it is not readily apparent whether individual lithic subassemblages resulted from tool production, the reduction of cores and the creation of tool blanks at primary reduction loci, the curation of blanks for future use at secondary deposition loci, scavenging of tool blanks from ancient deposits, the industrial activities of specialists or nonspecialists, or merely the accumulation of debitage waste that was discarded at a "dumping" locus.

Pertinent technological attributes that give evidence for these activities are discussed below, but it is important to note here that valid interpretation of these attributes depends initially on experiments in lithic replication. Since we lack historical documentation and ethnographic analogies to Neolithic core technologies, particularly naviform core technology, the only practical means available to establish a comparative standard for evaluation of the data is replicative experimentation.[1] For the following analyses, replicative experiments were conducted on the production and reduction of naviform cores, other types of blade cores and flake cores, and on tool-production techniques that were used at 'Ain Ghazal, all in order to understand the technological origins of the resulting debitage. Replication experiments also provided a clearer awareness of tool-blank criteria and tool-blank preparation.

In addition, an initial assessment of the temporal distribution of core types revealed important fundamental patterns in their occurrence during the various periods. Core data were compared to the analyses of debitage loci in order to evaluate evolving economic strategies in use during 'Ain Ghazal's lengthy occupation. These strategies are best considered in regard to the following:

1. Temporal changes in core production and reduction, especially concerning naviform cores
2. The range of core-reduction strategies used within a given period of occupation
3. Technological and economic implications of debitage loci and their distributions
4. Technological and economic implications of tool-production techniques

CORE DATA: CORE TYPOLOGIES AND THEIR TECHNOLOGICAL IMPLICATIONS

While general patterns of lithic assemblages of periods and phases are important to recognize, it is sometimes the case that by establishing generalizations the richness of an industry is unrecognized, or the merits of its diversity are unexplored. For this reason, 1,542 (Table 7.1) cores in the 'Ain Ghazal collection were studied to understand technological and chronological variables within and between subassemblages, and to assess the technological and economic significance of their attributes.

[1] Core refitting studies may be useful in this regard as well, but have doubtful practical application to large, multicomponent, townsite deposits such as 'Ain Ghazal where product dispersal and debitage disposal were ongoing events.

Naviform Blade Cores

The blade- and flake-core assemblages excavated during the field seasons from 1982 through 1996 were examined for this analysis, which comprised several types of flake cores, and blade/bladelet cores, including 339 naviform cores. Together, these data sets represented all of the phases of occupation at ‘Ain Ghazal (Table 7.2). These data are summarized below, and their interpretation reiterates some of the conclusions that were expressed in the general discussion in Chapter 6 of naviform core technology.

Predictably, naviform cores are the dominant cores in MPPNB contexts, accounting for over 60% of the total core assemblage. Non-naviform blade(let) cores equal 8.4% of the total, and flake cores comprise over 30% of the MPPNB cores. Technological attributes of naviform cores produced throughout the MPPNB showed remarkable consistency in material selection, core morphologies, and reduction tactics. Overwhelmingly, the best flint from the Huweijir geological deposit was used (99.9%). Reduction manipulations, such as the basic configuration of precores, establishment of core widths, and platform and core-back preparations were extremely standardized. Regularization also is apparent in the relatively large size of most spent cores that were discarded at blade-production loci (Plate 7.1). These cores commonly were abandoned while still capable of producing blades, a behavior that undoubtedly reflects a reasonably “stone rich” economic situation. Nonetheless, many naviform cores that were recovered throughout MPPNB occupation areas of the site were also reduced further as flake cores (Fig. 7.1), or transformed into tools, such as pecking stones or percussors (Plate 7.2). Also, a small number of naviform cores made of very fine-quality stone became extremely exhausted, tiny, bladelet or flakelet cores, a tactic that probably related to the highly-desirable properties of the material as tool-stone.

Table 7.1. Inventory of core types: all periods.

Flake Cores	N	%	Blade Cores	N	%	Total
Single Platform	434	41.8	Naviform	339	67.4	
Multi-platform	300	28.9	Single Platform	122	24.2	
Bidirectional	154	14.8	Opposed Platform	20	4.0	
Discoidal	107	10.3	Bidirectional	13	2.6	
Opposed Platform	40	3.9	Remnant	8	1.6	
Bipolar	3	0.3	Microblade	1	0.2	
Total	**1038**	100.0	**Total**	**503**	100.0	**1541**

Table 7.2. Distribution of basic core types by period.

Period	MPPNB		LPPNB		PPNC		YARM/PN		MIXED[a]		
	N	%	N	%	N	%	N	%	N	%	Total
Core Type											
Naviform cores	182	61.1	46[b]	21.5	10	4.5	10	2.8	91	20.4	339
Other blade cores[c]	25	8.4	9	4.2	22	10.0	53	14.6	55	12.4	164
Flake cores	91	30.5	159	74.3	189	85.5	300	82.6	299	67.2	1038
Total	**298**	100.0	**214**	100.0	**221**	100.0	**363**	100.0	445	100.0	**1541**

[a] These cores were in stratigraphically mixed contexts.

[b] This number is slightly inflated due to the inclusion of 29 naviform cores from the 1995 season in the analysis, but the rest of the core assemblage excavated in 1995 was not available for inclusion in this analysis.

[c] This category is composed of blade cores and bladelet cores that are not of naviform-core configuration.

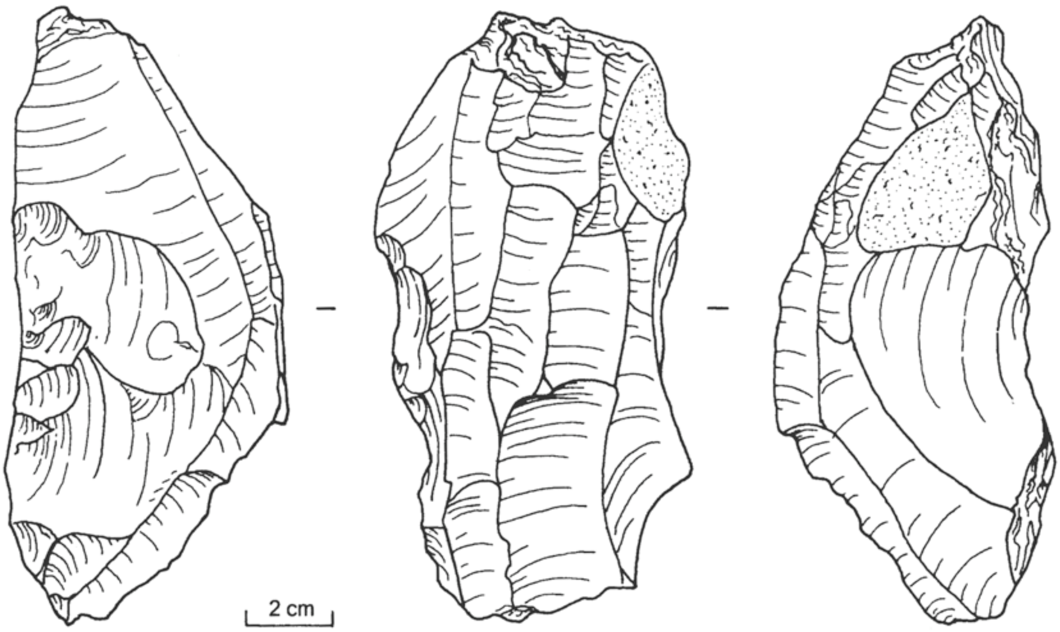


Fig. 7.1. MPPNB naviform blade core reduced as a flake core. *left* side view with core face on right. *center* face of core with remnant blade scars visible in middle of core.

Regardless of these events, a regularized, formal, core-reduction/blade-production approach persisted throughout the MPPNB accommodating various configurations of flint nodules to produce naviform cores that conformed to common constraints on morphology and size (Plates 7.3, 7.4). As discussed in Chapter 6, these characteristics are interpreted as reflecting standardization of the blade-production process.

In contrast, LPPNB naviform cores account for less than 22% of the cores in the sample,[1] other blade(let) cores for *ca.* 4%, and flake cores for over 74%. The MPPNB pattern was altered further so that consistency of material selection had deteriorated. Fine-quality Huweijir flint appears in somewhat lesser amounts and was augmented with more coarsely textured flint, stone that was little used for production of naviform cores during the MPPNB. Uniformity in naviform core morphology is much less apparent at LPPNB loci (Plate 7.5). Such reduction is evident in the generally smaller sizes, as well as the irregular shapes of LPPNB naviform cores. While core data alone do not reveal the use-life histories of LPPNB cores, these patterns reflect a broadening of resource choices and, perhaps, more industrious reduction of good-quality flint within the LPPNB community.

During the PPNC and Yarmoukian occupations, the LPPNB patterns of core occurrence and character were amplified, with flake cores (*ca.* 84%) far exceeding naviform cores (less than 5%) and other blade(let) cores (*ca.* 10% to 14%). Naviform cores from these periods generally exhibit reduction to the point of destruction, so that their origin as naviform cores is nearly indecipherable. Their final uses most often were as flake cores (Plate 7.6). At this point, it is im-

[1] The sample of naviform cores included 20 cores from the 1995 excavation, but the remainder of the core collection from this year was not available for analysis. This circumstance slightly increased the proportion of naviform cores and their apparent significance in the LPPNB sample; nevertheless, the overall trend is unaltered. Inclusion of this material was necessary for both technological and comparative purposes.

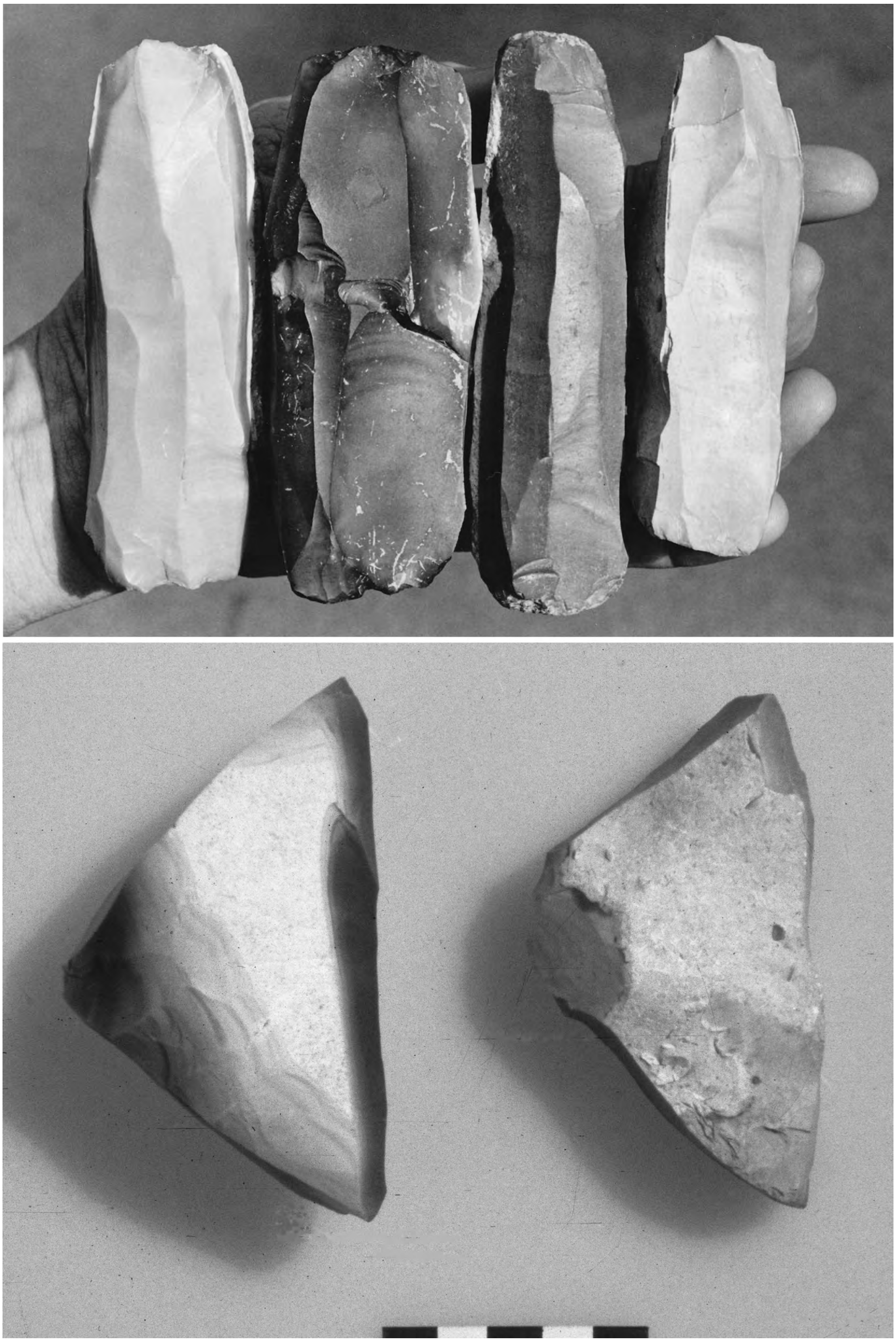


Plate 7.1. Naviform cores.
upper ‘Ain Ghazal MPPNB cores. Note regularization of core widths and typical large discard size.
lower side view of replica, left, and artifact. All artifacts depicted here and elsewhere in Plates 7.1 through 7.20 are from ‘Ain Ghazal deposits.

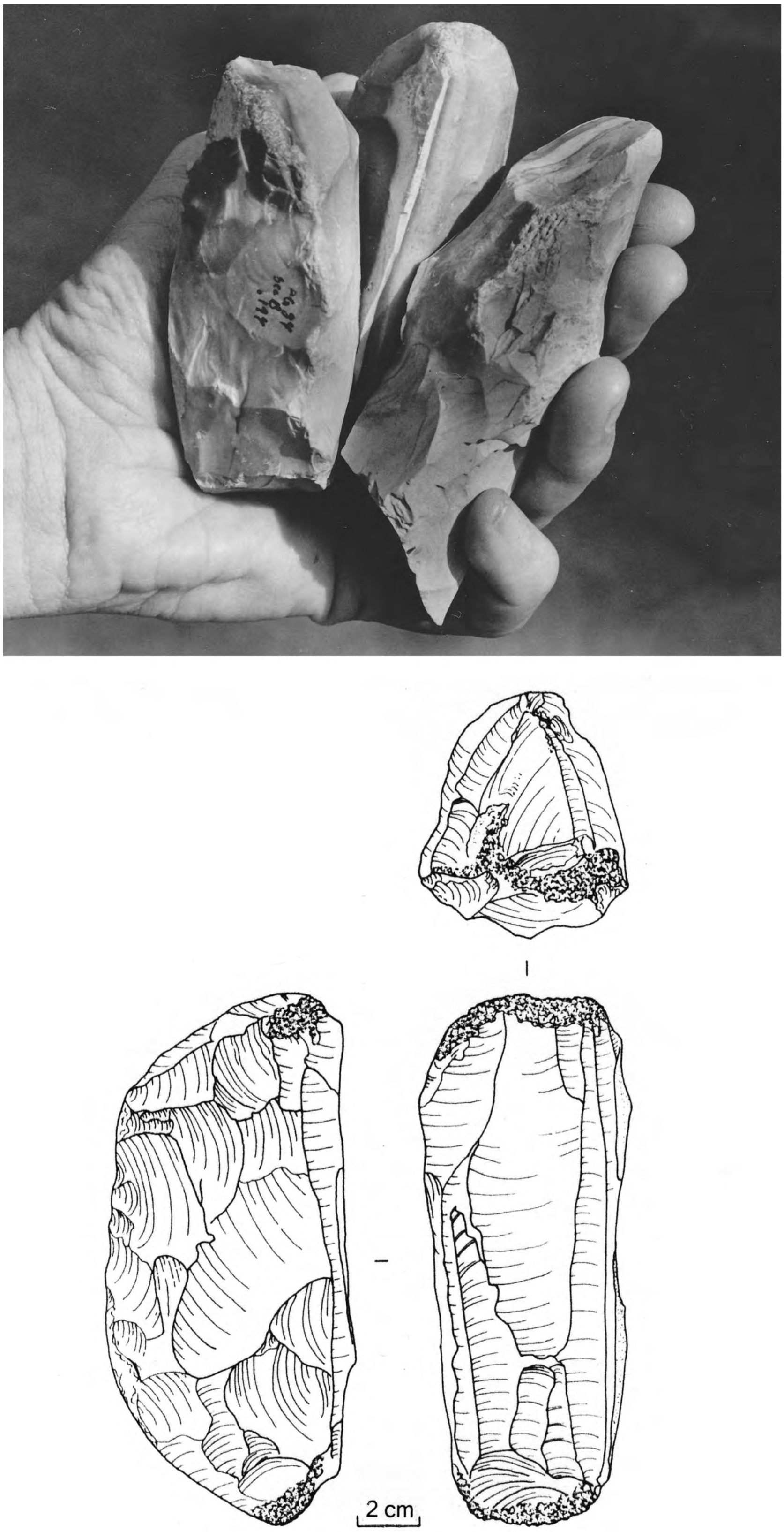


Plate 7.2. Exhausted MPPNB naviform cores recycled as percussors.
Note use of ridges and edges of cores for pecking or percussion.

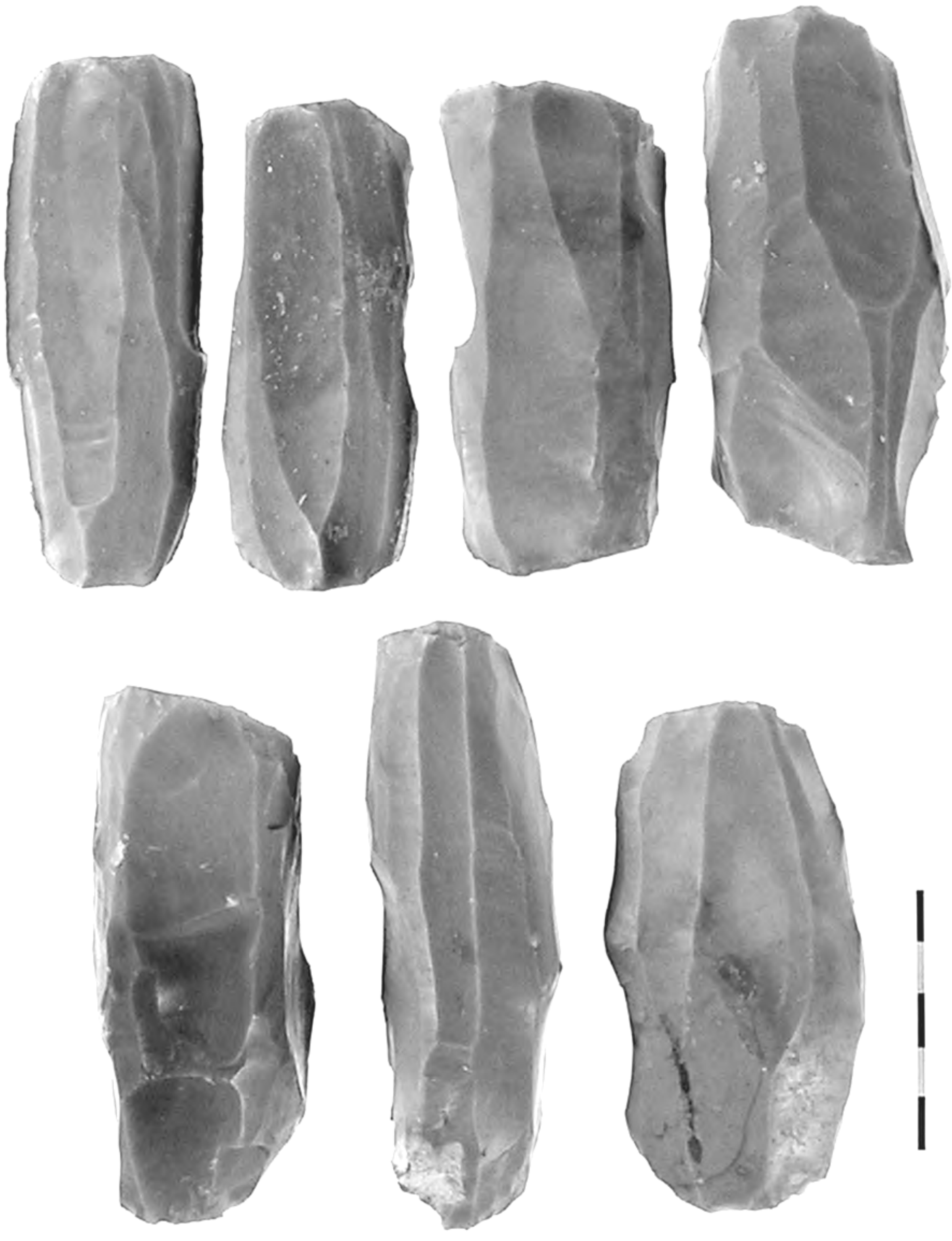


Plate 7.3. Face view of exhausted naviform cores from later MPPNB workshop (F14, locus 037). Note standardized morphology, sizes, and widths of cores.

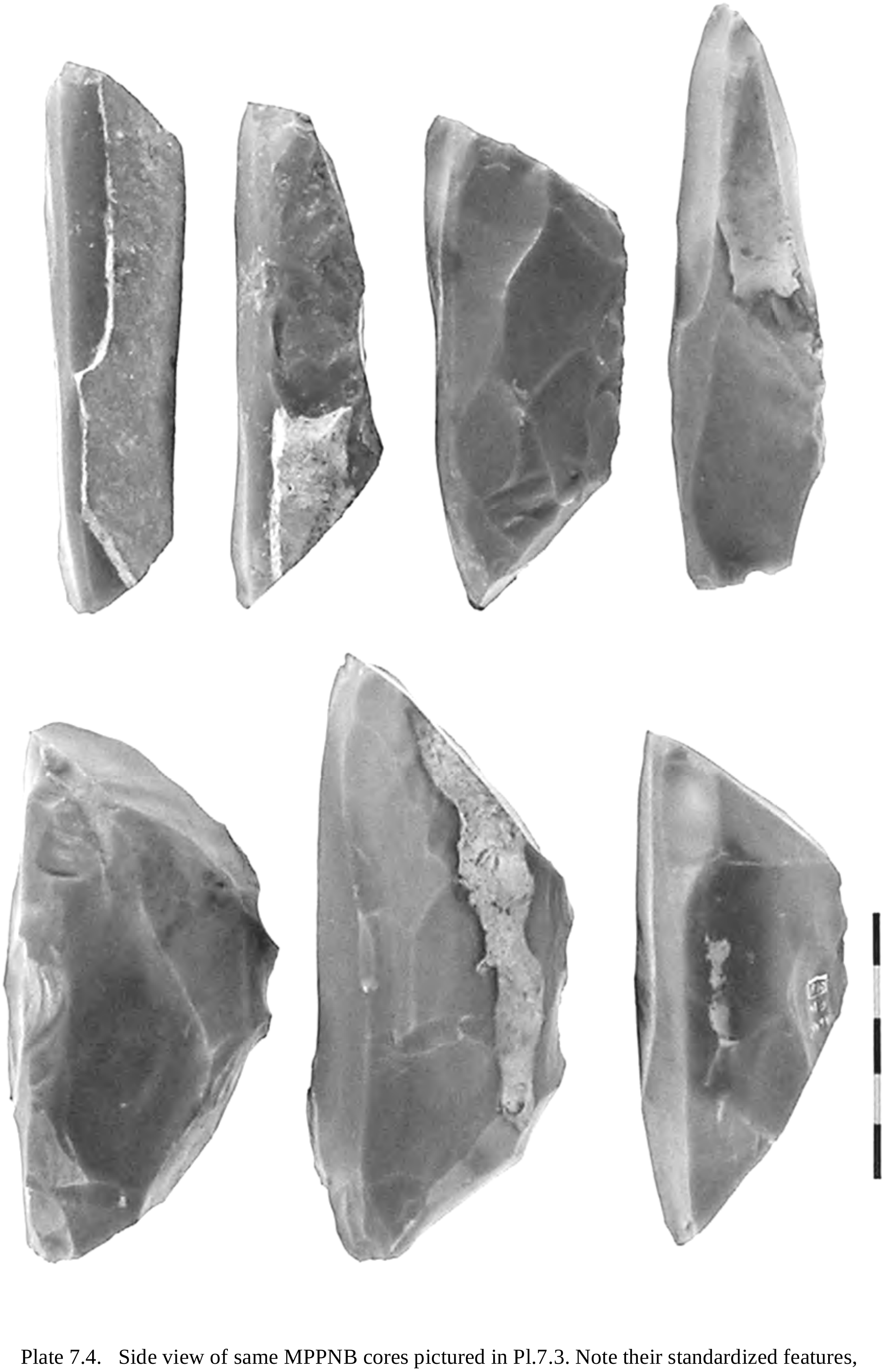


Plate 7.4. Side view of same MPPNB cores pictured in Pl.7.3. Note their standardized features, such as back trimming, side trimming, and straight working faces.

Plate 7.5. LPPNB naviform cores.
upper face view. *lower* side view, same cores, faces on right. Samples are from residential areas, nonworkshop chipping localities, and debitage debris dumps. Note unstandardized sizes and morphologies.

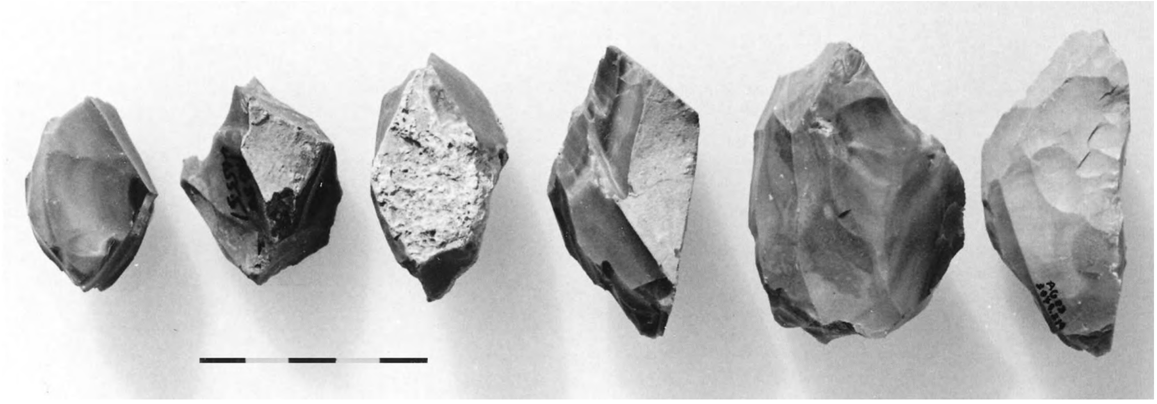


Plate 7.6. Naviform cores from PPNC and Yarmoukian contexts. Note obvious reduction as flake cores. Profiles, with faces of cores on left.

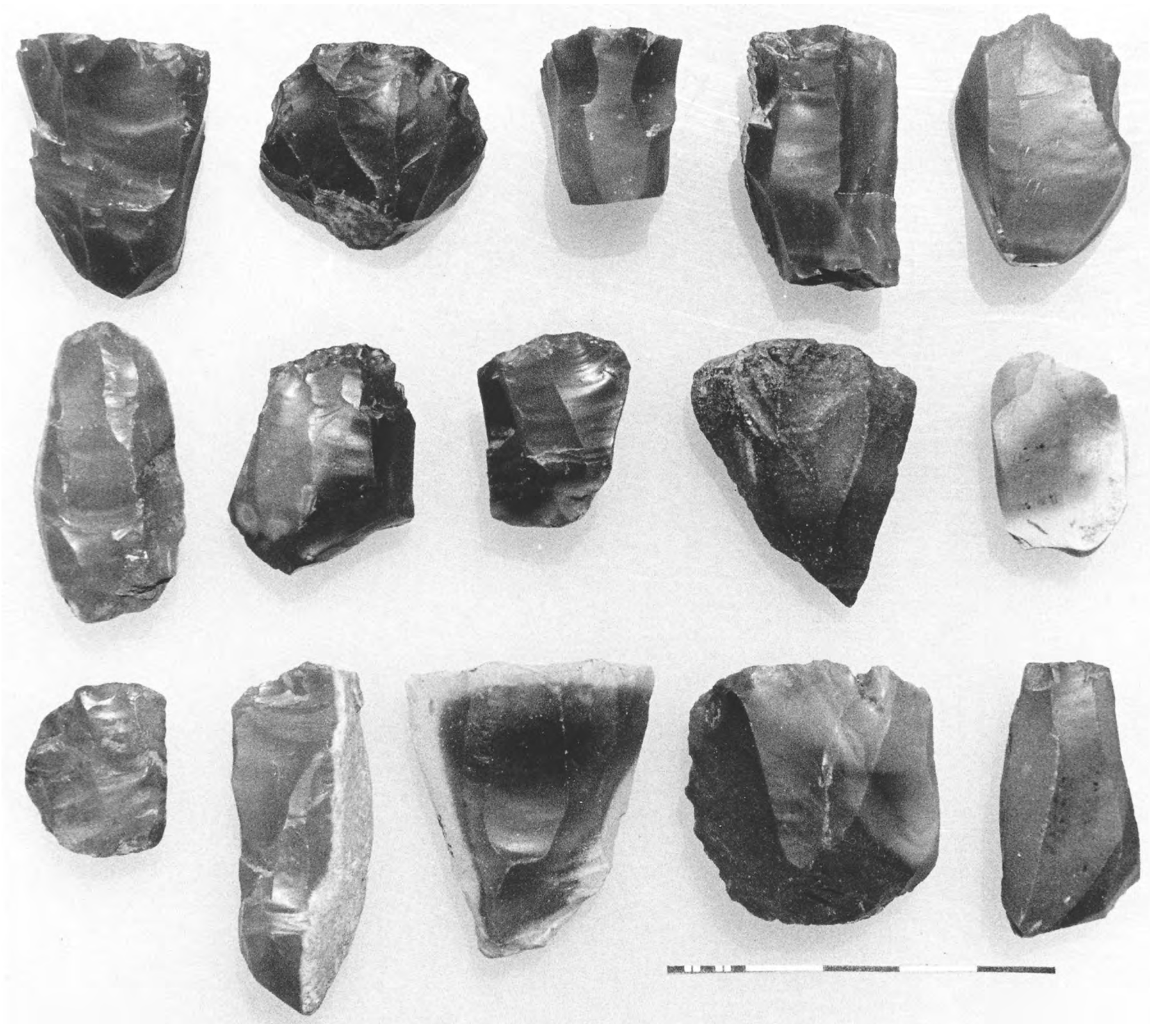


Plate 7.7. Typical single-platform bladelet cores. All periods.

portant to note that the presence of naviform cores in PPNC and Yarmoukian deposits does not necessarily give evidence for their initial production or reduction during these periods since they may have been reused cores that were gleaned from earlier deposits.

Non-Naviform Blade Cores

Throughout ‘Ain Ghazal’s occupation a small number of non-naviform blade(let) cores were produced. The 164 cores in this data base comprise between *ca.* 4% and 14% of the core populations for the various periods (Table 7.2), and represent a minor but consistent blank-production strategy. The majority are small bladelet cores (Plate 7.7), most of which were made from better-quality flint such as that found at Wadi Huweijir. The morphological configuration of many of these cores indicates that they could not have derived from an extended reduction of large blade cores, but were created originally as bladelet cores. Pebbles, flint chunks, and pieces of core-reduction debitage all served as bladelet-core blanks.

The remaining larger cores mainly were formed from wadi-rolled, flint cobbles, or of chert. Most (74.4%) are single-platform cores, although opposed-platform (12.2%), bidirectional (7.9%), and other (5.5%), sometimes fragmentary, cores also occur in the collection. All of these larger cores are informal blade cores (Plate 7.8), generally with single-facet platforms, minimal working faces, and unregularized morphologies, and bear little evidence of core maintenance or blade preparation. These reduction choices tended to produce coarse, unstandardized blade-blanks for tools. Such cores reflect casual blade-production strategies, and core production that undoubtedly relied upon easily accessible raw material available on, or adjacent to, the site proper.

Flake Cores

The 1,038 flake cores in this collection originated from all periods of occupation and demonstrate that the reduction of flake cores for tool blanks was a constant aspect of the lithic economy at ‘Ain Ghazal (Table 7.1). Even so, flake cores are represented in the lowest numbers in the MPPNB (31.5%), but constitute from *ca.* 70% to 85% of the reductions during all of the following periods (Table 7.2).

While flake cores were made of a variety of materials, there is an invariable pattern of raw material selection that also reflects a common repertoire of reduction strategies. The dominant material for large cores of all types was coarse-grained chert, although wadi-rolled flint was sometimes used as well. Diverse reduction tactics were used. Single-platform (41.8%) and multi-platform (28.9%) cores are dominant in all periods. Bidirectional (14.8%), and discoidal (10.3%) cores are common, and a small number (3.9%) of flake cores have opposed platforms (Table 7.1). During the Yarmoukian period, a few small pieces of very high-quality flint were reduced by bipolar reduction.[1]

[1] Bipolar reduction strategies are well-established internationally, and entail use of a hammerstone and anvil stone to break open and reduce small clasts of stone that could not be reduced easily otherwise. The strategy was commonly used when available clasts were small, or idiosyncratically when they were scarce, or otherwise especially desirable. The term “bipolar” indicates that the force of the blow rebounds from the anvil stone so the force is applied to the clast from both directions simultaneously, thus splitting the clast in two. The recent trend to use “bipolar” to describe a form of opposed, bidirectional blade detachment does not conform to accepted standard use of the term.

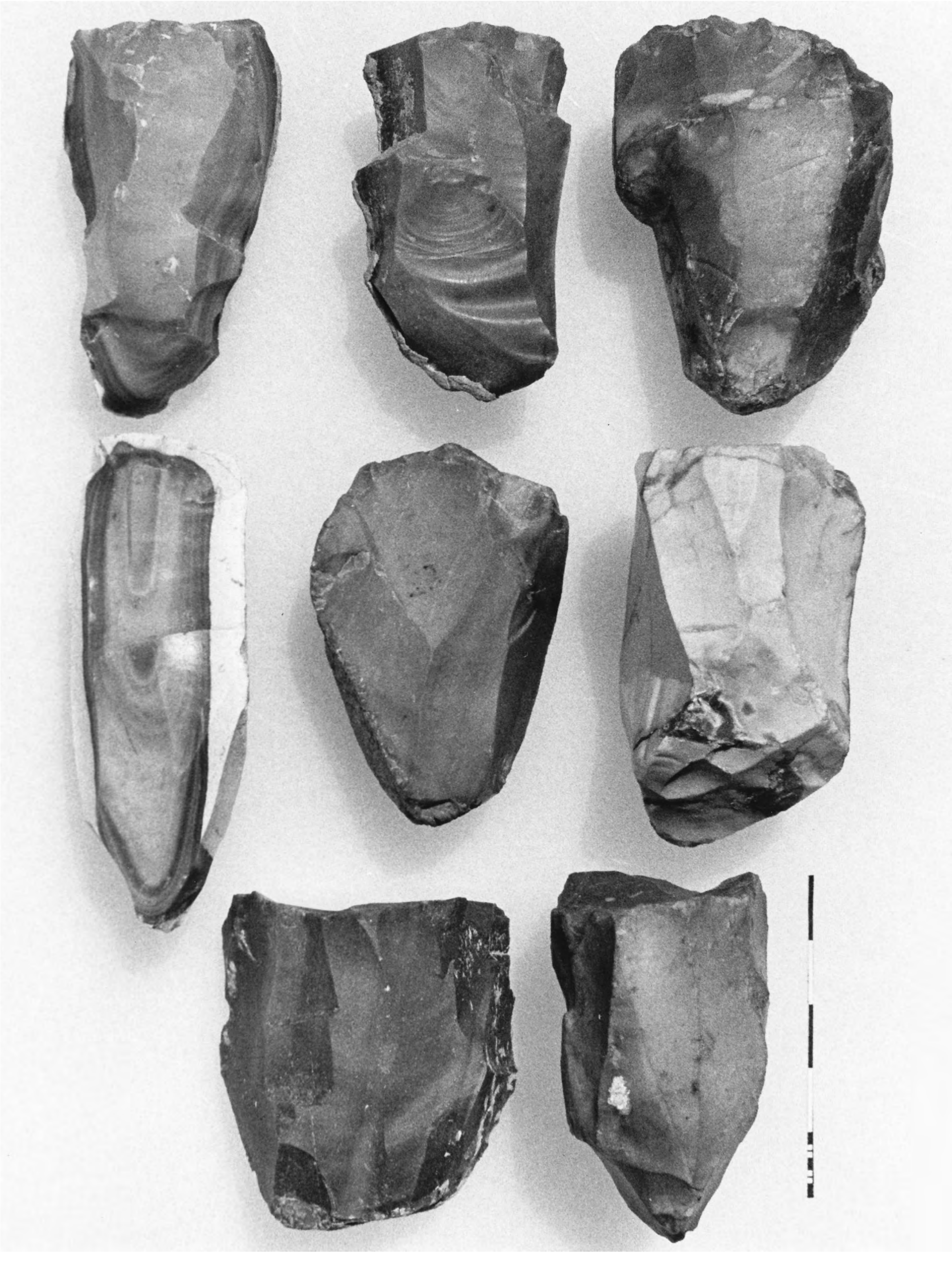


Plate 7.8. Single-platform blade cores. All periods. Most were produced from coarse flint or chert.

Experimental replication of these strategies of percussion flake-core reduction argues that these choices largely are material-dependent, and derive from the quality and configuration of the stone that was available or selected for use, as well as from the attributes of the desired flake blank. At ‘Ain Ghazal, large, single-platform flake cores (Plate 7.9) most often were made from large quarry flakes of chert, and the ventral surfaces were used as fortuitous platforms. As reduction progressed, some of these cores evidently became bidirectional or multi-platform cores (Plate 7.10) as various flaking options became available. Flake blanks produced from these cores primarily were formed into various heavy-duty tools, such as side-scrapers. Discoidal cores (Plate 7.11) often were made from better-grade wadi flint and generally produced smaller flake blanks with sharp lateral edges and hinge or step terminations. Such flakes frequently are found in ‘Ain Ghazal tool assemblages fashioned into a variety of cutting tools, perforators, and denticulates. Very small single-platform cores (Plate 7.9, lower), multi-platform cores of roughly spherical configuration (Plate 7.10, lower), or discoidal cores (Plate 7.11, lower) often were made from high-quality flint, such as good grades of wadi flint or small chunks of stone from the Huweijir source area. Flake blanks originating from such cores are quite small and generally have very sharp lateral edges. These flakes appear to have been used as unretouched tools, possibly as tiny cutting tools.

These patterns of core-and-flake production persisted throughout the occupational phases at ‘Ain Ghazal, as can be seen in Table 7.2. Temporal differences are mainly a matter of degree, so that the production of flake blanks rather than blade blanks became the major economic strategy in the LPPNB and continued into the PN. As this change was made, a concomitant change in resource use occurred as well. The use of Huweijir flint diminished and the use of coarser flints and cherts increased, along with a reliance on flake cores and flake tools. These latter core-and-blank manufacturing choices reflect a casual approach to stone-tool production and easy access to abundant chert and wadi-flint clasts that undoubtedly were acquired in the immediate environment of the site proper. This manner of tool production is a commonly observed occurrence in both stratified and single-component sites of the PPN and PN throughout the Levant, from Syria to southern Jordan (*e.g.*, Crowfoot Payne 1983; Roodenberg 1986; Gopher 1989; Nishiaki 1993; Baird 1995), and into Anatolia (Roodenberg 1989). Economic behaviors of this sort are best perceived as unspecialized tool-production options (*e.g.*, Gopher 1989; Nishiaki 1993), an evaluation that is discussed at length in the following chapter.

DEBITAGE LOCI: CHIPPING FLOORS, WORKSHOPS, AND DEBRIS DUMPS

Valid interpretations of the activities that occurred at a debitage locus depend on correct identification of the technological categories of debitage that result from core, blank, and/or tool production. The justification for this view is that debitage types result from specific knapping behaviors that accomplish distinctive reduction goals. Thus, they are purposefully created and they mark technologically significant behaviors. Identification of a population of debitage types, therefore, reveals the underlying behaviors, so that the technological process, including the relevant phase of the process, is made apparent.

Background

It is important to consider at this point a few examples of current debitage research, and how they relate to the above premise. In North America, debitage studies are quite common. Many of these concern the reduction of bifaces, bifacial flake cores, or flake blanks detached from such cores,

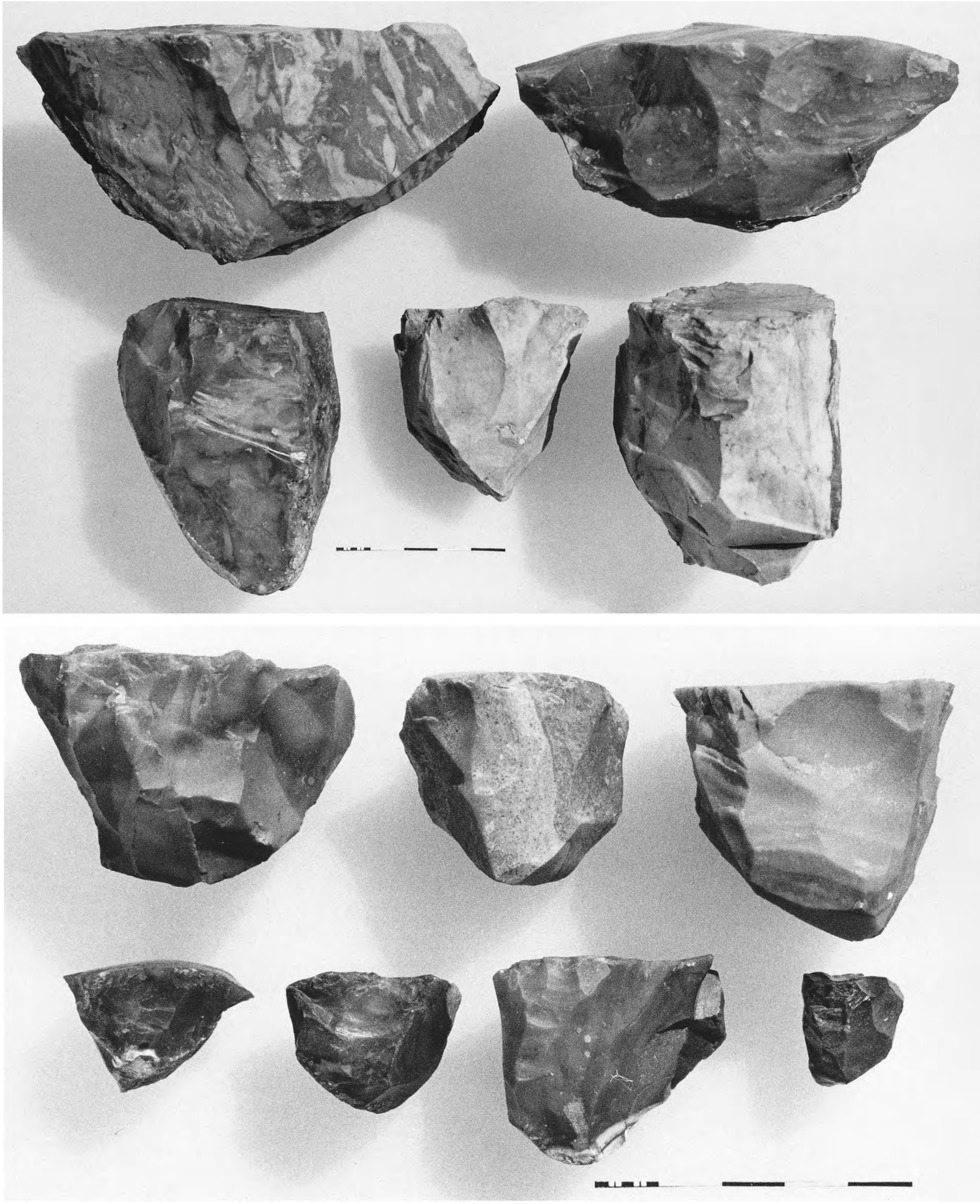


Plate 7.9. Single-platform flake cores.
upper large cores. Upper two were produced from large quarry flakes.
lower small cores characteristic of all periods. All cores shown here were made from coarse wadi flint.

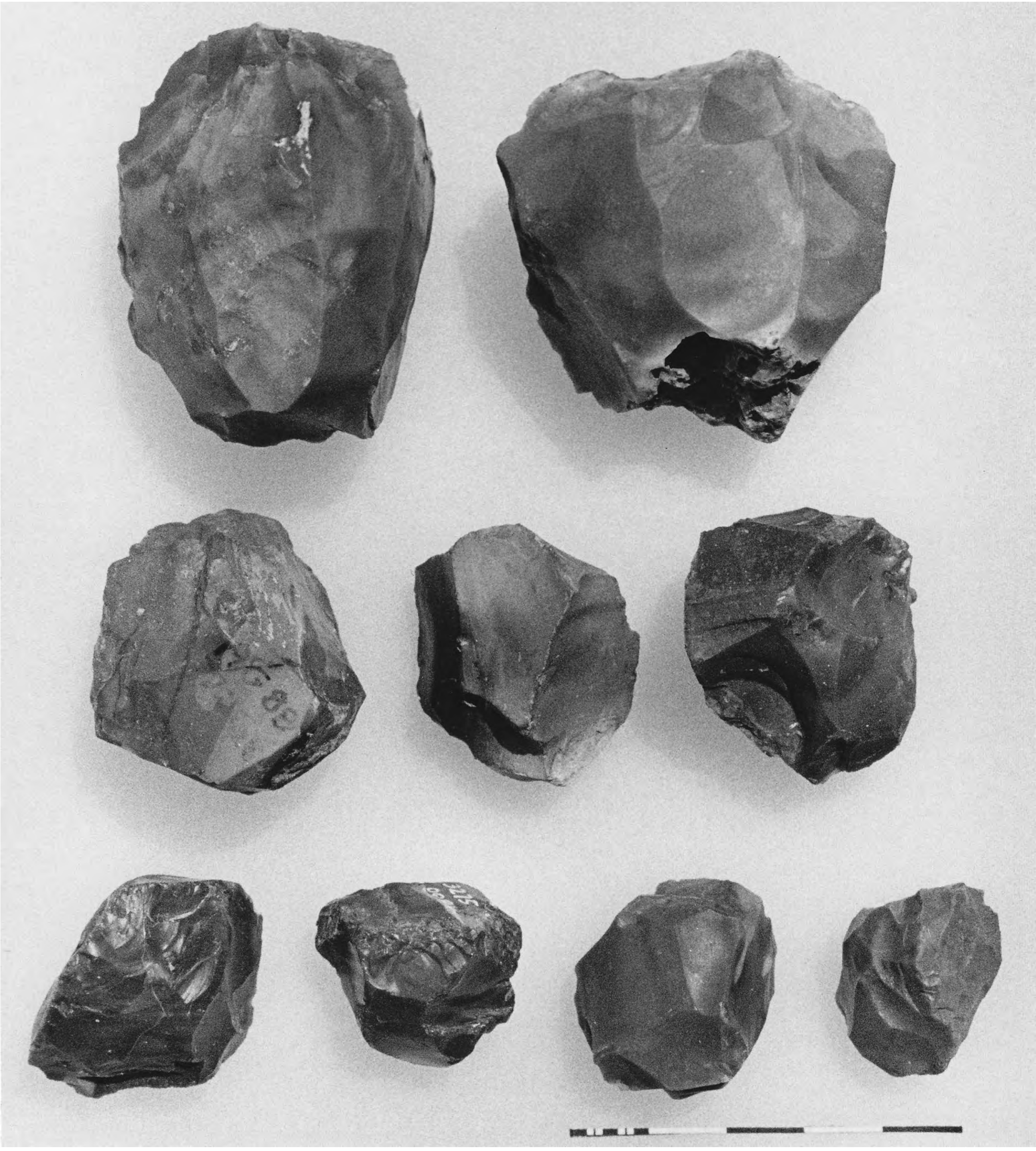


Plate 7.10. Multi-platform flake cores. Lower four are small, spherical cores that typically were made from Huweijir quality flint.

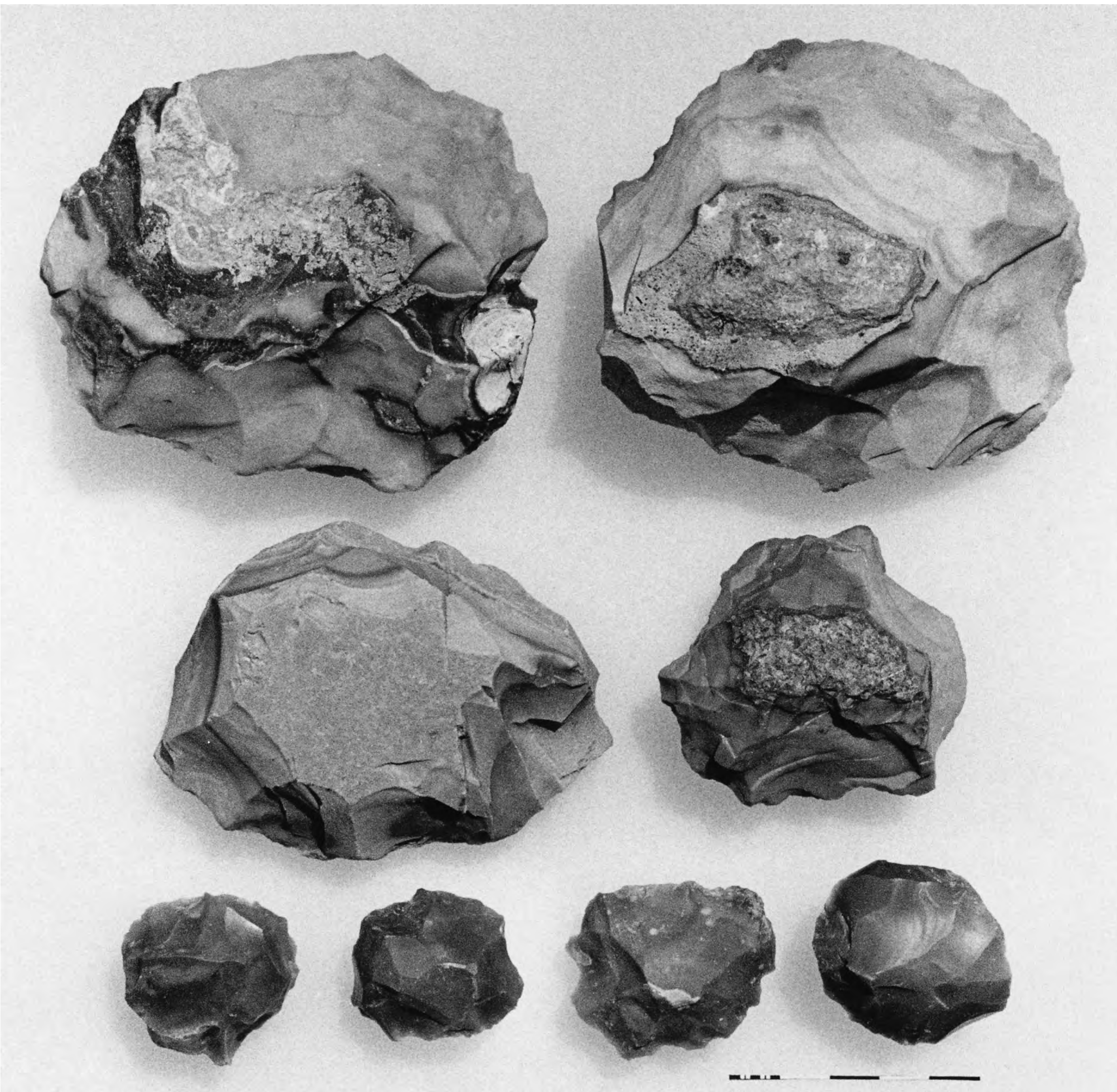


Plate 7.11. Discoidal flake cores. Upper four are of chert and poor-quality flint; lower four were made from excellent flint such as that found at the Huweijir mines.

and difficulties that arise when gleaning behavioral information from biface-production and/or -reduction debitage (Amick *et al.* 1989; Shott 1994). Some of these works use limited, experimentally derived, reduction data for comparative purposes and may appear to be technologically based. Nonetheless, they do not rely on meaningful data that relate to real technological behaviors (such as technologically derived blade or flake categories) to construct their interpretations. Pertinent underlying assumptions of these studies are that quantification of either nontechnological attributes such as flake weights or sizes, or of whole verses broken flakes, or of individual flake attributes, such as dorsal scar counts, or degree of cortex, will reveal the character of an assemblage (*e.g.*, Magne and Pokotylo 1981; Sullivan and Rozen 1985; Magne 1989; Mauldin and Amick 1989; Tomka 1989).

Representative examples of these studies are Sullivan and Rozen's (1985) use of shatter and flake-completeness ratios for determining reduction schemes of cores and bifaces, and "mass analyses" advocated by Ahler (1989) and others (*e.g.*, Mauldin and Amick 1989; Patterson 1990) whereby flake size-grading is used for similar objectives. Sullivan and Rozen stated that their method is "interpretation free" (1985: 758) since it is not dependent upon assessments of technological categories of debitage, categories that they felt were ambiguous and problematic. Their approach was seriously challenged by flint-knapping experiments that contradicted their conclusions and questioned the usefulness of their methodology (Amick and Mauldin 1989; Mauldin and Amick 1989; Tomka 1989). Similarly, mass analyses reduce assemblage variability, in this case to a single entity, debitage size, essentially ignoring technological debitage categories. Both of these approaches foster interpretations that necessarily are ambiguous or severely limited because the data selected for study are disconnected from the technological behaviors that created the assemblages. For example, neither of these approaches would lead even to differentiation of a blade industry from a flake industry, nor allow more subtle evaluations, such as stages of projectile point production. Shott noted that much of this research is still in the developmental stage, and that it is "plagued by the same equifinality problem noted for traditional, especially typological, studies" (1994: 99-100). However, the actual difficulty clearly is methodological and derives from the tenuous link between the data selected for analysis and the pragmatic enterprise of knapping stone.

The main point here is that producing stone tools is a technological activity and correct interpretation of residues of this activity requires technological knowledge and assessment of technological debitage categories. Nontechnological quantification of debitage (by weight, size, etc.), like similar quantifications of unspeciated animal bones, is very limited in terms of the useful behavioral information that may be generated. When one also considers their problematic applicability to real situations in which archaeological deposits may not be pristine but are altered by natural or human actions, it seems appropriate to suggest that more rewarding analytical paths are available.

Compare the above with J. Clark and Bryant's (1997; J. Clark 1997) technological studies of Maya blade-production debitage. Their extensive replicative research provided a comparative standard of technological debitage categories with which blade-core reduction sequences and flint-knapping strategies at a Maya debitage locus were defined. Their archaeological analyses identified strategies of core production, characterized the reduction process, identified the locus as a workshop site, went on to evaluate the workshop production output, and argued well that it reflected a specialist's flint-knapping enterprise.

Analytical Procedures and Rationale

For clarification, three sets of tasks structured the ‘Ain Ghazal debitage analysis. Briefly, these were:

1. To identify the nature of the production at a locus; that is, whether it resulted from flake-core or blade-core production or reduction, or from tool production;
2. To differentiate primary production loci from secondary debitage deposits, or disposal areas; and,
3. To distinguish activity areas from workshop loci.

The several more or less dichotomous concepts employed here have been extensively evaluated by recent research, especially that concerning Maya lithic assemblages, that contributed substantial analytical clarity. The discussion focusses on behaviors related to settled village living and pertinent data.

Production Loci

Where core-, blank-, or tool-production activities need to be ascertained, archaeological loci are compared to technological standards of expected categories of debitage derived from numerous replications. Technological debitage types and quantities are compared to expected normal frequencies of debitage types. Reduction products are inventoried, and missing components, if any, are identified. The following very basic assumptions guide these analyses:

1. Technologically consistent patterns of core-production debitage attest to core production;
2. Technologically consistent patterns of core-reduction debitage give evidence for core reduction, or flake or blade production; and,
3. Tool-production loci generally are represented by debitage assemblages that are not strictly consistent with either core production or core reduction.

This last pattern obtains because tool blanks are likely to be selectively acquired, chosen from all of the constituents of a primary production deposit and from the residues of several different core reductions, while the undesirable by-products remain as primary reduction residues. Debris from tool production and retooling also should be present, perhaps as sectioned blade fragments, waste spalls, as errors or failures from tool production, or as broken or discarded tools, etc. It is a well-documented pattern that tools or tool elements that are hafted, such as sickle or knife blades, or projectile points, are likely to be replaced at tool-manufacturing loci rather than where they were used, so that such discarded tools are expectable at tool-production loci or places where tools were repaired (Keeley 1982).

Primary and Secondary Deposits

The second consideration is identification of primary loci of core production and/or reduction, as opposed to loci of secondary deposition, such as places where waste disposal occurred. Currently, there is considerable support among debitage analysts for the usefulness of small debitage and microdebitage as major indicators of primary production activities. Ample experimental and archaeological data have demonstrated that this debitage is least likely to be removed from original depositional contexts by gleaning and cleaning (*e.g.*, Fladmark 1982; Behm 1983; Healan *et al.* 1983; Schiffer 1987). Caution clearly is necessary since various postdepositional processes, such as slopewash (Baumler 1985) and deflation (Nicholson 1983) can affect the presence of microlithic material in some deposits. Also, human waste-disposal behavior (*e.g.*, J. D. Clark and Kurashina 1981; Gould 1981; Deal and Hayden 1987; J. Clark 1986b, 1991) can alter the constituents of an original deposit. Nonetheless, the presence of microdebitage, especially when combined with technologically diagnostic small debitage, remains the most useful indicator of primary production residues and loci. Deposit contents need to be compared to an experimentally derived standard of expected technological categories of debitage, both large and small, for reliable evaluations to be made. Finally, ethnographic and archaeological data (*e.g.*, Gallagher 1977; Gould 1981; Healan *et al*. 1983; Shafer and Hester 1986; Hayden 1987; Michaels 1989; Healan 1992), and experience, strongly argue that extensive primary reduction areas are likely to be located in exterior locations, or, rarely, in workshop structures,[1] and probably will not be too far from residences or sources of stone.

Secondary deposits that are lithic disposal areas, or "dumps" of spent tools, blanks, and tool-production or core-reduction waste, in many cases can be distinguished from their primary counterparts on the basis of contextual data: waste pits of lithic trash, refuse in abandoned rooms, or debris inside structural interstices such as walls or under floors. Any of these deposits may be only lithic reduction waste, but they also may contain other industrial debris, ash and charcoal, household trash (Moholy-Nagy 1990; Healan 1992), or even human burials.[2] These deposits usually are quite apparent.

Assessments of the content and contextual integrity of loci deposits are also guided by the following observations. Primary depositional residues are apt to contain the expected array of technologically diagnostic debitage of the same parent resource, those that have not been removed for use, so that the deposit is technologically intact or coherent. It is not unrealistic here to think in terms of "fresh" or unaltered debitage. Lithic refuse dumps, on the other hand, often suffer from repeated use and disturbance so that their assemblages tend to result from a mixture of flint-knapping events, from a variety of resources, and from different efforts by different flint-knappers, as well as, perhaps, repeated gleaning. Consequently, they are less likely to reflect coherent reduction episodes. These are idealized standards, of course, and contextual and postdepositional data must be evaluated here as well.

Various modes of lithic "dumping behavior" have been well studied, both archaeologically and ethnographically, so that while there is much variety, several important patterns are apparent. Not surprisingly, there is general concurrence that sedentism and population denseness encouraged disposal of debris (Murray 1980; J. Clark 1986b; Schiffer 1987; *e.g.*, Gallagher 1977; J. D. Clark and Kurashina 1981; J. Clark 1991). Living in villages and towns, therefore, or even in semi-mobile circumstances, probably sanctioned elimination of most knapping refuse from privately and publicly used spaces, where it would have been hazardous, especially to bare feet. In contemporary situations when knapping debris is collected for disposal, the inconvenient or troublesome material that accumulates is collected and removed. Nonetheless, even when ground covers are used, very small flakes and microdebitage are likely to be overlooked or ignored, as among modern Lacandon, Tzeltal, and Chuj Maya (Deal and Hayden 1987; J. Clark 1991).[3]

---

[1] Cleanliness aside, lung damage, such as silicosis, from breathing rock dust is well known (Kalin 1981) and may have been recognized in prehistory (gunflint industry casualties notwithstanding).

[2] As at 'Ain Ghazal; personal observation of author.

[3] Two well known cases of Ethiopian obsidian knappers have been cited as evidence to the contrary, and should be considered. Gallagher (1977) observed that hide tanners knapped blanks from blocks of obsidian at the quarry, but transported flakes to the village where they were retouched over vessels that caught the debris, which was dumped a

This pattern is apparent among modern flint-knappers as well, so that when flint-knapping tarpaulins are used to collect the debitage, primary reduction areas routinely are marked by remnant microdebitage, small flakes and debris that “escape” from the tarpaulin because they are so small that they are blown about or otherwise displaced. The discarded material, however, contains quantities of larger, undesirable debitage that is not of tool-blank quality, and small debitage as well, but is unlikely to include all of the microdebitage. In this case, the discarded material may be recognized by a shortage of micromaterial and the primary deposit may contain only microdebitage, a pattern that has been noted by others (*e.g.*, J. Clark 1990). It is necessary, however, to leave conceptual space for exceptions to this pattern. For instance, knapping and disposal areas may be contiguous, occupying essentially the same area. In this case, a disposal pit may be excavated into or on the periphery of a flint-knapping floor and most of the debris incorporated into it, thus preserving microdebitage along with larger knapping debris in a pit feature as a discreet assemblage, a secondary deposit within its primary location.[1]

Activity Areas and Workshops

The third task is to identify the type of economic organization that is suggested by loci attributes. This aspect of the analysis is the most complex and the most problematic, and has fostered a variety of analytical approaches. Central to this study is the differentiation of “chipping floors,” or flint-knapping activity areas, from lithic “workshop” residues. Following modern conventions (J. Clark 1986a, 1987, 1990; Michaels 1989), chipping floors reflect the common, unspecialized production of cores, tool blanks, and/or tools as a normal aspect of a subsistence-based, lithic economy. They equate with work places of individual flint-knappers who produced lithic items for their own or familial use. Workshops, on the other hand, are interpreted as areas where specialist flint-knappers produced lithic products for use by nonfamily members of the community.

Since the realm of the specialist craftsperson includes the production of quantities of material for others, differential production and consumption rates have been used in some cases to identify workshop loci. Determining the scale of production can be problematic, however, even for large, well-documented deposits (*cf.* Spence 1981; Shafer and Hester 1983; Santley 1984; J. Clark 1986a; Mallory 1986; Maholy-Nagy 1990; Hester and Shafer 1992). Consequently scale is unlikely to be a successful index of specialized workshops for nonurban sites, such as ‘Ain Ghazal, where production may have been very modest and surpluses difficult to document.

J. Clark (1986a) proposed a lithic production continuum progressing from activity areas through three grades of workshops that differ in their degree of organization, diversity of their products, scale of production, and other attributes. Nonetheless, attributes that are diagnostic of activity areas and small, part-time workshops overlap so that the archaeological equivalents may be indistinguishable from one another. Activity areas may be associated with households;

---

short distance away. Clearly the blank-production debris, including microdebitage, was left *in situ* at the quarry, and would be recognized as such, even though the displaced tool-production material marked only the general area where it was produced. J. D. Clark and Kurashina’s (1981) flint-knapper *bought* a block of obsidian at a village market and judiciously knapped flakes from the block on a hide, and retouched flakes over containers, conserving *most* of the debris. It is not clear to what extent economy of use of purchased resources affected the latter case, but it is clear that the workshop floor was not studied for the presence of microdebitage. In both cases it would be wise to reflect on the comparative value of data regarding the disposal of glass with archaeological situations in which less hazardous tool-stone was used.

[1] One may expect such activity in flint-knapping areas on the fringes of villages, as at Kfar HaHoresh (Goring-Morris 1994) perhaps, where disposal space does not intrude into the principal living areas.

workshops may be located away from households, as suggested by some studies of Maya obsidian blade production. However, such data may relate better to large urban centers rather than to the lifeways and economic structures of small communities. Of note are some recent ethnographic studies that document a household association for workshops located in non-urban settings (*e.g.*, J. D. Clark and Kurashina 1981; Gould 1981; Moholy-Nagy 1990; J. Clark 1991).

The frequency of production localities within the larger population of debitage loci is more useful for discriminating between chipping floors and workshops in early Neolithic towns. Of importance here is whether core production and/or reduction were common activities that resulted in debitage generally becoming dispersed throughout a site, perhaps as household-related chipping floors. Or, conversely, whether production loci were poorly represented or rare occurrences, suggesting that knapping activities were concentrated in a few areas only, as one would expect workshop residues to be.

Thus, it is possible to identify centralized production indicative of craft specialization at the community level using site-specific data.[1] Analyses of this type rely on large samples with good context, but are more suitable than notions of production scale and organization for evaluations of nonurban sites where emerging specialization may have been on a part-time basis. Clearly, sample bias is a concern. It also is important to consider that aggregates of nonspecialist flint-knappers making use of a common knapping area could create infrequent, concentrated debitage deposits. Accordingly, analyses must include interpretations of loci character, and consider evidence for production standardization and flint-knapping skill, in addition to the frequency of loci distribution.

Application

Identification of primary core production and reduction residues, particularly those related to naviform core reduction, was the major concern for this study. In light of the above discussion, the most important criterion for locus selection was a high incidence of microdebitage and/or small debitage that resulted from core production and reduction. Naviform core-reduction loci, therefore, were identified by microdebitage and diagnostic small debitage created by blade production (*e.g.*, core-platform preparation elements and blade-platform isolation elements). The technological debitage categories presented in Chapter 6 that result from production of naviform cores and blades were used to evaluate these data sets. General technological categories of reduction debitage also were established from experimental replication of a variety of non-naviform blade cores and flake cores. Microdebitage and small debitage, such as core-production flakes (generally flakes not indicative of bifacial reduction), as well as coarse blades, platform spalls, and spent cores were used as potential evidence of other types of core reduction. Loci also were studied for evidence of tool production, tool maintenance, and retooling.

The analysis was guided by several further considerations. The depositional context of each locus was studied to evaluate the integrity of the deposit. Evidence for both secondary and primary deposition were considered, since secondary disposal of flint-knapping waste was thought a likely occurrence within the town proper and possibly was a dominant behavior. Most importantly, the pattern of attributes of each locus was evaluated in terms of its technological cohesiveness. That is, did the general character of a locus logically fit the expected debitage

[1] Therefore, regional analyses of production concentrations are not requisite for this type of assessment (*contra* Costin 1991: 27).

pattern of a given technological behavior? In addition to analyses of individual loci, patterns of locus distribution were appraised in order to determine their intrasite frequency. These concerns were addressed for all occupational periods. Particular attention was given to evidence of naviform core reduction in LPPNB, PPNC, and Yarmoukian deposits, since the nature of naviform core reduction during these periods is poorly researched and not well understood. Furthermore, the temporal and areal distribution of naviform core-and-blade production loci relate to both the economic organization and the longevity of naviform core reduction at ‘Ain Ghazal.

Debitage Sample

Data considered for this analysis resulted from an exposure of approximately 1% of the estimated maximum size of the townsite of ‘Ain Ghazal. While this exposure is unquestionably small, excavation procedures were structured to obtain comparable representative samples of the various occupational periods at ‘Ain Ghazal, so that both broad areas of contemporaneous deposits and the stratigraphic variability of the site were exposed and studied. This research resulted in the retrieval of many thousands of loci of lithic debitage, all of which were evaluated initially in order to select the debitage sample for this study. A stratified random sample of 400 of these loci was selected for technological analysis that represents all phases of the occupation. These loci consisted of discreet assemblages of concentrated lithic debitage that had contextual integrity. From this sample, 26 loci were selected for intensive study that were judged most likely to be remnants of core-production and core-reduction activities, and to be representative of the general character of debitage loci from each phase. These data are summarized by occupational phases and presented in Tables 7.3-7.6.

Pre-Pottery Neolithic: MPPNB

One hundred and seventy loci were evaluated and 10 were selected as most likely to be primary loci of naviform core reduction. These debitage assemblages were studied intensively to establish their technological and behavioral significance. Contextual interpretations and debitage distribution analyses are presented in Tables 7.3 and 7.7. Nearly all of the debitage (93.3%-99.9%) is high-grade flint that most likely was mined from the Wadi Huweijir flint mines.

Only two of the 170 loci (unit 3282, locus 122; unit F14, locus 037) appear to have been primary deposits of debitage resulting from the production and reduction of naviform cores. This assessment is based on the intensity of microdebitage and small debitage, as well as the abundance of all expected technological categories of core-production and core-reduction debitage. The first deposit was located on the west side of the Wadi Zarqa, in the Central Field excavation (see Fig. 1.2 and Plate 1.1), in an exterior location that was not associated with any structures. The deposit consisted of an extremely dense lens of flint debitage, approximately 0.5 meter thick, resting on basal clay. It is attributed to the earliest phase of the MPPNB occupation at ‘Ain Ghazal, which dates to *ca.* 8,300 Cal. BC. The rarity of this locus, one of only two primary reduction areas of all 170 loci studied, supports the interpretation that this assemblage consists of residue from a lithic workshop. In addition to production and reduction of naviform cores, a small amount of tool production also occurred here.

The second deposit (unit F14, locus 037) that contained primary naviform core-production and core-reduction debris was located on the east side of the Wadi Zarqa (Plates 7.12, 7.13). This extensive assemblage comprised a large, irregular feature underneath a courtyard near an LPPNB

Table 7.3. MPPNB Debitage by locus.

Unit	**3282**	**3283**	**3283**	**3077**	**3283**	**3283**	**3077**	**3081**	**3081**	**F14**
Locus	**122[a]**	**155[b]**	**133[b]**	**009[b]**	**013[c]**	**014[c]**	**007[c]**	**049[c]**	**030[c]**	**037[a]**
Core Preparation										
Flakes (biface-production[d])	1004	175	540	229	460	233	196	169	30	4151
Flakes (nonbiface-production)	152	46	260	90	304	136	58	49	134	281
Small flakes (0.5 - 1.5 cm)	1774[e]	673	750	488	303	148	113	86	50	3225
Flake fragments	1666[e]	142	1251	982	721	282	378	112	134	6265[e]
Microdebitage (<0.4 cm)	18680[e]	800	0	0	0	0	0	0	0	39228[e]
Faceting flakes	58	16	68	38	85	10	38	53	14	122
Core-trimming flakes; back, lateral	6	0	3	0	4	0	1	0	0	1
Platform spalls, all types	104	33	68	20	93	19	15	39	18	246
Core Reduction and Maintenance										
Crested blades and frags., all types	32	8	28	0	31	16	7	11	7	13
Initial blades and fragments, cortical	2	2	6	1	0	0	1	4	0	2
Intended blades, small blade(let)s	22	10	24	9	17	5	0	8	6	34
Hinge- and step-removal blades	21	11	26	5	10	2	5	16	2	12
Overshot blades	0	2	4	0	2	1	2	3	1	3
Profile-correction blades	15	4	11	8	53	11	11	6	0	16
Ridge-straightening blades	373	55	145	48	132	52	43	59	40	1312
Platform-isolation elements	369	124	128	90	150	11	3	47	10	1526
Core-platform preparation elements	75	57	93	103	82	12	15	14	0	546
Industrial waste blade fragments	582	177	454	155	444	154	81	74	67	1618
Blank-Production Waste										
Proximal blade fragments	132	39	134	36	104	36	30	107	35	318
Medial blade fragments	53	22	40	14	113	34	35	44	33	32
Distal blade fragments	8	15	19	9	91	21	10	19	29	29
Non-Huweijir Debitage										
Blades	0	1	2	1	6	0	3	0	4	0
Flakes	17	3	0	12	44	16	13	0	42	11
Other	0	0	6	0	0	0	0	19	0	0
Total debitage per unit	**25145**	**2415**	**4060**	**2338**	**3249**	**1199**	**1058**	**939**	**656**	**59002**
Tools and tool fragments[f]	122	48	132	59	315	146	373	185	226	47
Spalls, burin and chamfered-bit[f]	29	16	32	4	197	31	21	69	40	6
Weight (g), Huweijir	9438	4363	9881	3827	10409	4460	4906	3751	3432	31358
Weight (g), non-Huweijir	116	24	6	45	226	63	34	132	246	128
Total weight	**9554**	**4387**	**9887**	**3872**	**10635**	**4523**	**4940**	**3883**	**3678**	**31486**
Percent Huweijir	**98.8**	**99.5**	**99.9**	**98.8**	**97.9**	**98.6**	**99.3**	**96.6**	**93.3**	**99.6**
Cores, naviform	4	5	8	1	4	5	2	2	4	9
Cores, all other types	0	0	0	0	1	2	1	0	1	2

[a] As noted in the text, these are the only primary deposits of debris from naviform core production and reduction.
[b] Loci with secondary deposits that are waste dumps of material from core production and reduction.
[c] Loci with secondary deposits that are waste dumps of material from tool production.
[d] As used here, the term "biface-production" should be understood to include all types of "biface-thinning," or "biface-reduction" flakes that result from forming of bifacial surfaces, as on axes/adzes and naviform cores.
[e] Estimates based on weighed sample.
[f] Totals include items identified in debitage analysis and items identified in initial sorting of the collection. Weights of items removed in initial field sorting are not included here, but are minor.

Plate 7.12. Overview of East Field of ‘Ain Ghazal. Boundary of site extends about half way up the slope beyond modern structures along the Wadi Zarqa, as seen prior to excavations.

Plate 7.13. Excavation exposures of structure complexes on East Field slope, 1996. Late MPPNB workshop located in lower right complex (photo by H.G.K. Gebel).

Plate 7.14. East Field LPPNB structures. Late MPPNB workshop and associated debris pit (F14, locus 037), located under LPPNB courtyard floor. Location indicated by arrow.

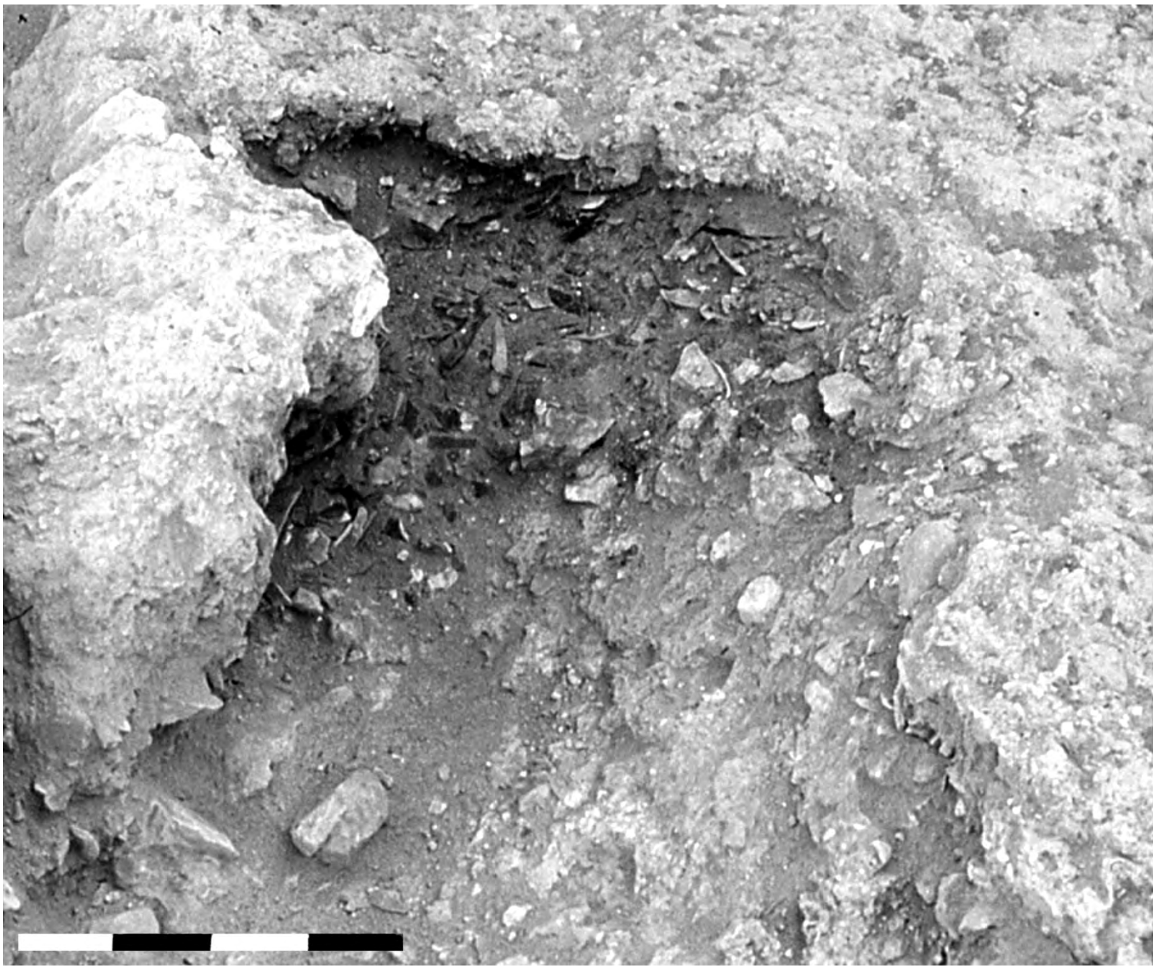


Plate 7.15. MPPNB workshop debris pit. Initial exposure of F14, locus 037 under courtyard floor. Scale increment 10 cm.

Plate 7.16. Two of the naviform cores from the MPPNB workshop deposit, as found.

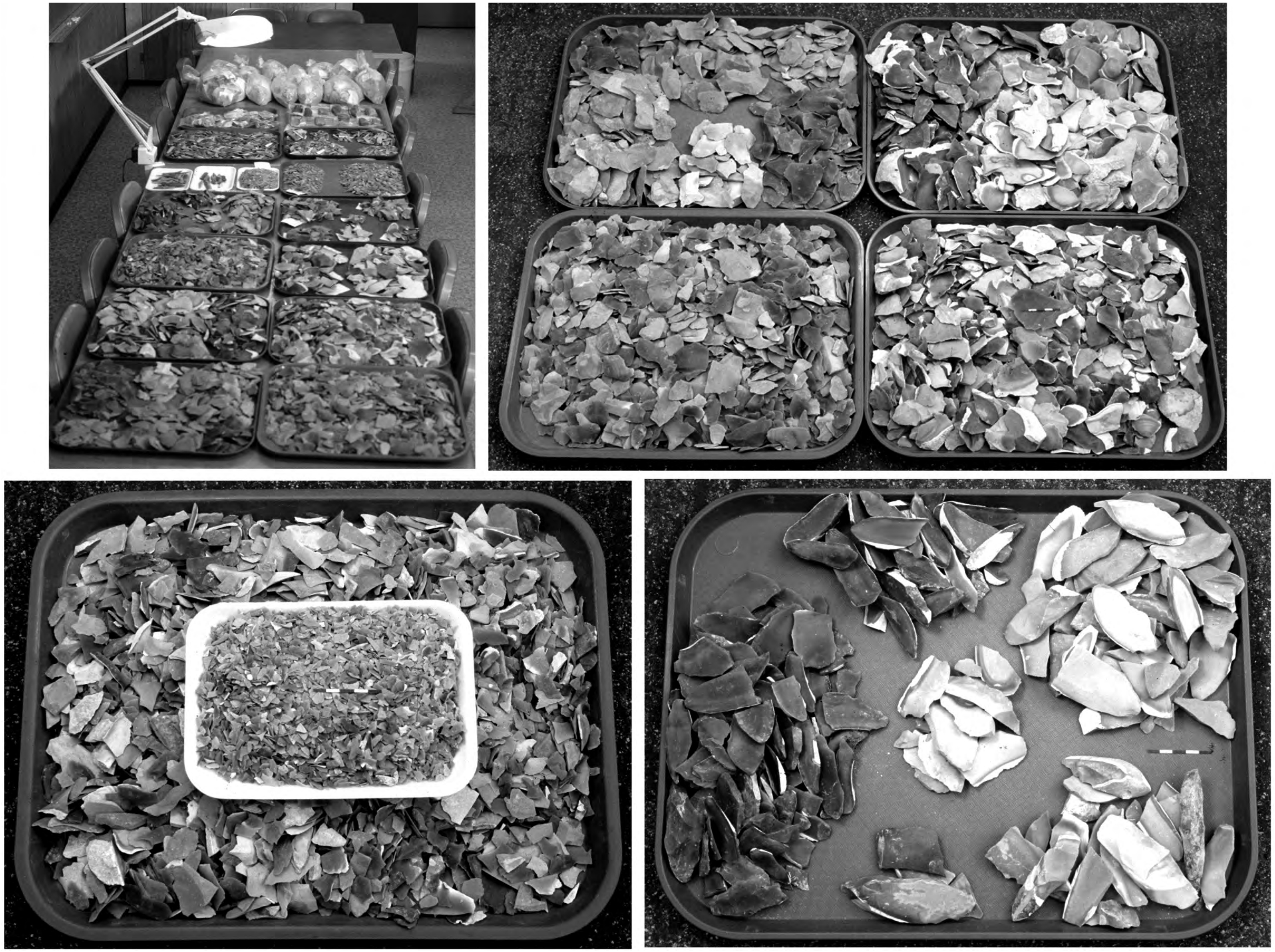


Plate 7.17. Workshop debitage, F14, locus 037. *clockwise from upper left* overview; samples of biface-production flakes; platform spalls; flake fragments and micro debitage.

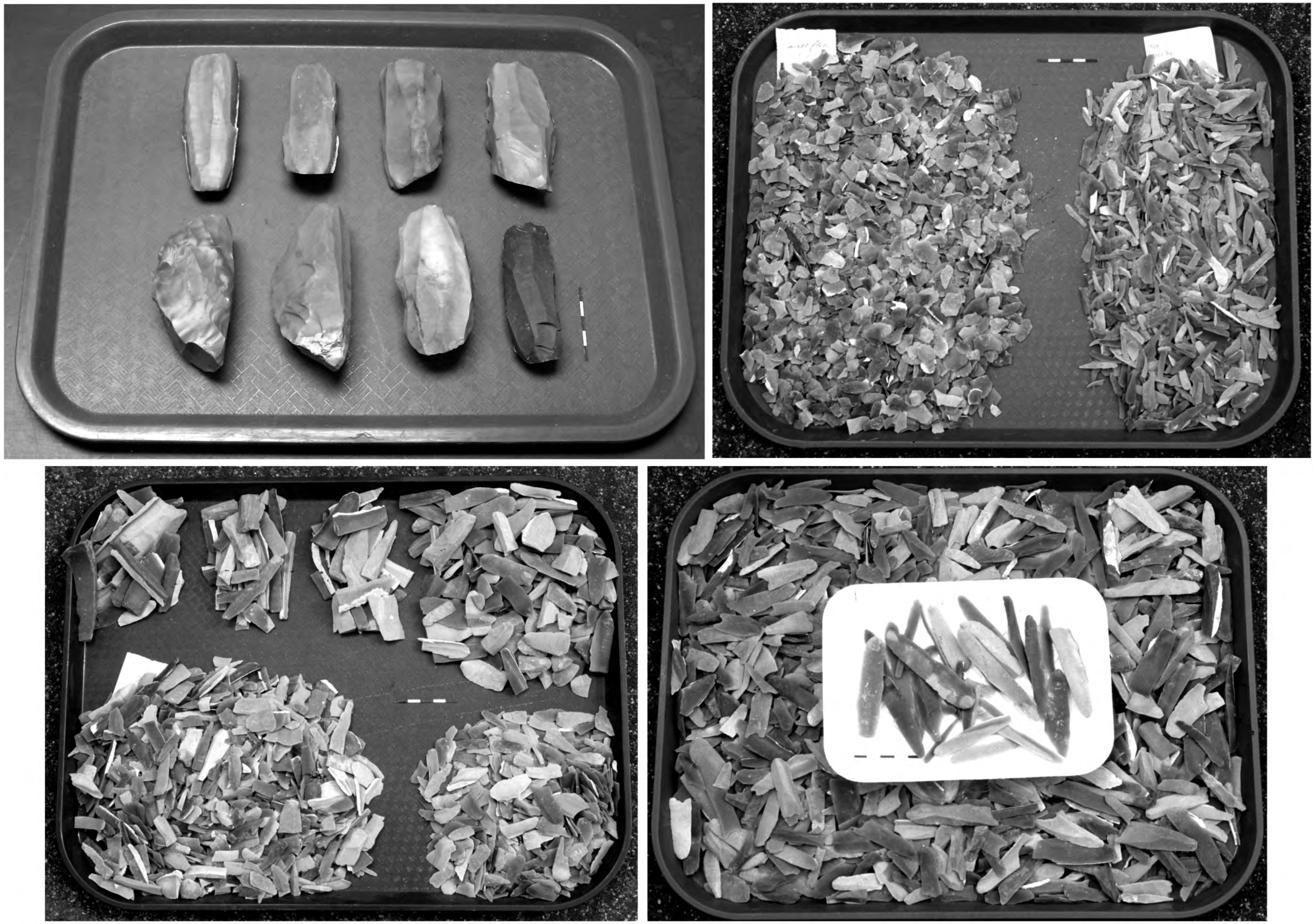


Plate 7.18. Workshop F14, locus 037, more debitage. *clockwise from upper left* naviform cores; edge-preparation flakes and platform-isolation elements; ridge-straightening blades underneath tray of blade products; blade fragments.

structure (Plates 7.14, 7.15, 7.16). It appears to consist of waste that was intentionally deposited in a pit that later became covered with the courtyard. Abundant microdebitage within and around the locus argues that the deposit was within the area where it was initially created, suggesting that the larger portion of the debris was cleaned from the adjacent area and conveniently disposed of in the waste pit below.

There is no doubt that the debitage at this locus represents a complete, core-production and core-reduction assemblage and that naviform cores and blades were produced at this locus (Plates 7.17, 7.18). Regardless of its proximity to the LPPNB structure, in all respects the reduction debitage, including the cores, conforms to the MPPNB pattern of naviform core preparation and to the constraints of blade production that typify the MPPNB. All of the flint is good-quality stone, although it appears to have been selected from variable deposits of Huweijir flint and possibly from other comparable flint sources. A small amount of tool production is evident in this debitage, an attribute that mimics the workshop locus attributed to the early MPPNB. It also is noteworthy that the cores that were retrieved from this deposit were well-configured in nearly identical fashion with morphological attributes that attest strongly to highly competent and standardized flint-knapping skills (Plate 7.18). In comparison to the larger assemblage of debitage loci, the uniqueness of this deposit argues that this locus was the residue of workshop activities, and possibly may be attributed to a single craftsperson. Ultimately, a year after the initial distribution of this manuscript and publication of the MPPNB data (Quintero 1997) a radiocarbon date was obtained for this locus of 8,775 " 75 B.P. placing it towards the latter portion of the MPPNB. It appears that the LPPNB courtyard and associated structure were constructed on top of a late MPPNB flint-knapping workshop area and waste disposal pit.

The remaining eight MPPNB loci represent two different types of activities. The three loci in the first group were all waste-disposal areas that contained naviform core-production and core-reduction debris, and small amounts of tool-production debitage. All three loci (unit 3283, loci 155 and 133; unit 3077, locus 009) were exterior pits, and apparently resulted from the disposal of primary reduction debris, perhaps originating from a single workshop. The first two of these loci were excavated into the same location during different phases of the site occupation, suggesting that this area was used, or reused, over a lengthy period.

The second set of loci contains debitage that is consistent with tool production, but not with the production and reduction of naviform cores. With one possible exception, all of these assemblages (unit 3081, locus 049; unit 3283, loci 013 and 014; unit 3077, locus 007) were waste dumps that contained large amounts of tool-production debris. Since tool production need not generate very much microdebitage, it was difficult to distinguish primary tool-production areas from dumps of tool-production waste based on the presence of microdebitage. Therefore, contextual data were used for this purpose. The disposal localities were exterior pits, dumps behind walls, or floor fill in the interiors of abandoned structures. One locus (unit 3081, locus 030) had an exterior provenience and dispersed deposit within a compacted soil lens and may have been a tool-production chipping floor. Nonetheless, internally, its constituents do not differ from the waste dumps of tool-production debitage.

The tool-production debitage at these loci is characterized by edge-modified (“trimmed”) projectile point preforms, partially formed projectile points with manufacturing breaks, numerous burin spalls, bit spalls from chamfered pieces, and abundant waste from sectioning blades (Plates 7.19, 7.20). This latter category of blank-production waste is dominated by proximal and distal blade fragments, most of which are proximal, bulbar ends that were sectioned just distal of the

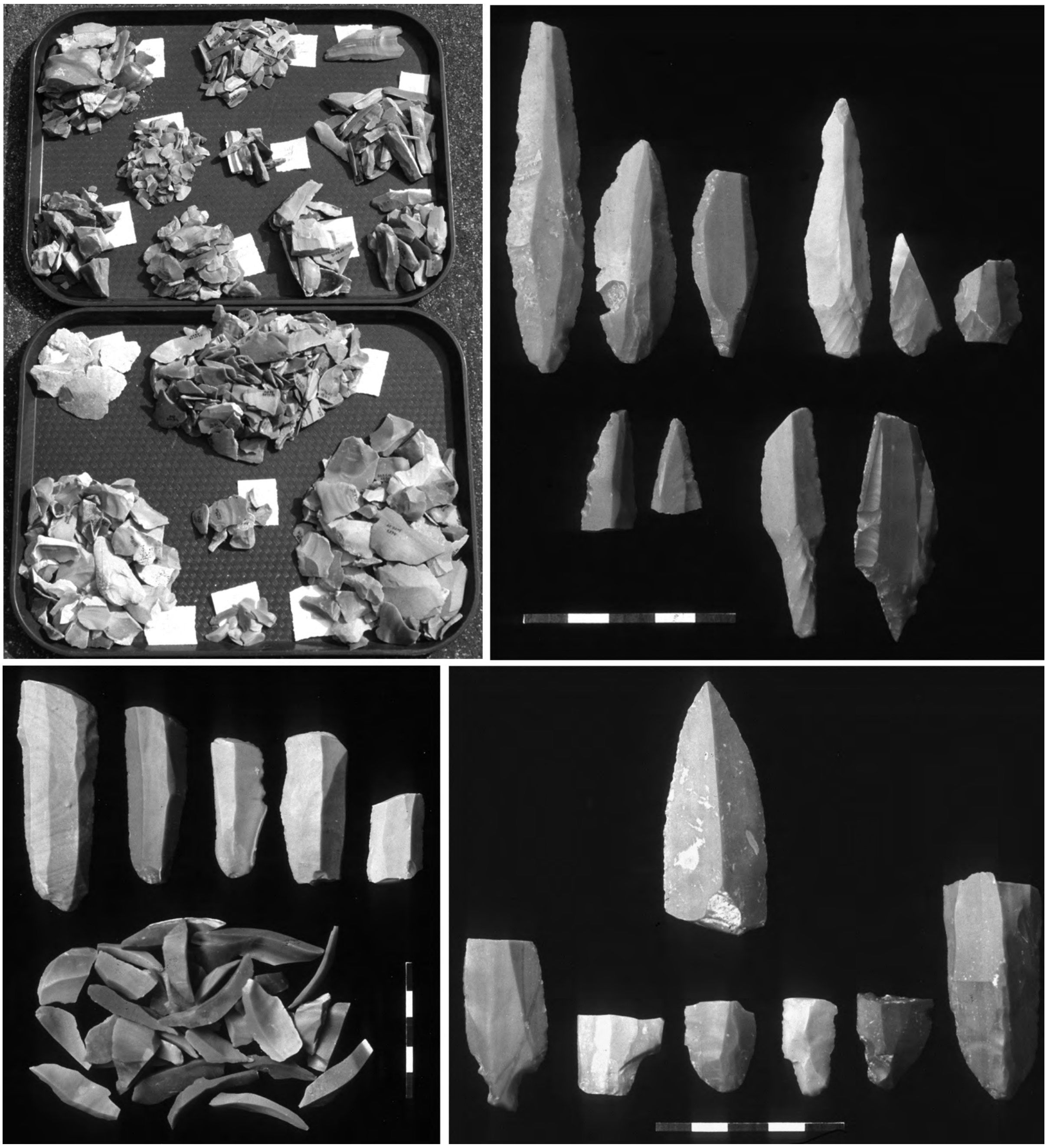


Plate 7.19. Tool-production debitage and tools. *clockwise from upper left* overview of sample; projectile point production breaks and reuse discards; knife and projectile point hafts and tip breaks; chamfered-bit tools and bit spalls.

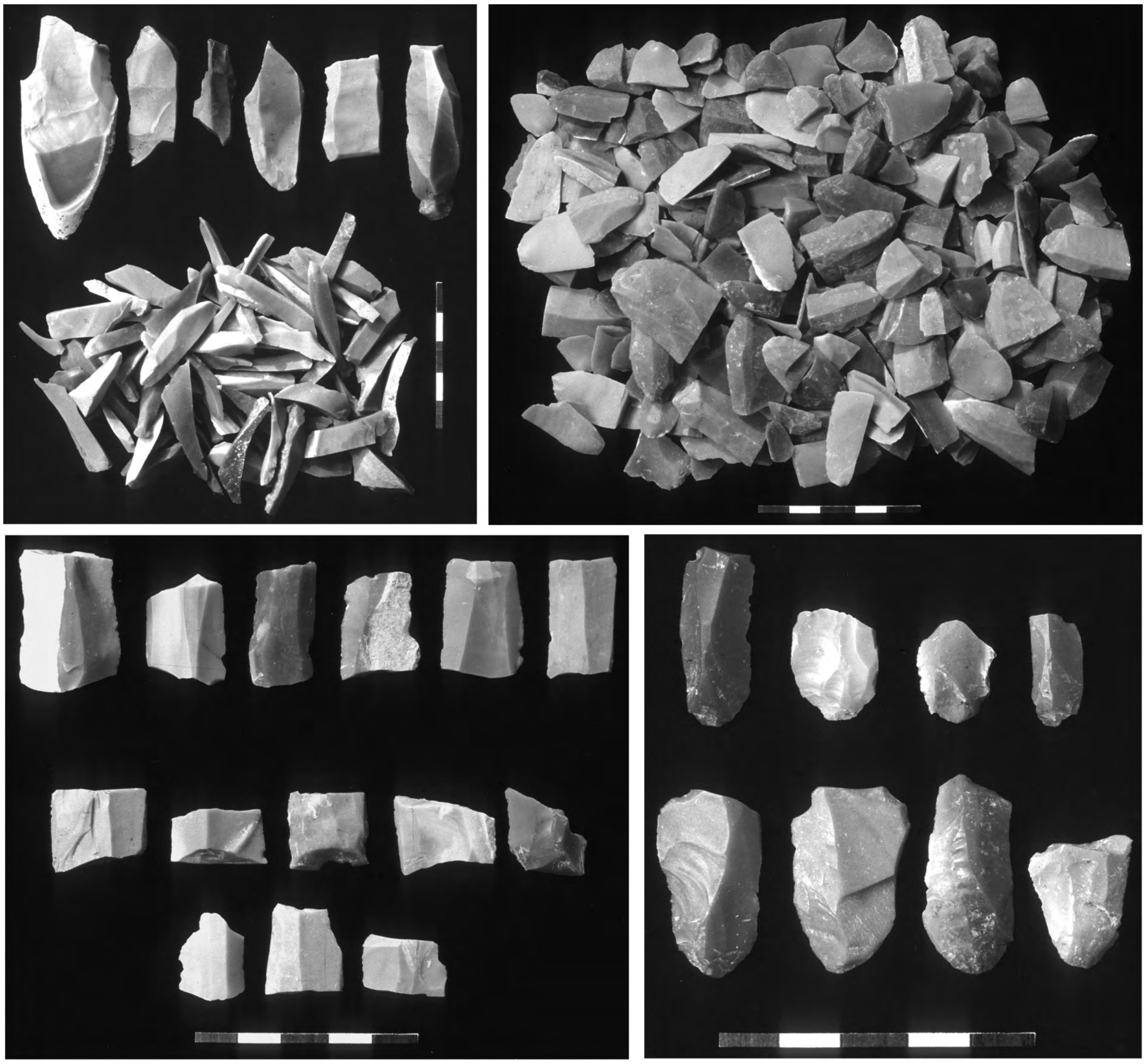


Plate 7.20. Tool-production debitage and tools. *clockwise from upper left* burins and burin spalls; bent-sectioned proximal blade segments; notched and bent proximal blade segments; struck-sectioned medial blade segments.

bulb. Blades were trimmed in a variety of manners: bending, or snapping off the proximal and distal ends; percussion sectioning by striking on the dorsal, and sometimes on the ventral, surfaces while the blades were supported on an anvil; controlling the break by notching and then bending; initiating perverse fractures, or angled breaks; and by notching and segmenting with burination. Some of the bending breaks certainly could be due to pre- or post-depositional breakage, as from trampling, but given the consistent morphology and size of the blade segments, and the larger pattern of trimmed blades that they clearly duplicate, it is likely that the majority were intentionally sectioned.

Retooling activities are obvious, as seen by the large numbers of broken, used tool fragments, especially tools that usually are hafted, such as sickle blades, knife blades, awls/borers, and projectile points. Also, whole, high-quality blades of tool-blank quality are essentially absent, as are most of the usable mid-sections of good blades. However, ridge-straightening blades, that are less desirable as tool blanks, are common discards. Flakes, flake tools, and flake cores also occurred in low frequencies in the tool-production dumps. Notably, flake cores are nearly absent from the workshop loci and from the loci containing naviform core-reduction debris.

Pre-Pottery Neolithic: LPPNB

Ninety loci were evaluated, and seven representative loci were selected for intensive analysis (Tables 7.4 and 7.7). All of these deposits contain debitage from tool production, or flake-core reduction and tool production. And, all are best interpreted as secondary depositions that are waste-disposal dumps.

The first locus (unit 3300, locus 035) was a small, exterior waste pit containing rubble and tool-production debris from a wide range of flints and cherts. The assemblage discarded at locus 035 also contains a few coarse, chert blades and numerous flakes made from poor-quality flint and chert. The second locus (Unit 3300, locus 040) was an exterior, waste-disposal pit containing debitage dominated by a single variety of brown, grainy flint, most of which consisted of biface-production flakes and small, biface edge-preparation flakes. It is possible that this deposit primarily resulted from the production of a biface, likely an axe or adze. A few, poor-quality blades with unprepared platforms are also present. As in most of the LPPNB loci, these deposits also contained a small quantity of tool-production debitage and broken and discarded tools of Huweijir flint, such as sickle-blade segments and cutting tools.

Unit 3275, locus 034, was a trash disposal area outside of an apparently abandoned LPPNB house. It contained faunal bones, charcoal, and debitage from core reduction and tool production, and broken tools. The deposit comprised a relatively large inventory of blades, some from naviform cores, and also flakes and flake cores, and broken, discarded tools and tool-production debris. However, no microdebitage or other diagnostic waste from naviform-core reduction was present. Unit 3300, locus 046, probably was a waste-disposal area of rubble, and core-reduction and tool-production debitage that accumulated some distance away from structures. However, there is some indication that this locus may have incorporated a tool-production chipping area, but extensive slope wash redeposited it into thick colluvium. The last three loci all reflect disposal of waste debris from tool production. These secondary deposits occurred in various areas of the community. Unit 5518, locus 016, was waste disposed of inside an abandoned LPPNB house that apparently had burned during the occupation of the town. Unit 5493, locus 029, was an exterior colluvial deposit on a hillside some distance from structures. It contained faunal bones, fire-cracked rock and lithic waste, including a broken axe. Unit 3330, locus 029, was an exterior debris pile with lithic tool-production waste associated with a waste-disposal pit.

Table 7.4. LPPNB debitage by locus.

Unit Locus	5493 029[b]	5518 016[b]	3275 034[a]	3300 046[a]	3300 029[b]	3300 035[b] H/NH[c]	3300 040[b] H/NH[c]
Core Preparation							
Flakes (undifferentiated)	15	10	112	164	46	0	0
Flakes (biface-production[d])	0	0	0	0	0	114/0	2/394
Flakes (nonbiface-production)	0	0	0	0	0	131/226	47/88
Small flakes (0.5 cm to 1.5 cm)	3	11	8	43	13	154/43	39/591
Flake fragments	1	8	11	73	21	105/75	15/120
Microdebitage (<0.4 cm)	0	0	0	0	0	0/0	0/0
Faceting flakes	0	0	0	0	0	0/0	3/0
Core-trimming flakes, back and lateral	0	0	0	0	0	0/0	0/0
Platform spalls, all types	1	0	12	10	2	11/1	0/0
Core Reduction and Maintenance							
Crested blades and fragments, all types	0	0	0	0	0	4/0	0/0
Initial blades and fragments, cortical	0	0	0	0	0	0/1	1/0
Intended blades and small blade(let)s	17	5	152	68	5	11/6	1/13
Hinge- and step-removal blades	0	0	0	0	0	1/0	0/3
Overshot blades	0	0	0	0	0	3/0	0/1
Profile-correction blades	0	0	0	0	0	0/0	0/0
Ridge-straightening blades	0	0	0	0	0	12/0	0/0
Platform-isolation elements	0	0	0	0	0	0/0	0/1
Core-platform preparation elements	0	0	0	0	0	0/0	0/0
Industrial waste blade fragments	0	0	0	0	0	26/4	3/7
Blank-Production Waste							
Proximal blade fragment	0	0	0	0	0	0	14/0
3/2 Medial blade fragment	0	0	0	0	0	9/0	9/0
Distal blade fragment	0	0	0	0	0	5/0	0/3
Total debitage	**37**	**34**	**295**	**358**	**87**	**600/356**	**123/1223**
Percent Huweijir (by count)[e]	**NA**	**NA**	**NA**	**NA**	**NA**	**62.8**	**9.1**
Tools and tool fragments[f]	3	1	41	37	7	194	33
Spalls, burin and chamfered-bit[f]	0	0	5	0	1	12	0
Cores, naviform	0	0	1	0	0	0	0
Cores, all other types	1	0	2	3	1	11	0

[a] Loci with secondary deposits that are waste dumps of core production and reduction, and tool production.
[b] Loci with secondary deposits that are waste dumps of material from tool production.
[c] "H" is flint that appears to be from the Huweijir flint-mine source. "NH" is lithic material that is not from the Huweijir flint source, but appears instead to be wadi-rolled flint or coarse bedded chert.
[d] As used here, "biface-production" should be understood to include all types of "biface-thinning," or "biface-reduction" flakes that result from forming of bifacial surfaces, as on axes/adzes or naviform cores.
[e] The flint in these loci is quite variable in quality. For instance, high-quality Huweijir flint comprises less than 10% of the debitage at locus 040, while 72% is moderately coarse flint of uncertain origin and may be less characteristic flint from Wadi Huweijir, and 19% is wadi flint or chert. Not all loci were sorted by material.
[f] Totals include items identified in debitage analysis and items identified in initial sorting of the collection.

Some interesting patterns are apparent in the LPPNB debitage loci that are quite different from those seen in the MPPNB loci. The high proportion of Huweijir flint that typified MPPNB loci clearly is lacking in these LPPNB waste-disposal areas, as is microdebitage. In fact, the smaller quantity of highly siliceous Huweijir flint at these loci (11%-34%) exemplifies the pattern observed in the larger sample of LPPNB loci. These data imply that resource exploitation shifted at ‘Ain Ghazal during the LPPNB to use of a wider range of flints, a range that included lesser-quality stone. Thus, debitage data from the tool-production waste dumps support the interpretation of core data presented earlier, and suggest that constraints on the selection of lithic material, and on what was considered appropriate stone for tool production, became less rigid during the LPPNB. At this writing, there are no known LPPNB naviform-core reduction loci from ‘Ain Ghazal.

Pre-Pottery Neolithic: PPNC

Fifty-two PPNC loci were evaluated and five loci were selected as representative samples and were intensively analyzed (Tables 7.5 and 7.7). Two loci (unit 3300, locus 013; and unit 4455, locus 044) are interpreted as small flint-knapping areas that were situated outside of, but near, structures. These debitage assemblages consist of relatively large amounts of small flakes, such as edge-preparation flakes that result from preparing edges of bifaces or platforms of cores, and biface-production flakes. Tool-manufacturing debitage also is common, reflecting production of numerous tools of moderate-quality flint and chert, including several bifaces and an axe. In addition, large flakes and flake cores of chert and wadi-rolled flint are well represented. Naviform core-reduction debitage is uncommon, however, and microdebitage is absent. Since tool production and the reduction of chert flake cores generally create only small quantities of microdebitage, the lack of microdebitage at these production loci is not problematic. Large quantities of microdebitage would be expected, however, from the production and reduction of naviform cores. Consequently, it seems reasonable to conclude from these data that these two PPNC loci resulted from tool production and the reduction of flake cores, and not from the production or reduction of naviform cores.

The remaining three loci (unit 5315, locus 010; unit 5515, locus 007; and unit 5515, 016) were outdoor debris pits or disposal areas containing small quantities of lithic tool-production waste and discarded flakes. None of these loci contained small flakes, debitage that would be expected at primary flint-knapping areas where flake cores were reduced. In addition, all three of these assemblages are composed of extremely diverse lithic resources and do not reflect technologically consistent assemblages. It appears from these data that flake cores of chert and wadi-rolled flint were reduced at small flint-knapping areas, such as the first two loci, and that debitage from such reductions was deposited at areas appropriate for waste disposal in various parts of the town.

Flakes of wadi-rolled flint and chert dominate all five of these collections and were important sources of tool blanks, but high-quality flint that probably originated in the Wadi Huweijir mines is present also. Much of this material is naviform core-and-blade production debitage that was used for production of many types of flaked-stone tools. It is clear, however, that the small amount of naviform core-and-blade production debitage present in these deposits was not created at these loci, or at any other PPNC locus that was evaluated for this analysis. In all cases, this PPNB-type debitage consists of disparate elements that do not comprise technologically coherent assemblages. In addition, most of this material appears in PPNC contexts as tools or debris from tool production; yet, it is of such technologically poor quality that it would have been discarded

Table 7.5 PPNC debitage by locus.

Unit Locus	3300 013[a] H/NH[c]	4455 044[a] H/NH	5315 010[b] H/NH	5515 007[b] H/NH	5515 016[b] H/NH
Core Preparation					
Flakes (biface-production[d])	169/59	50/14	0/0	1/0	20/0
Flakes (nonbiface-production)	44/204	32/281	17/30	10/98	9/44
Small flakes (0.5 cm to 1.5 cm)	310/84	56/88	0/0	0/0	0/0
Flake fragments	372/209	70/143	10/12	10/28	0/0
Microdebitage (<0.4 cm)	0/0	0/0	0/0	0/0	0/0
Faceting flakes	5/0	4/0	0/0	0/0	3/0
Core-trimming flakes, back and lateral	0/0	0/0	0/0	0/0	0/0
Platform spalls, all types	5/0	1/0	1/0	2/0	1/0
Core Reduction and Maintenance					
Crested blades and fragments, all types	1/0	0/0	1/0	1/0	1/0
Initial blades and fragments, cortical	0/0	0/0	0/0	0/1	0/0
Intended blades and small blade(let)s	1/0	0/0	0/0	0/3	0/0
Hinge- and step-removal blades	1/0	2/0	0/0	1/0	0/0
Overshot blades	0/0	0/0	0/0	0/0	0/0
Profile-correction blades	0/0	0/0	0/0	0/0	0/0
Ridge-straightening blades	6/0	2/0	0/0	2/0	3/0
Platform-isolation elements	0/0	1/0	0/0	0/0	0/0
Core-platform preparation elements	2/0	2/0	0/0	0/0	0/0
Industrial waste blade fragments	73/3	7/1	7/0	0/0	17/2
Blank-Production Waste					
Proximal blade fragment	19/1	2/7	0/0	1/0	0/0
Medial blade fragment	12/2	0/0	0/0	2/0	0/0
Distal blade fragment	4/0	1/0	0/0	0/0	0/0
Total debitage	**1024/562**	**230/534**	**36/42**	**30/130**	**54/46**
Percent Huweijir (by count)	**78.0**	**30.0**	**46.2**	**18.8**	**54.0**
Tools and tool fragments[e]	167	73	4	13	22
Spalls, burin and chamfered-bit[e]	7	2	0	0	0
Cores, naviform	0	0	0	0	0
Cores, all other types	13	14	4	7	1

[a] As noted in the text, these loci are flint-knapping "chipping floors" that resulted from the reduction of non-naviform cores and the production of tools.
[b] These loci are secondary deposits: waste from tool production and reduction of non-naviform cores.
[c] "H" is flint of highly variable quality, but apparently from the Huweijir source. "NH" is material that is not from the Huweijir flint source, but appears instead to be wadi-rolled flint or coarse chert.
[d] As used here, the term "biface-production" should be understood to include all types of "biface-thinning," or "biface-reduction" flakes that result from forming of bifacial surfaces, as on axes/adzes and naviform cores.
[e] Totals include items identified in debitage analysis and items identified in initial sorting of the collection.

as mere production waste during the PPNB. For example, high-quality blades, the intended products of naviform core reductions, rarely appear in PPNC assemblages. Rather, small segments of industrial-waste blades and core-maintenance blades are common, and these were used as tool blanks. Finally, as observed above, no microdebitage or small debitage from naviform core-and-blade production was located in any of the intensively studied deposits, or at any of the remaining PPNC loci that were evaluated for this study. All of these observations strongly affirm that naviform cores were neither produced nor reduced during the PPNC at ‘Ain Ghazal. Rather, old PPNB debitage apparently was gleaned from these ancient deposits for tool production by later occupants of the site.

The PPNC loci discussed here are similar to those in the larger PPNC sample. Taken together, they give evidence for a broad pattern of tool production at ‘Ain Ghazal, a pattern in which small flint-knapping localities and waste-disposal areas occurred throughout the PPNC component of the town. This pattern suggests that flake cores and tools were not created by a few specialists, but by most community households for their own use. In addition, tool-stone appears to have been generally available in the immediate environment of ‘Ain Ghazal by collecting from wadi gravels, quarrying from bedded chert on the site, and by scavenging ancient cultural deposits.

Yarmoukian Pottery Neolithic

Ninety-six loci from Yarmoukian deposits were evaluated for this study. Four loci (unit 3673, loci 002 and 004; unit 4273, loci 006 and 007) were selected as representative of the larger pattern and intensively analyzed (Tables 7.6 and 7.7). These four assemblages reveal the general debitage character and distribution that prevailed during this period at ‘Ain Ghazal. Two of these loci (unit 4273, loci 006 and 007) are small exterior areas of compacted soil and flint debris located near residential structures. Based on their depositional context, as well as the attributes of the debitage, these deposits are interpreted as activity areas where modest amounts of flint-knapping occurred. The other two loci are waste dumps of debitage and rubble located in floor-fill in abandoned structures. All four of these debitage assemblages consist of debris from tool production and from flake-core reductions. The majority of the tools are extensively used flake tools of various configurations, although a small number of tools were fashioned from very small blade segments or blade-production debris of fine-quality flint that probably was from the Wadi Huweijir mine area. Coarse-grained wadi flint and chert resources account for 42% to 95% of the raw material used.

As with the PPNC deposits, none of the 96 loci evaluated for this study contained microdebitage or technologically coherent debitage from naviform-core production or reduction. Rather, the typically small percentage of debitage in these assemblages that resulted from the reduction of naviform cores is best explained as gleaned PPNB debris. These data reflect generalized tool-production and resource-procurement tactics, similar to those that are seen in the PPNC deposits, in which flake cores and tools were manufactured by individuals for their own needs.

Blades, Flakes, and Tool Production

Tool-production activities were evaluated for all of the occupational periods, and previously mentioned patterns of production are summarized here. During the MPPNB, tools fashioned from blade-core products and debitage appeared to have been manufactured both in workshop settings where naviform cores and blades were produced, and in a variety of other loci that were associa-

Table 7.6. Yarmoukian PN debitage by locus.

Unit Locus	4273 006[a] H/NH[d]	4273 007[a] H/NH	3673 003/004[b] H/NH	3673 002[c] H/NH
Core Preparation				
Flakes (biface-production[e])	0/0	0/0	0/0	0/0
Flakes (nonbiface-production)	23/195	0/111	258/206	141/680
Small flakes (0.5 cm to 1.5 cm)	0/5	0/5	0/0	3/11
Flake fragments	16/119	0/32	95/86	37/140
Microdebitage (<0.4 cm)	0/0	0/0	5/0	0/0
Faceting flakes	0/0	0/0	0/0	1/0
Core-trimming flakes, back and lateral	0/0	0/0	0/0	0/0
Platform spalls, all types	1/0	0/0	9/0	5/0
Core Reduction and Maintenance				
Crested blades and fragments, all types	0/0	0/0	1/0	2/0
Initial blades and fragments, cortical	0/0	0/0	0/0	0/0
Intended blades and small blade(let)s	0/0	0/0	7/4	1/0
Hinge- and step-removal blades	0/0	0/0	0/0	0/0
Overshot blades	0/0	0/0	0/0	0/0
Profile-correction blades	0/0	0/0	0/0	0/0
Ridge-straightening blades	0/0	0/0	7/0	28/5
Platform-isolation elements	0/0	0/0	0/0	0/0
Core-platform preparation elements	0/0	0/0	0/0	0/0
Industrial waste blade fragments	18/0	8/0	41/10	22/5
Blank-Production Waste				
Proximal blade fragment	0/0	0/0	0/0	0/0
Medial blade fragment	0/0	0/0	0/0	4/1
Distal blade fragment	0/0	0/0	0/0	0/0
Total debitage	**58/319**	**8/148**	**423/306**	**242/842**
Percent Huweijir (by count)	**15.4**	**5.1**	**58.0**	**22.0**
Tools and tool fragments	135	77	98	313
Spalls, burin and chamfered-bit	0	3	1	2
Cores, naviform	0	0	0	0
Cores, all other types	20	15	6	16

[a] As noted in the text, these loci are flint-knapping "chipping floors" that resulted from reduction of non-navifrom cores and production of tools.
[b] These combined loci originated as a single secondary deposit of waste material from tool production and from reduction of non-naviform cores.
[c] Debitage and debris at this locus comprise a large waste dump used as fill in an abandoned room.
[d] "H" is flint that appears to be from the Huweijir flint mines. "NH" is lithic material that is not from the Huweijir flint source, but appears instead to be wadi-rolled flint or coarse chert.
[e] As used here, the term "biface-production" should be understood to include all types of "biface-thinning," or "biface-reduction" flakes that result from forming of bifacial surfaces, as on axes/adzes and naviform cores.

Table 7.7. Inventory of loci character: all periods.

ted with

Period Unit/ Locus	Naviform Core Workshop[a]	Non-naviform Core Chipping Floor[b]	Naviform Core/Blade Waste[c]	Non-naviform Core/Tool Waste[d]	Tool-Prod. Waste[e]	Context
MPPNB						
3282/122	X	--	--	--	--	Lens, not at structures
3283/013	--	--	--	--	X	Trash fill/abandoned room
3283/014	--	--	--	--	X	Trash fill/abandoned room
3283/155	--	--	X	--	--	Exterior pit, at structure
3283/133	--	--	X	--	--	Exterior pit, at structure
3077/007	--	--	--	--	X	Trash pit in plaza
3077/009	--	--	X	--	--	Trash lens outside structure
3081/049	--	--	--	--	X	Trash fill/abandoned room
3081/030	--	X(?)	--	--	X(?)	Lens, not at structures
F14/037	X	--	--	--	--	Lens/pit in courtyard
LPPNB						
3300/035	--	--	--	--	X	Exterior trash pit
3300/040	--	--	--	--	X	Debris pit, not at structures
3300/029	--	--	--	--	X	Debris pile, exterior
3300/046	--	X(?)	--	X(?)	--	Refuse disposal outside, in colluvium
3275/034	--	--	--	X	--	Trash dump at abandoned LPPNB house
5518/016	--	--	--	--	X	Trash fill in abandoned and burned house
5493/029	--	--	--	--	X	Trash dump outside, in colluvium
PPNC						
3300/013	--	X	--	--	--	Exterior compacted lens
4455/044	--	X	--	--	--	Exterior lens near wall
5315/010	--	--	--	X	--	Debris pit/fill
5515/007	--	--	--	X	--	Debris pit/fill
5515/016	--	--	--	X	--	Debris pit/fill
PN						
4273/006	--	X	--	--	--	Compacted lens near structure
4273/007	--	X	--	--	--	Compacted lens near structure
3673/003-004	--	--	--	--	X	Trash fill/abandoned room
3673/002	--	--	--	X	--	Trash fill/abandoned room

[a] Primary deposit of naviform core-production and -reduction debitage; also contained a small amount of tool production debris. A workshop locus of craft specialization.
[b] Primary deposit of non-naviform core-production and -reduction debitage and tool-production debris. An activity area of nonspecialized, subsistence-based flint-knapping.
[c] Secondary deposit of waste from the production and reduction of naviform cores and blades.
[d] Secondary deposit of waste from the production of non-naviform blade(let) and/or flake cores and tools.
[e] Secondary deposit of waste from tool-production activities.

ted with household structures. Tool production in workshops was evidenced by a few broken tools. However, workshop debitage assemblages contain fairly large numbers of proximal and distal blade segments, which probably are the residue (or "industrial waste") from sectioning blades for tool production. Medial blade portions were poorly represented, suggesting that these were taken out of, or traded out of, the workshop as tool blanks. Tool production *per se*, however, was much less apparent than at the other areas, suggesting that production of cores and blades was the more significant workshop function, while tool production was a primary activity at other, nonworkshop, flint-knapping loci.

Although flake cores and blade(let) cores of wadi flint and chert were reduced for tool blanks at nonworkshop loci in small numbers, blanks for most tool production (*ca.* 93%) at any given tool-production locus clearly consisted of a wide range of naviform core-and-blade production products, and debitage from a variety of Huweijir flints. As noted above, tool blanks appeared to have been assorted pieces selected from disparate reductions, rather than technologically consistent material from a few reductions. Flint-knapping loci of tool production, therefore, appear to reflect procurement, and possibly curation, of blanks acquired from naviform core-reduction workshops.

Distribution and curation of tool blanks is supported by the discovery of an isolated cache of 82 blade-blanks of mostly reddish Huweijir flint that was recovered from beneath the floor of an MPPNB residence (Plate 7.21). The blades were apparently wrapped in a bundle, then apparently placed in a sub-floor cache pit where they were stored, presumably for future use (Plate 7.22). Apparently the cache was forgotten, and at some point it was covered over with floor plaster. The common morphological attributes of the blades suggest that these items were intended products of core reduction that were selected as blanks for several specific tool types, especially for projectile points and for cutting tools (*e.g.,* sickle blades) (Plates 7.23-7.26).[1]

Tool blanks and tool-production residues also were distributed generally throughout the loci that were tested from the remaining periods of 'Ain Ghazal's occupation. Taken together, these data argue that tool production during all periods was a common task that was undertaken at the household level. Replicative experiments conducted for this research also attest to the ease of production of Neolithic blade-and-flake tools. The advantage of blade-tool blanks, especially those that were "preconfigured" with a specific tool in mind, is that they required little retouching to produce finished PPNB tools. Often, only a hafting area needed to be created, or a blade needed to be trimmed slightly. These tasks would have been completed in a just a few minutes. This fact is readily apparent when comparing blades from the cache assemblage with typical projectile points and sickle blades from PPNB contexts (Plates 7.23-7.26). Flake-tool blanks were similarly selected for appropriate flake morphology to created nonformalized tools. Therefore, most flake tools required only modest alteration of the flake blank to create a finished tool. Consequently, none of these tools required extensive skills, continual maintenance of skill levels with constant practice, or the expertise of specialists in order to produce them. All were within the capabilities of the average person.

PPNC and PN tool production was structured in a similar manner. However, since blades were not manufactured during these periods but were scavenged for tool production, the advantage of blade-tool blank "preconfiguration" was lost. Tools were fashioned mainly from flakes or from poor-quality or broken blade pieces, and occasionally from discarded PPNB blade tools.

[1] A more extensive assessment of these data are presented in Karnes and Quintero (2007).

Plate 7.21. MPPNB blade cache. Eighty-two blade blanks recovered beneath an MPPNB house floor. Cache consists of blades of high-quality flint, such as that from the Huweijir mines.

Plate 7.22. MPPNB blade-cache bundle, as found beneath a plastered floor.

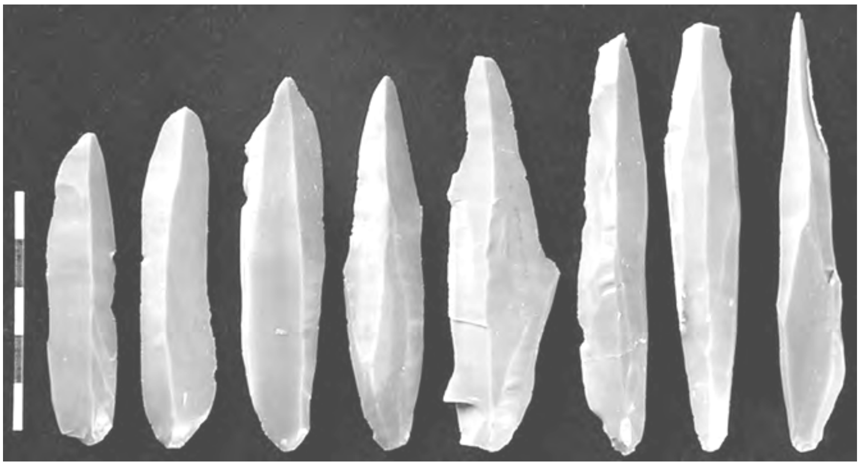


Plate 7.23. Potential projectile point blanks in blade cache.

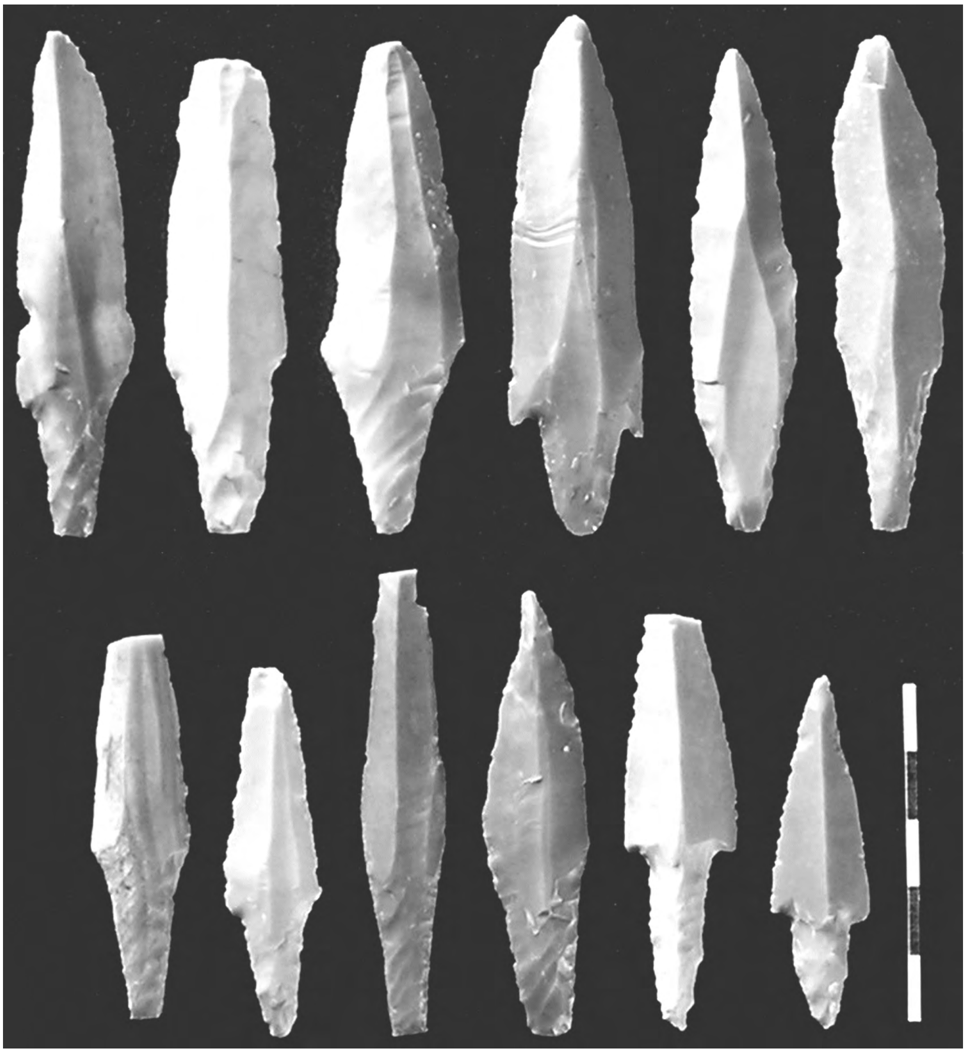


Plate 7.24. Typical PPNB projectile points. Compare with potential projectile point blanks from PPNB blade cache depicted in Plate 7.23. The “preconfigured” blanks could easily be converted into projectile points such as these.

Plate 7.25. Potential sickle blade blanks in blade cache.

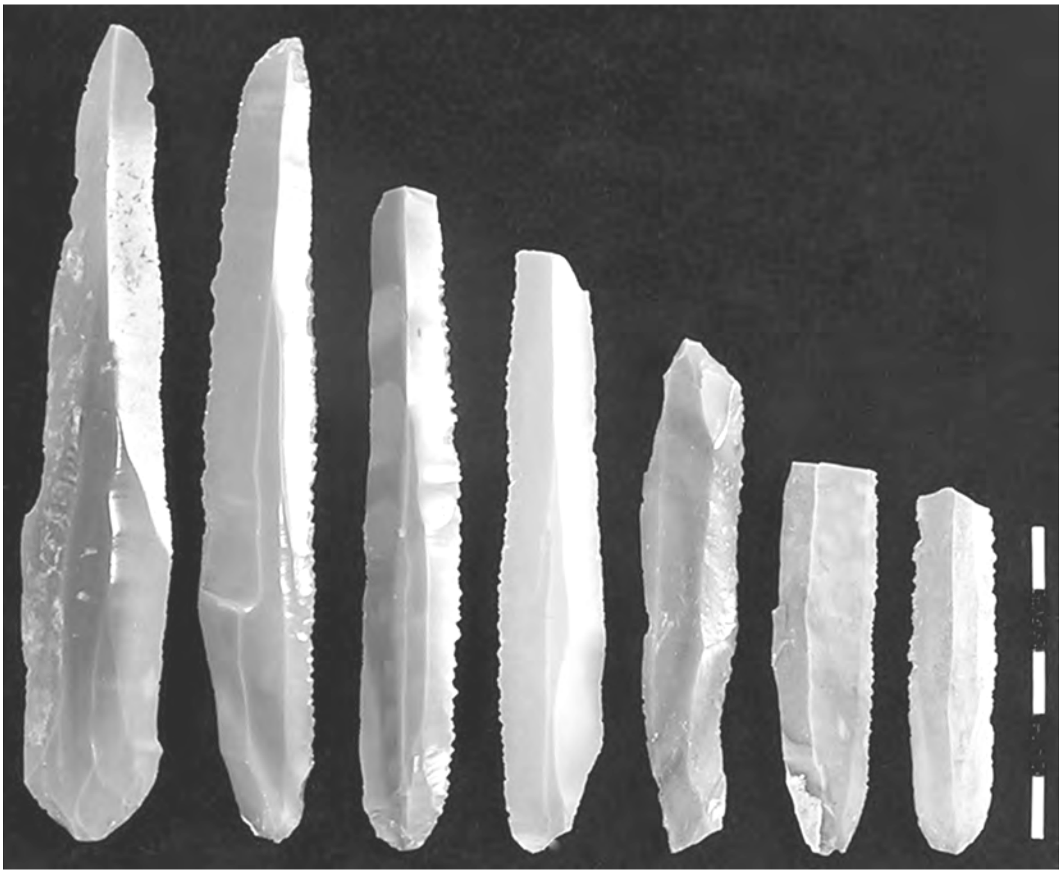


Plate 7.26. Typical PPNB sickle blades. Compare with sickle blade blanks in Plate 7.25.
Note the minimal amount of alteration necessary to fashion such sickle blades from these blanks.

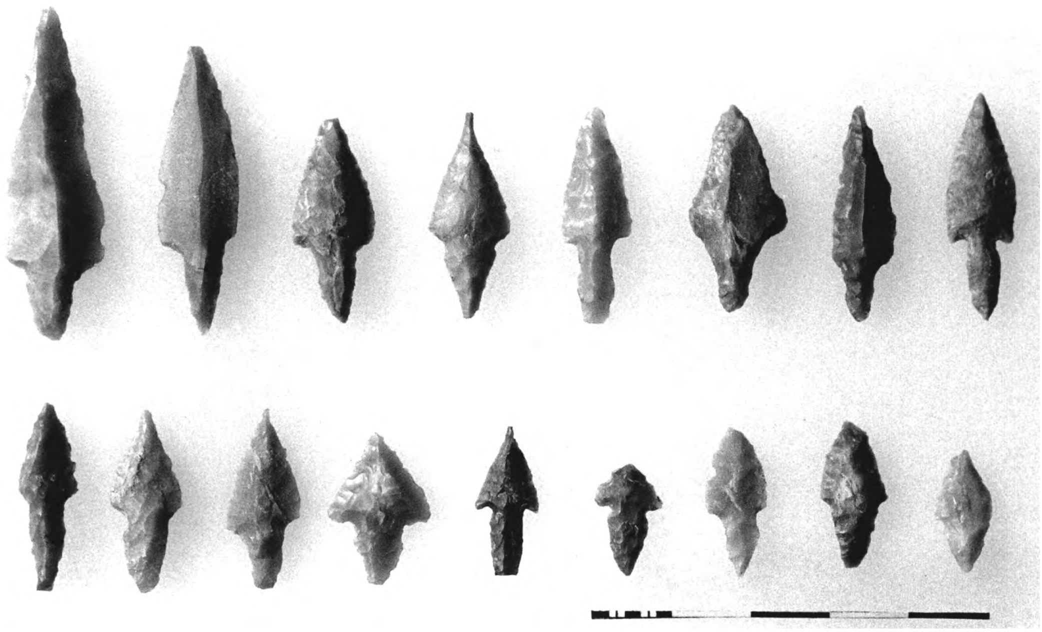


Plate 7.27. PPNC/PN projectile points. Most of these small points were made from extensively pressure-flaked blade fragments, or in some cases, from flakes. Some likely were resharpened a number of times during the course of retooling (as, for instance, those on the bottom row) and finally discarded in tool-production loci. All are easily made.

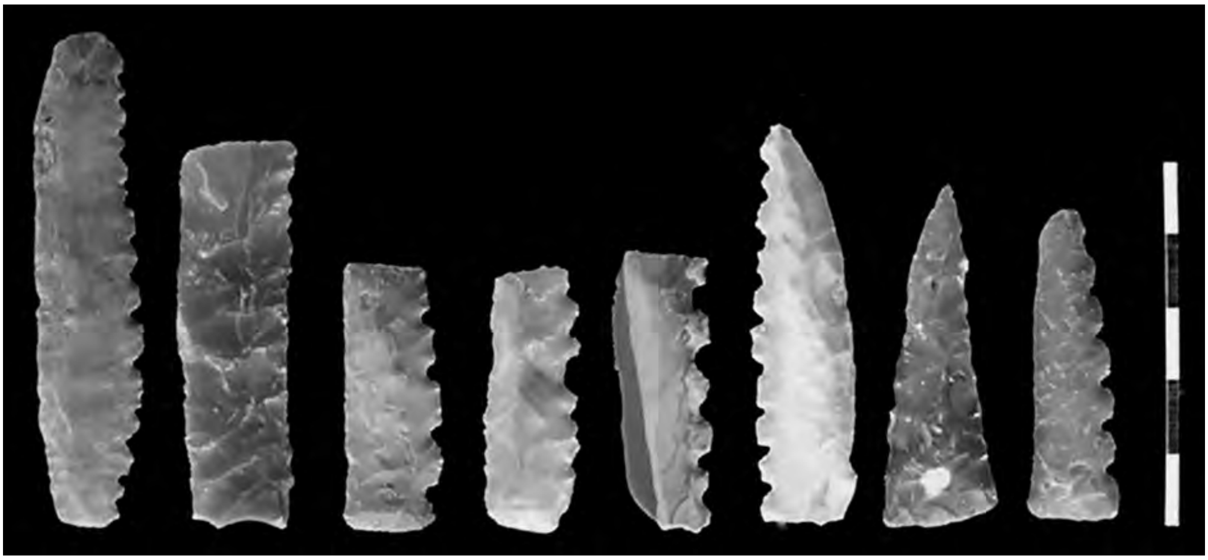


Plate 7.28. PPNC/PN sickle blade elements. Various forms are evident. Most are extensively pressure-flaked blade segments or flakes; some are heavily serrated, possibly reflecting attempts to fashion good cutting edges on ancient, poor-quality blade fragments.

Consequently, formal tools, such as projectile points (Plate 7.27) and sickle blades (Plate 7.28), usually are smaller than their PPNB counterparts and more heavily retouched, often with extensive pressure flaking. Nonetheless, replicative experiments demonstrated that none of these tools are so difficult to produce that they would have required the skills of specialized flint-knappers.

In sum, the data from all periods are compatible with nonspecialized tool production by many community members, probably by most households for their own use, during all of the occupational phases.[1]

SUMMARY

The small number of MPPNB loci (one early MPPNB, one late MPPNB) that resulted from primary production of naviform cores and blades, compared to the large number of tool-production loci and waste-disposal loci (168) throughout the MPPNB exposure of the townsite, imply that naviform core reductions were executed by a few flint-knappers, specialists who knapped at workshop localities. Further, these specialists provided blades for tool-production for the rest of the community. While it is possible that the two core-and-blade production loci were chipping areas that were used by the general community, this alternative seems unlikely for several reasons. First, the naviform cores and reduction debris from the late MPPNB workshop were so standardized that they attest to the work of a single individual. Second, tool production and disposal of the resulting lithic waste occurred throughout the site, and most of these locations are associated with structures that appear to be residences. However, very little tool production occurred at the naviform core-reduction loci. That blanks but not tools would be produced consistently by nonspecialist flint-knappers at a common community flint-knapping area[2] seems illogical and is counter to expected patterns of flint-knapping behavior as observed in most ethnographic and modern situations, including those in town settings.

Likewise, it seems unreasonable that residential flint-knapping, as revealed by these data, would be limited in all cases to tool production and the reduction of non-naviform cores, rather than including naviform core production and reduction, if these activities were all within the purview of nonspecialist flint-knappers. A more credible interpretation is that blade-tool blanks were produced from the reduction of naviform cores by specialists at their workshop localities, and then distributed to other community members who took the blanks to their residences for their own tool-making activities. The loci distribution pattern supports this view, a view that is strengthened by the residential association of the blade cache. The ‘Ain Ghazal blade cache likely represents a common economic transaction in which blades were obtained by trade from the community flint-knapper, then stored in the home until they were needed to refurbish tool kits. It should be noted here that a similar blade cache of tool blanks and partially finished blade tools was recovered from a PPNB residential structure at Beidha.[3]

---

[1] Further corroboration of nonspecialized household tool production is found in the axe/adze assemblages from ‘Ain Ghazal. A detailed study of the use-life phases of the artifacts, and of loci of their distribution throughout the community, confirmed that axes and adzes were made in and around individual residences. This pattern persisted throughout the occupation of the site. See Quintero and Hintzman (2007).

[2] On the other hand, it is quite common among specialists and nonspecialists alike for early stages of flint-knapping, such as cobble sectioning, trimming quarry flakes, and blank production, to occur at quarry sites, and for tools to be produced near residences (*e.g.*, Deal and Hayden 1987; Hayden 1987; J. Clark 1990).

[3] The cache of 111 blades and tools was recovered from the floor of a burned PPNB residence at Beidha (see

At these latter, widely distributed, tool-production loci, nonspecialist community members occasionally reduced their own flake cores and non-naviform blade(let) cores for tool blanks, sometimes using wadi flint and coarse chert, or discarded naviform cores. Numerous naviform cores appear to have been cycled out of the primary workshop areas, perhaps as redistributed or gleaned material. Such cores were then reused as flake cores or tool blanks at tool production loci, and ultimately were discarded as waste from these activities. Nonetheless, many of these extensively used cores still exhibit regularized features that attest to their initial production by highly skilled flint-workers. These flake-core reduction and tool-production activities are not represented at the naviform core-reduction loci, but should be present, if these areas were used by non-specialist, community members.

Thus, the distribution pattern as well as the content of the MPPNB debitage loci from ‘Ain Ghazal argue that both specialized and generalized flint-knapping supported the production of stone tools during the MPPNB. The lithic economy of the town appears to have been reliant upon a few individual craftspeople who made and reduced naviform cores in order to supply blade-tool blanks to other households in the community. Nonspecialist flint-knappers within individual households made their own tools, mainly from blade-blanks acquired from specialists, but also occasionally using flake cores or non-naviform blade(let) cores that they reduced themselves.

The data from LPPNB cores and debitage loci are tentative, primarily because the LPPNB has not been well studied at ‘Ain Ghazal and the sample is limited. Nonetheless, the lithic data presented here suggest that naviform core-and-blade production continued, but that reliance on naviform core technology and on precisely controlled blade production began to diminish during the LPPNB. Several factors justify this interpretation. First, the data clearly support the presence of a primary workshop locality for the production of naviform cores and blades into the late MPPNB. While we are now lacking an LPPNB workshop, it is clear that naviform core reduction was not reflected at any of the 90 LPPNB loci reviewed for this study. Thus, there are no data that support naviform-core reduction in or near household settings. Also, continuity of core-production and reduction appears to be evident in naviform cores and blades, and in core-related debitage found throughout the LPPNB loci. However, lesser-quality flint and flint of more diverse configurations often were selected by knappers for production of naviform cores, so that, while morphological attributes of naviform cores reflect the formal processes of reduction, the cores and blade products often appear less regularized. Consequently, blade-tool blanks generally are less well-configured than during the PPNB and the resulting tools, such as projectile points, are not as finely crafted. Given the above circumstances, it seems correct to proposed that the craft continued but that it was on the decline.

Importantly, exploitation of flake cores far surpasses the reduction of naviform cores during this period. This circumstance is made apparent by the large numbers of flake cores of chert and wadi flint that are present at secondary deposits of tool-production waste, and by the fact that exhausted naviform cores were invariably exploited as flake cores, or sometimes as crude, non-naviform blade(let) cores, at tool-production loci. The dramatic increase of flake core reductions at tool-production loci, and concomitant decrease in naviform core reductions, is strong support for a shifting reliance on generalized tool-production tactics. Possible reasons for this decline in

---

Kirkbride 1967: 10, Plate V; Mortensen 1988). The Beidha cache was once contained in what appeared to have been a small, wooden box, and consisted of 100 blades produced from bidirectional (probably naviform) cores, some of which were retouched near the pointed ends, and 11projectile point preforms and nearly-finished or finished tools. There is little doubt that the box contained a tool-maker’s collection of material dedicated to projectile-point production, unlike the blanks for a variety of tools in the ‘Ain Ghazal cache.

naviform core technology are discussed in the following chapter. However, it is important to note here that unspecialized reduction of flake cores and non-naviform blade cores is still complemented by naviform core technology, giving evidence for the stability and continuity of a varied technological system.

PPNC and Yarmoukian data support only the presence of generalized strategies of tool production during both of these periods, whereby flake cores and occasionally blade(let) cores were reduced by individual flint-knappers for their own use. Importantly, tool blanks also appear to have been scavenged from ancient PPNB debitage deposits. No data support the continued reduction of naviform cores during the PPNC and Early PN periods at ‘Ain Ghazal. Likewise, no data argue for the continued reliance on workshops and the expertise of specialist flint-knappers during the PPNC and Yarmoukian periods at ‘Ain Ghazal. These circumstances suggest that naviform core technology ceased to be a viable economic entity during the PPNC.

Chapter 8

SUMMARY EVALUATION

Research presented in the previous chapters provides essential technological data pertinent to the industrial organization of lithic economies during the occupation of ‘Ain Ghazal. Taken together, these data revealed several economic choices that were made to provide subsistence tools for the daily activities of its townspeople. Specific considerations, summarized below, included the organization of raw material acquisition, tool-production technologies, and the intrasite distribution of lithic production loci. These data present a detailed, initial record of the evolving lithic economy of the town. An evaluation of the development of naviform-core technology and its economic role within the community is presented here, together with an interpretation of its historical significance within the context of the greater Levantine area.

ORGANIZATION OF LITHIC TECHNOLOGIES AT ‘AIN GHAZAL

Naviform-Core Technology and Specialized Production

The framework for this analysis was initially presented in Chapter 4 and concerns certain technological evidence of specialized, as opposed to generalized, economic organization, especially as these concepts relate to Neolithic village settings (*e.g.*, Evans 1978; Tosi 1984; J. Clark 1986a, 1987; Michaels 1989; Yerkes 1989). The data are evaluated for each period of occupation at ‘Ain Ghazal, commencing with the production of naviform cores and blades during the MPPNB. Major technological features, or indicators, of craft specialization are considered. As noted, most of these attributes give evidence of specialized production expertise, production efficiency, or standardized manufacturing tactics that produced a standardized product. Individually or collectively, all of these indicators can suggest that a few craft specialists provided for the production of blades for fashioning tools at ‘Ain Ghazal.

Accessing Resources that are Difficult or Costly to Acquire

As noted above, blades at ‘Ain Ghazal were not made from weather-checked or wadi-rolled flint from exposed deposits. Rather, pristine nodular flint was obtained from seam mines in the walls of the nearby wadis. The specific raw material requirements of the naviform core-and-blade industry compelled stoneworkers to extract fresh flint nodules of high quality from nearby geological formations with a substantial mining effort. The extensive mining excavations of the Huweijir wadi and precariously undercut grottos argue this fact. While it is not feasible to date directly the duration of the mining activity, diagnostic naviform debitage attests to its exploitation during the PPNB. Furthermore, the extremely high ratio of Huweijir flint in the MPPNB debitage loci and tool inventories gives strong support for a major mining effort to have occurred at this time.

It is probable that the industrial organization involved continual production of blades to supply ongoing tool needs, as tools were damaged, lost, or needed replacement, and as new households required supplies. This production endeavor would have required ongoing extraction of flint through persistent mining efforts because there was a constant and increasing demand for tool blanks as the population of the community expanded. Recall that only a limited number of blades could be obtained from each core. Once obtained, flint nodules had to be transported to the village area, which was the center of the local economy. Seen in this light, the raw flint for tool production was both difficult and costly to acquire.

Because reliable supplies of good flint were needed to meet the growing demand for high-quality blades in the Neolithic economy, flint procurement for the local blade industries probably entailed the organizational efforts of flint-knapping specialists. A relevant consideration is the highly selective acquisition of thin, high-quality nodules of flint from the Huweijir flint mines that were transported back to the workshop area for reduction. The narrow range of desirable nodule characteristics makes it likely that specialists in flint-working would have organized and supervised the mining effort or carried it out themselves since, clearly, not any nodule would do. There also is some indication that specialists managed and controlled access to blade-core flint. For instance, high-quality flint nodules generally were not used for flake-core reductions at household-related chipping areas, in spite of the superior attributes of this material for production of most flake tools. Clearly, nonspecialist members of the community did not use pristine nodules of high-quality flint for flake production. These circumstances suggest that the mining effort itself, including the organization of extraction and transportation of flint, and subsequent use of the flint, were likely to have been regulated by specialists, stone-workers who secured and safeguarded their essential raw material.

While it is true that an individual family probably required only a modest number of blades per year, the ever-increasing demands of the community each year would have been considerable. Recent estimations (G. Rollefson, personal communication 1997) suggest that ‘Ain Ghazal’s population continued to increase throughout the MPPNB, finally reaching nearly 2,500 to 3,000 people in the later portion of the phase, or perhaps about 600 families. By this time, as the village expanded, *ca.* 600 to 1,200 nodules *at a minimum* would have been extracted from the Huweijir mines each year. As indicated by the deeply cut seam mines, with each passing year well-configured nodules of high-quality flint would have been increasingly difficult to obtain and the mining investment of time and energy, etc., would have grown. In such a situation, it is probable that the role of specialists in raw material selection and management would have intensified. In this manner, technological organization would have been responsive to changes in the condition and accessibility of raw material, so that economic strategies would have altered to suit new needs (see Nelson 1991: 57).

Technical Difficulty in Production and High Level of Production Skill

Contrary to common assumptions (*e.g.,* Pope and Pollock 1995), determinations of technical difficulty and production skill are not subjective criteria, but are testable by experimentation. Replicative analyses conducted for this research demonstrated that both of these criteria characterize the production of naviform cores and their reduction into blades during the MPPNB. Blade production was a complex task that required considerable skill in all levels of the knapping process *for consistent production of fine-quality blades*, so that there can be no doubt that the skills of specialists were needed to produce such blades. As discussed above, one of the most obvious and compelling substantiations of this fact is the necessity to maintain the requisite skill levels for blade production continually via a regular investment of flint-knapping time. Occasional or sporadic knapping episodes, as would have been the case with nonspecialized production, would not have allowed the yield of high-quality blades that characterize the industry, especially during the MPPNB when the quality of naviform cores and blades was at its finest. Given these considerations, it is evident that naviform core-and-blade technology at this time was a highly developed craft that involved the work of specialists. While most people probably did fabricate their own tools and weapons, they undoubtedly lacked the requisite investment of time and energy, and probably lacked the requisite skill, to produce their own blades.

Standardization of the Core-and-Blade Production Process and Error-Reduction Strategies

Standardization reflects two economically relevant features: production strategies that indicate control of the technological process by a few craftspeople, thereby limiting variability, and selection for repetitive, and therefore efficient, production. Rice (1991: 268) noted that standardization indicative of craft specialization is expressed in a "relative degree of homogeneity" in products or in the process of production. Consequently, standardization is not necessarily measurable or quantifiable but may be assessed with reference to certain manufacturing or technological characteristics. Such assessments were used here.

The detailed documentation of naviform core-and-blade production processes discussed in Chapter 6 presents a strong case for standardization of the industry. Resource selection essentially was limited to the highest grade of flint available, and to a restricted range of configurations of raw material. Preferential selection of nodule configurations and regularized flint-knapping strategies produced standardized precore forms. Core morphologies were carefully constrained when cores were produced and during the process of reduction by a standard repertoire of maintenance and error-correction tactics. Exhausted naviform cores have standardized attributes that reflect these actions. The naviform core shape was uniquely configured to provide sustained control over all aspects of the blade-production process. No other available form of percussion-blade core had this advantage. These manufacturing and technological characteristics all argue that production was standardized, a result of the efforts of craft specialists.

Standardization of Products

The standardized nature of the blade products fashioned from naviform cores is well-recognized in blade-tool assemblages and from the core-reduction loci in MPPNB contexts. While standardization of blade products is accepted *a priori*, the economic implication of such standardization is at issue. Standardization relates to prevailing industrial strategies and production skills that were necessary to create blade products of common configuration. Consequently, standardization of blade products is evaluated here in these terms.

As noted previously, both naviform core morphology and the process of blade production were carefully controlled to ensure the reproduction of certain common features in the blades that were produced. The most significant of these features are: regularization of blade widths (resulting from standardization of core widths), straight blade profiles (due to the design and maintenance of the core face), conventional lengths (an effect of constraints on core size), and standardized blade topographies (essentially resulting from preconceived notions of desirable blade morphologies and from the ability to preconfigure the design of the blade on the core face).

Replication experiments demonstrated that consistent reproduction of these attributes, as in the hundreds of core reductions and tens of thousands of blades studied in this sample, was due to a specialized production process and to the skill of a limited number of flint-knapping specialists who performed and perfected routine blade-production tasks.

Production Efficiency

Traditionally, this characteristic relates to the need for increasingly efficient production to meet the tool demands of a growing population. At ‘Ain Ghazal, production efficiency resulted from the choice of the most efficient core form, the naviform core, for the basis of the lithic blade-tool economy. Standardization and efficiency were enhanced by careful selection of a relatively narrow range of nodule qualities, sizes, and morphologies for core blanks. Replicative experiments demonstrated that the naviform core configuration was most effective for consistent production of good blade blanks of standardized configurations. An awareness on the part of the PPNB community of a need for increased production efficiency is evident in this case. The evidence is not by measurements of increases in production output per se (although output likely increased when compared to the less-standardized blade production evident during the Epipaleolithic and PPNA), but by the exclusive selection of the naviform core design and the technological advantages the design had to offer over other blade-core forms. That this choice was made for practically all blade production over a period of nearly 1,300 years of village occupation attests not only to the economic value of these traits, but to the soundness of the initial economic choice to rely on this core form. The overall effect of this technological choice on the growing PPNB community at ‘Ain Ghazal was economic security resulting from the ability to produce dependable, standardized products for the production of essential tools.

Workshops or Specialized Work Areas

The individual character and distribution of debitage loci from the MPPNB occupation of ‘Ain Ghazal reflected a complex pattern that included the production and reduction of naviform cores at specialized workshop settings. Blades produced at these locations were then distributed according to some unknown system of reciprocity to individual households for tool production. These data give evidence for a specialized aspect of the tool-production economy in which craft specialists supplied blade blanks to the general population.

Standard Production Tool Kits

Tool kits for the production and reduction of naviform blade cores are quite minimal, consisting only of a variety of hammerstones of varying configurations and qualities, and abraders that are used for platform preparation. One would expect to find these tools at workshop localities, but the archaeological evidence for such standard production equipment is very rare. Only a few blade-production hammerstones and abraders have been identified. It is possible that lack of data is due to the vagaries of sampling strategies or to the fact that such tools are not habitually recognized in the field as flint-working tools. When considering the strength of the conclusions presented above, however, failure to identify substantial quantities of production tools is not seen as detrimental to this analysis.

Summary

In light of the above discussions, there is clear and compelling evidence that the implementation of naviform core-and-blade technology at ‘Ain Ghazal involved craft specialization. At the present time, all available data suggest that the enterprise probably was organized in a few selected households in the community, in some ways similar to household industries, or “cottage industries.”[1] If this interpretation is correct, it follows that blade-making probably was accomplished by part-time craft specialists who supplied blades for the immediate community. Such rudimentary role differentiation based on skill would be consistent with an elementary level of social stratification, as suggested by burial data, for instance, as discussed above. No complex distributional arrangements are implied at this incipient stage of specialization, nor are there any substantiating lines of evidence to support such an interpretation. Instead, blades may simply have been directly traded from the producers to the consumers within the community. Industries organized at this level are common in self-supporting peasant communities (see Brumfiel and Earle 1987: 5), of which villages such as ‘Ain Ghazal, Jericho, Beidha, and Basta were the earliest representatives.

Reliance on high-quality tool stone was a major economic consideration for the PPNB villagers. That stone was mined locally rather than imported into the economy is clear. Ease of access to flint resources, as at the nearby Huweijir mines documented here, was an important economic choice, one that must have affected the growth and economic stability of the community. Dependency on the resource must have grown as the town grew and the need for a consistent supply of stone tools increased. It is logical to assume that the first people to establish a village at this spot did so because it offered all of the major requirements for settled living: arable soil, plentiful and diverse biotic resources, permanent water, and flint for tool production.

In terms of its lithic economy, then, the evidence evaluated here indicates that ‘Ain Ghazal had an autonomous economic structure that persisted from its inception until it ceased to be occupied. During the flourishing period of the MPPNB, the trend toward specialization developed with the dependence on naviform-core technology. This economic feature augmented, but did not supplant, the existing generalized economy.

PPNB Technological Dualism

Evaluation of the lithic data from ‘Ain Ghazal, therefore, also argues for a dual economic structure during the PPNB. This system combined part-time craft specialization for the production of naviform cores and blades with generalized, household production of tools and reduction of nonformalized blade cores and flake cores. Thus, it appears that a longstanding, unspecialized, subsistence-based lithic economy was augmented with specialized production of blades, beginning early in ‘Ain Ghazal’s occupation and becoming more refined as the Neolithic population there expanded. This flexible scheme provided a diversified economy in which the individual hunter/gatherer/farmer could be self-sustaining, but also had the economic option to rely on part-time specialists for tool blanks for the production of many important household tool needs. Similar patterns of economic dualism supporting both blade-making specialists and generalized subsistence endeavors existed in other contexts with the development of agrarian

[1] But without the usually implied link with local markets; see Prentice (1983: 19-22).

economies,[1] suggesting that this feature was a common economic adjustment that accommodated florescent neolithization processes.

The presence of a flake-based component of Neolithic assemblages is well documented. Others have suggested that such flake-core production represents either opportunistic (*e.g.*, Gopher 1989) or expedient (*e.g.*, Nishiaki 1993) tool-production behavior. Opportunistic technological behavior commonly refers to unplanned, *ad hoc* actions, or "immediate technological responses" (Rice 1991: 65) to an unforeseen opportunity. While such behavior undoubtedly occurred at ʻAin Ghazal, it does not characterize the generalized tool-production economy seen here. Expedient technological strategies, on the other hand, reflect predictable behaviors, and are usually associated with planned activities, such as manufacturing time, and raw material acquisition, and storage (Parry and Kelly 1987; Nelson 1991).[2] Also, opportunistic technologies more often equate with mobile groups, while expedient technologies tend to be associated with sedentary populations. Given these respective attributes, it seems clear that the generalized component of Neolithic economies, whether in the PPNB or elsewhere, depicts expedient strategies.

The data presented above reflect a florescent period of the Neolithic when ʻAin Ghazal grew in size and population, townspeople evidently developed a reliance on an agrarian economy and on animal husbandry, and enjoyed economic security. Given this situation, it is not surprising that lithic production sites within the town give evidence for a varied and dynamic stone-tool economy, one that apparently included a reliance on specialist flint-knappers and blade-production workshops in conjunction with a domestic, household economy that continued to be used in the production of flakes and tools.

During the LPPNB there was a marked increase in population at ʻAin Ghazal, reflecting similar changes that occurred throughout the Jordanian highlands and other corresponding districts of the southern Levant. This population spike is attributed to influxes of people from other communities, such as Beidha and Jericho that were abandoned about this time (Rollefson 1987b, 1989a, 1996, 1997). Lithic data from this period show a striking shift in economic strategies to a greater reliance on unspecialized production tactics. While reduction of naviform cores is still evident, it no longer dominated the tool-production industry. As noted above, reduction of naviform cores diminished and production of flake cores at generalized tool-production loci increased. The dual economic pattern persisted, therefore, but the emphasis shifted. Causes of such changes in the lithic economy are not always clear, but it is quite likely that these technological choices were "tracking"[3] general economic adaptations in the community that accommodated local demographic stress and accompanying sociocultural changes, and possibly detrimental environmental issues as well. According to recent interpretations (Rollefson

---

[1] This pattern is particularly well documented in Mesoamerica with the shift from archaic hunting and gathering to agrarian economies (*e.g.*, MacNeish *et al.* 1967; J. Clark 1981, 1987; Hole 1986; also see Parry and Kelly 1987). Interestingly, such economic dualism appears to have persisted into urban periods as well, and is found in Early Bronze contexts especially, in large portions of the Levant and into Turkey, for instance, where craft specialists made Canaanean blades that augmented the generalized production of flake tools (*e.g.*, Rosen 1997).

[2] However, Binford's (1977a) discussion of the differences between expedient and curational behaviors suggests that in this context expedient is the more opportunistic activity. Not surprisingly, much confusion is evident in the literature.

[3] This term is borrowed from Shafer and Hester (1983: 539) who used it in an analogous context where there was a similar shift in lithic economic structures of Mayan occupations at Colha. The lithic economy was seen as echoing shifts in general adaptive patterns of the larger Mayan population.

1996, 1997),[1] the LPPNB occupation at ‘Ain Ghazal withstood a marked increase in population such that the community spread across both sides of the Wadi Zarqa. It is possible that this population expansion taxed the existing economic system. Lithic specialists may have been less able to cope with increases in demand for blade-tool blanks, so that the quality of blade blanks declined. And, townspeople had to produce more flake-tool blanks for their own needs. Such a situation also could have been exacerbated by fluctuations in the availability of necessary tool-stone materials.

At this point, when population demands were at their greatest, the Huweijir flint mines and other comparable flint sources in the area would have suffered the effects of 750 - 1,000 years of exploitation. Judging from the extensive exploitation of the many seam mines and now-barren, collapsed mine structures observable today, good flint became difficult to obtain. It is for this reason, perhaps, that most naviform cores reduced during the LPPNB were “pushed harder” by further reduction as blade cores and, finally, as flake cores, so that they were reduced far beyond comparable cores from the MPPNB. This explanation also clarifies the greater variability in choices of stone for naviform-core production that is apparent in the LPPNB lithic economy. Acquisition of good tool-stone at the mine site may have become so difficult that other sources also had to be used.

There are numerous indications that the population ultimately reached phenomenal levels during the latter LPPNB as the town swelled in size to over 12 hectares. It also has been proposed that gradual degradation of the local environment occurred coincident with this growth, and continued into the PPNC (Rollefson 1996, 1997). This situation may have compounded the need for drastic changes in the economy.

PPNC and Yarmoukian Generalized Technologies

At ‘Ain Ghazal, as socioeconomic stability faltered, the dual lithic-economy system collapsed and lithic specialization ceased. It is clear from the data presented here that production of naviform cores and blades did not persist into the PPNC and PN periods. Data document *only* the presence of generalized strategies of lithic core reduction and tool production during these periods. These activities were varied and included exploitation of on-site tool-stone sources, scavenging of old PPNB lithic deposits for recyclable material for tool production, a reliance on flake cores and blade(let) cores, and changes in tool-production strategies. The analyses presented above argue strongly that all of these activities were organized at a generalized household level; specialized blank-production activities that were in evidence during the PPNB were no longer functioning.

Significant changes in sociocultural domains, including ritual practices, subsistence activities, architectural choices, etc., also have been documented. Importantly, there are now convincing arguments that these events coincided with widespread ecological stress in the vicinity of the community (Rollefson and Köhler-Rollefson 1989; Rollefson 1996, 1997). Ultimately, these circumstances, possibly combined with a deteriorating natural environment, led to at least partial abandonment of the town.

The striking alteration of the lithic economy was coincident with events that began in the

[1] For a recent update of these effects on concomitant social organizational changes at ‘Ain Ghazal see Rollefson (2004), and for LPPNB Basta see Gebel (2004).

PPNC and continued into the Pottery Neolithic. Ultimately, stability returned to ‘Ain Ghazal in the PN with the development of a new suite of socioeconomic choices configured by the needs of the now-small agrarian community. But a specialized lithic economy evidently was no longer economically viable in these new circumstances. It seems reasonable to conclude that the decreases in population size and socioeconomic complexity were not conducive to the reinstitution of craft specialization. The lithic data presented here, then, mirror the larger economic situations; they suffered change in order to accommodate environmental, demographic, and socioeconomic crises.

THE EVOLUTION OF NEOLITHIC ECONOMIES

The ‘Ain Ghazal data demonstrate that naviform core-and-blade technology underwent a very clear and understandable historical development responding to the economic needs of the community. This interpretation of its evolutionary course also brings reasonable clarity to the many puzzling changes in the lithic economies of the greater Levantine Neolithic. Economic conditions prior to its florescence and after its decline were structured by environmental and sociocultural frameworks far different from those of the Pre-Pottery Neolithic. Expectedly, the resulting technologies contrast sharply and reflect the conditions that configured them. These differences were discussed within the context of the changing character of the town, and are considered below in the context of broader trends in economic adjustments within Levantine communities in a somewhat expanded temporal framework.

Epipaleolithic: An Economic View

The Epipaleolithic/Natufian period was characterized by sparse, dispersed populations generally thought to have been organized into bands. However, broad interaction within regions is suggested by continuity in cultural remains. Some researchers (Bar-Yosef 1991b: 389) see this pattern as evidence of “macrobands” that shared common cultural adaptations and stylistic traits. Whatever the nature of the social structure of Epipaleolithic/Natufian peoples, it is clear that cultural demands on technology were not rigorous, as populations were largely composed of dispersed, autonomous groups of mobile hunter-gatherers who saw to their own basic economic needs.

In the southern Levant these needs were met by a technology that emphasized the production of flakes and percussion blade(let)s. With time, microlithic technologies that relied on the production of percussion bladelets were common, and microlithic tool elements (*e.g.*, lunates and other geometrics) became an important added feature of the lithic economy. Many forms of microliths could be used as interchangeable insets in a variety of compound tools.[1] Because microlithic elements could be made from bladelets of many forms and sizes, including very small ones, standardized blade configurations and sizes were not essential. It is apparent that the need for blades was met by a variety of core configurations (large and small) and by numerous reduction strategies. While small single-platform percussion-blade cores were prevalent, there was much variability, and bidirectional, or otherwise unstandardized, opportunistic blade-core forms were used, as were bidirectional opposed-platform cores that may be considered “naviform prototypes,” as mentioned in Chapter 6.

The blade technology was therefore neither rigorously structured nor standardized. Tool

[1] For example, see *Thinking Small: Global Perspectives on Microlithization* (Elston and Kuhn 2002).

needs of the Epipaleolithic/Natufian most likely were met by a generalized lithic economy and stone-working was more casual and was less precisely organized than the naviform core-and-blade technology. It generally is assumed that individuals, or at least individual households, were self-reliant. Since Epipaleolithic/Natufian populations are commonly construed as reasonably mobile groups, it is sensible technologically that many tools were fashioned of easily replaceable parts manufactured by the tool user. It should be noted that increasing similarity among late Natufian assemblages has been attributed by some to a decrease in mobility and the development of cultural uniformity in knapping strategies (Bar-Yosef 1991b: 388). It is tempting to consider that these groups relied on both expedient and opportunistic tool-making strategies. Nonetheless, it is likely that stone was knapped by individuals primarily for their own use; there is no evidence suggesting the emergence of specialized production of lithic tools or any other specialized craft groups at this time.

Pre-Pottery Neolithic: Specialized and Generalized Economies

There are now several important sites in the southern Levant that give evidence for the initial transition to "settled village living" that occurred in the PPNA (see Chapter 2). A lesser appreciated transition was the deletion of microlithic industries from technological repertoires and an increased reliance on production of large blades. The socioeconomic mechanism that accompanied the development of these first villages is not fully understood, but sedentism and population expansions are central issues. As populations expanded and became nucleated in villages, a subsistence economy relying on tethered cultivation and ovicaprid husbandry emerged, complementing the existing reliance on gathering and hunting. Research presented here suggests that increasing economic momentum from population growth required greater technological rigor and predictability to accommodate the tool needs of the growing Neolithic economies. Consequently, the naviform core-reduction strategy was developed in response to these needs, and gradually became dominant.

While the essence of the technology was known in Epipaleolithic times, the naviform core-reduction strategy was selected from a number of known core-reduction approaches and perfected by early Pre-Pottery Neolithic flint-knappers. The unique qualities that it possessed allowed greater reliability in blank production for PPN tools. As sedentism and nascent agrarian economies progressed and populations expanded, villagers sought larger, more regularized blade blanks for production of the common repertoire of subsistence tools and weapons.

Within this context, the task of blade-core reduction gradually shifted from each individual to those who were most skillful, and regularized blade production became economically beneficial. Thus, versatile, standardized blade blanks would have been traded to community members for fashioning into a variety of tools. The logical effect was production of large blades that were easily transformed into a variety of tools by less skillful consumers. Recall that blades produced from naviform cores were essentially preshaped so that tool production was relatively easy. If a sickle blade was lost, or a projectile point was broken, it would have been easy to replace using blanks that were acquired from a specialist's supplies, and perhaps from domestic caches, as at 'Ain Ghazal and Beidha. On a pragmatic level, one should consider that hafting large, regularized blades into handles or shafts is easier and less time consuming than hafting multiple small blades or insets, and generally makes a stronger, more durable tool. Blanks of standard configuration could also fit into existing tool hafts, saving enormous time and effort in haft production.[1]

[1] Experience has shown that the standard production time to complete a fletched, compound arrow, for example, is

Given these observations, it is not surprising that naviform core-and-blade technology ultimately evolved into a specialized craft in the context of large PPNB communities, and became a primary foundation for tool production. Also within this context, the generalized, household production of tools and informal flake-core reductions provided the complementary component of the dual lithic economy. In this regard, the more important issue may be the expanded complexity of the PPNB economy over earlier organizational schemes. The new structure incorporated specialized blank production into an existing generalized economic system in order to facilitate an individual community member's ability to fashion and to maintain easily a standard complement of subsistence tools.

If the economic choices made at 'Ain Ghazal are typical Neolithic strategies, it is likely that many formative Neolithic towns of comparable scale located elsewhere maintained locally independent lithic economies as a fundamental aspect of their organization. The ordinary stone tools for daily activities in these first peasant communities would have been supplied locally, within the context of the community, in much the same manner as staple foodstuffs must have been provided for town members. The prevailing Neolithic lifestyle suggested here would seem to rely to a large extent on the security and dependability of the local lithic economy and its ability to meet the needs of the community.

Village life saw the expansion of sedentary populations for the first time in Levantine prehistory. Many large villages in the southern Levant undoubtedly comprised population clusters that were substantial in size, large enough to provide appropriate socioeconomic settings for beginning stages of craft specialization. Some became towns, ultimately supported substantial populations, and became regional centers. It is possible that these "central settlements" had a significant economic role during the PPNB as centers of craft specialization that met regional economic needs. While data supporting regional exchange of blades from naviform cores currently are lacking for 'Ain Ghazal, economic studies of regional exchange at other central settlements, for example at Basta,[1] may be different. Certainly we need to accommodate regional diversity and other patterns of development. Many smaller communities would not have had sufficient economic complexity to support specialization, but may have been exchange partners. Nonetheless, that the initial trend toward craft specialization began in these communities during the PPNB is no longer in doubt.

Finally, it is apparent that a fundamental necessity for the development of such settlements was immediate access to abundant supplies of good flint for tool production. Without such resources, settled Neolithic communities, particularly large central settlements, could not have flourished. Consequently, ready access to tool stone would have been a necessary condition for formation of these earliest Neolithic societies. And, as argued here, specialization of the lithic economy would have been instrumental for the evolution of the Neolithic pattern of living. The significance of these patterns cannot be overstated. As Mortensen so profoundly observed (1988: 20), ". . . 'the domestication of flint' was an important aspect of the neolithization process, perhaps as significant as the domestication of plants and animals; all three prepared the way for the process of change encompassing the 'Neolithic Revolution'."

In the broader Neolithic context it seems profitable to discuss craft specialization in

---

about seven hours of labor, if all of the materials are on hand.

[1] New discoveries at LPPNB Basta suggest that the town was a regional supplier of blades from naviform cores to smaller local communities (Gebel 2004).

behavioral terms in light of the socioeconomic environment in which Pre-Pottery Neolithic blades were produced, the technological constraints of blade production as elicited from replicative studies, the economics of stone acquisition, and the standardized nature of the blade technology. That is the approach taken here. While the conclusion that Pre-Pottery Neolithic blade technology involved craft specialization is based primarily on first-hand archaeological data from ‘Ain Ghazal, and draws on data from other sites in Highland Jordan, the published record indicates that the pattern probably prevailed throughout the Levant in settings with similar socioeconomic circumstances. Moreover, the same socioeconomic setting that led to specialization in blade technology presumably fostered other technically complex processes that may have required craft specialization, such as the burnt-lime technology that involved plaster production and the fashioning of plaster statuary.[1] These data contradict the traditional view that developing Neolithic towns had simple, unspecialized economies.

However, the socioeconomic setting of the Pre-Pottery Neolithic, with its flourishing villages and growing agrarian economy finally came to an end. This transformation may well have begun in the LPPNB as populations aggregated at central settlements and destabilized their economic balance. A shift in the lithic economy resulted, and the complex craft technologies of the PPNB gradually came to an end.

Pre-Pottery Neolithic C: Collapse of Economic Dualism

The economic crisis at the end of the Pre-Pottery Neolithic resulted in abandonment of many large village sites and disbanding of large population centers. Ultimately, there was a reorganization of populations into smaller, less substantial settlements, a pattern that continued into the Pottery Neolithic. A period of economic restructuring and stasis ensued. Nonintensive farming and nomadic pastoralism appear to have been main aspects of the new adaptive pattern in much of the southern Levant. This economic restructuring promoted substantially altered regional lithic economies as well. Such changes in lithic assemblages are well-documented throughout the Levant (*e.g.*, Crowfoot Payne 1983; Roodenberg 1986; Baird 1995), and clearly reflect broad regional adaptations. It now seems apparent that the regional economic infrastructure that supported craft specialization in blade technology collapsed. The ensuing socioeconomic organization of smaller populations accommodated a dispersed, partially transient population clustered in small hamlets. Consequently, throughout the southern Levant less structured lithic production prevailed, reflecting the overall lethargy in the economy, and generalized tool-blank production, mainly in the form of flake-core reduction, became the normal economic mode. The dual economic structure that had supported the growth of early Neolithic towns had ended.

CONCLUDING THOUGHTS

This consideration of naviform core-and-blade technology at ‘Ain Ghazal took an evolutionary and an economic perspective. Placing the technology within this broad framework allowed appraisal of Neolithic blade production as an economic adaptation, one that related to both earlier and later developments. This view made it possible to understand the evolution of the technology by addressing how it fulfilled the tool needs of the times, and how it articulated with other aspects of the Neolithic economy. At the same time, a detailed study of the unique technical

[1] For a discussion of the use of lime plaster in the Pre-Pottery Neolithic and some of the socioeconomic implications of production, see Gourdin and Kingery (1975), Kafafi (1986), Garfinkel (1987), Kingery *et al.* (1988), and Rollefson (1990b).

nature of naviform cores and blades provided an understanding of early Neolithic socioeconomic patterns that would not have been apparent otherwise.

Certainly it is true that other economic choices were made to accommodate neolithization in other areas of the world, such as in Mesoamerica, China, India, and other portions of the Near East. Each situation would have required consideration of its own repertoire of technological options. For the Levant, development and florescence of naviform-core technology within the context of craft specialization suited the economic climate of the time. The longer view is that in the Levant the economic organization of naviform-core technology during the Neolithic is the earliest evidence yet discovered of lithic craft specialization. It adds substantial weight to the growing body of evidence that indicates that industrial craft specialization had its genesis in the Neolithic.

BIBLIOGRAPHY

Abbès F.

1994 Techniques de débitage et gestion de silex sur le Moyen-Euphrate (Syrie) au PPNA final et au PPNB ancien. In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 299-312. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

2003 *Les Outillages Néolithiques en Syrie du Nord: Méthods de Débitage et Gestion Laminaire durant le PPNB.* British Archaeological Reports - Intern. Series 1150. Oxford, Archaeopress.

2007 Le débitage laminares de la fin du PPNA (Jerf el Ahmar, Mureybet, Cheikh Hassan). In L. Astruc, D. Binder, and F. Briois (eds.), *Technical Systems and Near Eastern PPN Communities*: 127-136. Antibes, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Ahler S.A.

1989 Mass analysis of flaking debris: studying the forest rather than the tree. In D.O. Henry and G.H. Odell (eds.), *Alternative Approaches to Lithic Analysis*: 85-118. Archaeological Papers of the American Anthropological Association 1. Washington, American Anthropological Association.

Amick D.S. and Mauldin R.P.

1989 Comments on Sullivan and Rozen's "Debitage analysis and archaeological interpretation." *American Antiquity* 54: 166-168.

Amick D.S., Mauldin R.P., and Binford L.R.

1989 The potential of experiments in lithic technology. In D.S. Amick and R.P. Mauldin (eds.), *Experiments in Lithic Technology*: 1-14. British Archaeological Reports - Intern. Series 528. Oxford, B.A.R.

Arnold J.E.

1985 Economic specialization in prehistory: methods of documenting the rise of lithic craft specialization. In S.C. Vehik (ed.), *Lithic Resource Procurement: Proceedings from the Second Conference on Prehistoric Chert Exploitation*: 37-58. Occasional Paper 4. Carbondale, Center for Archaeological Investigations, Southern Illinois University.

1987 Technology and economy: microblade core production from the Channel Islands. In J.K. Johnson and C.A. Morrow (eds.), *The Organization of Core Technology*: 207-237. Boulder, Westview Press.

Asch D.L.

1979 On sampling size problems and the use of nonprobabilistic sampling. In J.E. Mueller (ed.), *Sampling in Archaeology*: 170-191. Tucson, University of Arizona Press.

Aspinall A., Feather S.W., and Phillips A.P.

1981 Further analyses of southern French flint industries. In *Third International Symposium on Flint, 24-27 Mei 1979 - Maastricht*: 92-93. Staringia 6. Nederlandse Geologische Vereniging.

Astruc L., Binder D., and Briois F. (eds.)

2007 *Technical Systems and Near Eastern PPN Communities*. Antibes, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Audouze F. and Leroi-Gourhan A.

1981 France: a continental insularity. *World Archaeology* 13: 170-189.

Baird D.
1995 Chipped stone raw material procurement and selection in the Neolithic Azraq Basin: implications for Levantine Neolithic cultural developments. In K. ‘Amr, F. Zayadine, and M. Zaghloul (eds.), *Studies in the History and Archaeology of Jordan V, Art and Technology throughout the Ages*: 505-514. Amman, Department of Antiquities of Jordan.

Balcer B.
1980 A study of socio-economic aspects of Neolithic flint working on the example of the Funnel Beaker Culture (FBC). In R. Schild (ed.), *Unconventional Archaeology: New Approaches and Goals in Polish Archaeology*: 87-107. Wrocław, Instytut Historii Kultury Materialnej, Polska Akademia Nauk.

Balkan-Atlı N.
1994 The typological characteristics of Aşıklı Höyük chipped stone industry. In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 209-221. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Balkan-Atlı N., Binder D., Cauvin M.-C., Biçakçi E., Deraprahamian G., and Kuzucuo™lu C.
1999 Obsidian: sources, workshop and trade in central Anatolia. In M. Özdo™an and N. Başgelen (eds.) *Neolithic in Turkey, the Cradle of Civilization. New Discoveries. Text*: 133-145. Ancient Anatolian Civilizations Series 3. Istanbul, Arkeoloji ve Sanat Yayınları.

Banks L.D.
1990 *From Mountain Peaks to Alligator Stomachs: A Review of Lithic Sources in the Trans-Mississippi South, the Southern Plains, and Adjacent Southwest.* Memoir 4. Norman, Oklahoma Anthropological Society, University of Oklahoma.

Banning E.B. and Byrd B.F.
1987 Houses and the changing residential unit: domestic architecture at PPNB ‘Ain Ghazal, Jordan. *Proceedings of the Prehistoric Society* 53: 309-325.

Barkai R., Gopher A., and Weiner, J.
2007 Quarrying flint at Neolithic Ramat Tamar: an experiment. In L. Astruc, D. Binder, and F. Briois (eds.), *Technical Systems and Near Eastern PPN Communities*: 25-32. Antibes, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Barton C.M. and Clark G.A.
1993 Cultural and natural formation processes in late Quaternary cave and rockshelter sites of western Europe and the Near East. In P. Goldberg, D.T. Nash, and M.D. Petraglia (eds.), *Formation Processes in Archaeological Context*: 33-52. Monographs in World Archaeology 17. Madison, Prehistory Press.

Baruch U. and Bottema S.
1991 Palynological evidence for climatic changes in the Levant *ca.* 17,000-9,000 B.P. In O. Bar-Yosef and F.R. Valla (eds.), *The Natufian Culture of the Levant*: 11-20. Archaeological Series 1. Ann Arbor, International Monographs in Prehistory.

Bar-Yosef O.
1980 Prehistory of the Levant. *Annual Review of Anthropology* 9: 101-133.
1981 The Epi-Paleolithic complexes in the southern Levant. In J. Cauvin and P. Sanlaville (eds.), *Préhistoire du Levant*: 389-408. Paris, Éditions du Centre National de la Recherche Scientifique.
1983 The Natufian in the southern Levant. In T.C.Young, P.E.L. Smith and P. Mortensen (eds.), *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia*: 11-42. Studies in Ancient Oriental Civilization 36. Chicago, Oriental Institute, University of Chicago.
1989 The PPNA in the Levant - an overview. *Paléorient* 15.1: 57-63.
1990 The Last Glacial Maximum in the Mediterranean Levant. In C. Gamble and O. Soffer (eds.), *The World at 18,000 B.P., 2, Low Latitudes*: 58-77. London, Unwin Hyman.

1991a The search for lithic variability among Levantine Epi-Palaeolithic industries. In *25 Ans d'Études Technologiques en Préhistoire: Bilan et Perspectives*: 319-335. Juan-les-Pins, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

1991b Stone tools and social context in Levantine prehistory. In G.A. Clark (ed.), *Perspectives on the Past: Theoretical Biases in Mediterranean Hunter-Gatherer Research*: 371-395. Philadelphia, University of Pennsylvania Press.

1991c Raw material exploitation in the Levantine Epi-Paleolithic. In A. Montet-White and S. Holen (eds.), *Raw Material Economies Among Prehistoric Hunter-Gatherers*: 235-250. University of Kansas Publications in Anthropology 19. Lawrence, University Press of Kansas.

1996 Late Pleistocene lithic traditions in the Near East and their expressions in early Neolithic assemblages. In S.K. Kozlowski and H.G.K. Gebel (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent, and their Contemporaries in Adjacent Regions*: 207-216. Studies in Early Near Eastern Production, Subsistence, and Environment 3. Berlin, ex oriente.

Bar-Yosef O. and Belfer-Cohen A.

1989a The origins of sedentism and farming in the Levant. *Journal of World Prehistory* 3: 447-498.

1989b The Levantine "PPNB" interaction sphere. In I. Hershkovits (ed.), *People and Culture in Change: Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic, and Neolithic Populations of Europe and the Mediterranean Basin*: 59-72. British Archaeological Reports - Intern. Series 508.1. Oxford, B.A.R.

1991 From sedentary hunter-gatherers to territorial farmers in the Levant. In S.A. Gregg (ed.), *Between Bands and States*: 181-202. Occasional Paper 9. Carbondale, Center for Archaeological Investigations, Southern Illinois University.

1992 From foraging to farming in the Mediterranean Levant. In: A.B. Gebauer and T.D. Price (eds.), *Transitions to Agriculture in Prehistory*: 21-48. Monographs in World Archaeology 4. Madison, Prehistory Press.

Bar-Yosef O. and Gopher A. (eds.)

1997 *An Early Neolithic Village in the Jordan Valley. Part I: The Archaeology of Netiv Hagdud*. American School of Prehistoric Research - Bulletin 43. Cambridge, Peabody Museum of Archaeology and Ethnology, Harvard University.

Bar-Yosef O. and Kislev M.E.

1989 Early farming communities in the Jordan Valley. In D.R. Harris and G.C. Hillman (eds.), *Foraging and Farming: The Evolution of Plant Exploitation*: 632-642. One World Archaeology 13. London, Unwin Hyman.

Bar-Yosef O. and Valla F.R. (eds.)

1991 *The Natufian Culture in the Levant*. Archaeological Series No. 1. Ann Arbor, International Monographs in Prehistory.

Bar-Yosef O., Gopher A., and Goring-Morris A.N.

1980 Netiv Hagdud: A Sultanian mound in the lower Jordan Valley. *Paléorient* 6: 201-206.

Baumler M.F.

1985 On the interpretation of chipping debris concentrations in the archaeological record. *Lithic Technology* 14: 120-125.

Becker C.

1991 The analysis of mammalian bones from Basta, a Pre-Pottery Neolithic site in Jordan: problems and potential. *Paléorient* 17.1: 59-75.

Becker C.J.

1951 Late-Neolithic flint mines at Ålborg. *Acta Archaeologica* (Denmark) 22: 135-152.

Behm J.A.

1983 Flake concentrations: distinguishing between flintworking activity areas and secondary deposits. *Lithic Technology* 12: 9-16.

Bender F.
1968 *Geological Map of Jordan (1:250,000)*. Hannover, German Geological Mission in Jordan, Geological Survey of the Federal Republic of Germany.
1974 *Geology of Jordan*. Contributions to the Regional Geology of the Earth - Supplementary Edition of Volume 7. Berlin, Gebruder Borntraeger.
1975 *Geology of the Arabian Peninsula, Jordan*. Geological Survey Professional Paper 560.1. Washington, United States Geological Survey.

Bergman C.A. and Newcomer M.H.
1983 Flint arrowhead breakage: examples from Ksar Akil, Lebanon. *Journal of Field Archaeology* 10: 238-243.

Bialor P.A.
1962 The chipped stone industry of Çatal Hüyük. *Anatolian Studies* 12: 67-110.

Bienert H.-D., Gebel H.G.K., and Neef R.
2004 *Central Settlements in Neolithic Jordan*. Studies in Early Near Eastern Production, Subsistence, and Environment 5. Berlin, ex oriente.

Binder D. and Balkan-Atlı N.
2001 Obsidian exploitation and blade technology at Kömürcü - Kaletepe (Cappadocia, Turkey). In I. Caneva, C. Lemorini, D. Zampetti, and P. Biagi (eds.) *Beyond Tools. Redefining the PPN Lithic Assemblages of the Levant*: 1-16. Studies in Early Near Eastern Production, Subsistence, and Environment 9. Berlin, ex oriente.

Binder D. and Perlès C.
1990 Stratégies de gestion des outillages lithiques au Néolithique. *Paléo* 2: 257-283.

Binford L.R.
1962 Archaeology as anthropology. *American Antiquity* 28: 217-225.
1968 Post-Pleistocene adaptations. In S.R. Binford and L.R. Binford (eds.), *New Perspectives in Archaeology*: 313-341. Chicago, Aldine.
1973 Interassemblage variability – the Mousterian and the 'functional' argument. In C. Renfrew (ed.), *The Explanation of Culture Change: Models in Prehistory*: 227-254. Glouster Crescent, Duckworth.
1977a Forty-seven trips: a case study in the character of archaeological formation processes. In R.V.S. Wright (ed.), *Stone Tools as Cultural Markers: Change, Evolution and Complexity*: 24-36. Prehistory and Material Culture Series 12. Canberra, Australian Institute of Aboriginal Studies.
1977b Introduction. In L.R. Binford (ed.), *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spacial Analysis, and Systems Modeling*: 1-10. New York, Academic Press.
1981 *Bones: Ancient Men and Modern Myths*. New York, Academic Press.

Binford L.R. and Sabloff J.
1982 Paradigms, systematics and archaeology. *Journal of Anthropological Research* 38: 137-153.

Binford S.R.
1968 Variability and change in the Near Eastern Mousterian of Levallois facies. In S.R. Binford and L.R. Binford (eds.), *New Perspectives in Archaeology*: 49-60. Chicago, Aldine.

Bordes F.
1961a Mousterian cultures in France. *Science* 134: 803-810.
1961b *Typologie du Paleolithique Ancien et Moyen*. Memoire 1. Bordeaux, Publications de l'Institut de Préhistoire de l'Université de Bordeaux.
1973 On the chronology and contemporaneity of different Palaeolithic cultures in France. In C. Renfrew (ed.), *The Explanation of Culture Change: Models in Prehistory*: 217-226. Glouster Crescent, Duckworth.
1981 Vingt-cinq ans après: le complèxe Moustérien revisté. *Bulletin de la Société Préhistorique Française* 78: 77-87.

Bordes F. and Crabtree D.
1969 The Corbiac blade technique and other experiments. *Tebiwa* 12:1-21.

Borkowski W., Migal W., Salacinski S., and Zalewski M.
1991 Possibilities of investigating Neolithic flint economies, as exemplified by the banded flint economy. *Antiquity* 65: 607-627.

Bosch P.W.
1979 A Neolithic flint mine. *Scientific American* 240.6: 126-132.

Boschian G.
1995 The “San Bartolomeo” shelter: a flint exploitation site in central Italy. *Archaeologia Polona* 33: 31-40.

Bradley B.A. and Giria Y.
1996 Concepts of the technological analysis of flaked stone: a case study from the High Arctic. *Lithic Technology* 21: 23-39.

Braidwood L.S., Braidwood R.J., Howe B., Reed C.A., and Watson P.J. (eds.)
1983 *Prehistoric Archaeology Along the Zagros Flanks*. Oriental Institute Publications 105. Chicago, Oriental Institute, University of Chicago.

Braidwood R.J.
1948 *Prehistoric Men*. Chicago Natural History Museum Popular Series - Anthropology 37. Chicago, Chicago Natural History Museum Press.
1952 *The Near East and the Foundations for Civilization: An Essay in Appraisal of the General Evidence*. Eugene, Oregon State System of Higher Education.

Braidwood R.J. and Braidwood L.S.
1960 *Excavations in the Plain of Antioch I*. Oriental Institute Publications 61. Chicago, Oriental Institute, University of Chicago.

Braidwood R.J. and Howe B.
1960 *Prehistoric Investigations in Iraqi Kurdistan*. Studies in Ancient Oriental Civilization 31. Chicago, Oriental Institute, University of Chicago.

Brézillon M.N.
1983 *La Dénomination des Objects de Pierre Taillée: Matériaux pour un Vocabulaire des Préhistoriens de Langue Française*. Gallia Préhistoire - Supplement 4. Paris, Éditions du Centre National de la Recherche Scientifique.

Brittain H.G.
1990 Luminescence spectroscopy. In D.C. Perry (ed.), *Instrumental Surface Analysis of Geologic Materials*: 283-309. New York, V.C.H. Publishers.

Brumfiel E.M. and Earle T.K.
1987 *Specialization, Exchange, and Complex Societies*. Cambridge, Cambridge University Press.

Budziszewski J.
1990 Remarks on methods of studying prehistoric areas of flint exploitation. *Cahiers du Quarternaire* 17: 217-224.

Byrd B.F.
1988 The Natufian of Beidha: report on renewed field research. In A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan: the State of Research in 1986*: 175-197. British Archaeological Reports - Intern. Series 396.1. Oxford, B.A.R.
1994 Public and private, domestic and corporate: the emergence of the Southwest Asian village. *American Antiquity* 59: 639-666.

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.
1985 Experiments with Danish Mesolithic microblade technology. *Journal of Danish Archaeology* 4: 23-39.

Calley S.
1984 Le débitage natoufien de Mureybet: étude préliminaire. *Paléorient* 10.2: 35-48.
1985 Le nucléus en obsidienne du Néolithique de Cafer Höyük (Turquie). Étude préliminaire sur les techniques de taille. *Cahiers de l'Euphrate* 4: 87-107.
1986a *Technologie du débitage à Mureybet, Syrie, 9e - 8e Millénaire*. Lyon: Maison de l'Orient Méditerranéen (C.N.R.S. - Université Lumière - Lyon 2) - Archaeological Series 2. British Archaeological Reports - Intern. Series 312.1, 2. Oxford, B.A.R.
1986b L'atelier de Qdeir 1 en Syrie: exploitation des nucléus naviformes a la fin du PPNB, 6e millénaire: première approche. *Paléorient* 12.2: 49-67.

Caneva I., Conti A.M., Lemorini C., and Zampetti D.
1994 The lithic production at Çayönü: a preliminary overview of the aceramic sequence. In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 253-266. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Cauvin J.
1968 *Les Outillages Néolithiques de Byblos et du Littoral Libanais: Contribution à l'Étude de la Révolution Technologique chez le Premiers Agriculteurs.* Études et Documents d'Archéologie V. Beyrouth, Direction de l'Instruction Publique et des Beaux-arts.
1978 *Les Premiers Villages de Syrie – Palestine du IXème au VIIème Millénaire Avant J.C.* Collection de la Maison de l'Orient Mediterranéen Ancien 4 - Série Archéologique 3. Lyon, Maison de l'Orient.
1979 Les fouilles de Mureybet (1971-1974) et leur signification pour les origines de la sedentarisation au Proche-orient. *Annual of the American Schools of Oriental Research* 44: 19-48.
1994 *Naissance des Divinitiés, Naissance de l'Agriculture: la Révolution des Symboles au Néolithique*. Paris, Éditions du Centre National de la Recherche Scientifique.

Cauvin M.-C. and Cauvin J.
1993 La séquence néolithique PPNB au Levant nord. *Paléorient* 19.1: 23-31.

Cauvin M.-C. and Coqueugniot E.
1988 L'oasis d'el Kowm et le Kébarien géométrique. *Paléorient* 14.2: 270-282.

Childe V.G.
1951 *Man Makes Himself.* (Originally published 1936.) New York, Mentor.
1952 *New Light in the Most Ancient East*. New York, Praeger.

Clark G.A.
1991 A paradigm is like an onion. In G.A.Clark (ed.), *Perspectives on the Past: Theoretical Biases in Mediterranean Hunter-Gatherer Research*: 79-108. Philadelphia, University of Pennsylvania Press.
1992 Wadi al-Hasa Palaeolithic settlement patterns: Negeb and south Jordan models compared. In M. Zaghloul, K.'Amr, F. Zayadine, R. Nabeel, and N.R. Tawfiq (eds.), *Studies in the History and Archaeology of Jordan IV, Sites and Settlement in Jordan*: 89-95. Amman, Department of Antiquities of Jordan.
1993 Paradigms in science and archaeology. *Journal of Archaeological Research* 1.3: 203-234.

Clark G.A., Coinman N.R., Lindly J., and Donaldson M.
1987 A diachronic study of Paleolithic and Aceramic Neolithic settlement patterns in the Wadi Hasa, west-central Jordan. In A. Hadidi (ed.), *Studies in the History and Archaeology of Jordan III, Trade, Communications, and International Relations throughout the Ages*: 215-223. Amman, Department of Antiquities of Jordan.

Clark J.D. and Kurashina H.
1981 A study of the work of a modern tanner in Ethiopia and its relevance for archaeological interpretation. In R.A. Gould and M.B. Schiffer (eds.), *Modern Material Culture: The Archaeology of Us*: 303-321. New York, Academic Press.

Clark J.E.
1981 The Early Preclassic obsidian industry of Paso de la Amada, Chiapas, Mexico. *Estudios de Cultura Maya* 13: 265-284.
1982 Manufacture of Mesoamerican prismatic blades: an alternative technique. *American Antiquity* 47: 355-376.
1986a From mountains to molehills: a critical review of Teotihuacan's obsidian industry. In B.L. Isaac (ed.), *Economic Aspects of Prehispanic Highland Mexico*: 23-74. Research in Economic Anthropology - Supplement 2. Greenwich, CT, JAI Press, Inc.
1986b Another look at small debitage and microdebitage. *Lithic Technology* 15.1: 21-33.
1987 Politics, prismatic blades, and Mesoamerican civilization. In J.K. Johnson and C.A. Morrow (eds.), *The Organization of Core Technology*: 259-284. Boulder, Westview Press.
1990 Fifteen fallacies in lithic workshop interpretation: an experimental and ethnoarchaeological perspective. In Y.Y. Sugiura and P.M.C. Serra (eds.), *Etnoarqueología: Primer Coloquio Bosch-Gimpera*: 497-512. México, Universidad Nacional Autónoma de México.
1991 Flintknapping and debitage disposal among the Lacandon Maya of Chiapas, Mexico. In E. Staski and L.D. Sutro (eds.), *The Ethnoarchaeology of Refuse Disposal*: 63-88. Anthropological Research Paper 42. Tempe, Arizona State University.
1995 Craft specialization as an archaeological category. In B.L. Isaac (ed.), *Research in Economic Anthropology* 16: 267-294. Greenwich, CT, JAI Press, Inc.
1997 Prismatic blademaking, craftsmanship, and production: an analysis of obsidian refuse from Ojo de Agua, Chiapas, Mexico. *Ancient Mesoamerica* 8: 137-159.

Clark J.E. and Bryant D.D.
1991 The production of chert projectile points at Yerba Buena, Chiapas, Mexico. In T.R. Hester and H.J. Shafer (eds.), *Mayan Stone Tools: Selected Papers from the Second Maya Lithic Conference*: 85-102. Monographs in World Archaeology 1. Madison, Prehistory Press.
1997 A technological typology of prismatic blades and debitage from Ojo de Agua, Chiapas, Mexico. *Ancient Mesoamerica* 8: 111-136.

Clark J.E. and Parry W.J.
1990 Craft specialization and cultural complexity. In B.L. Isaac (ed.), *Research in Economic Anthropology* 12: 289-346. Greenwich, CT, JAI Press, Inc.

Clarke D.L.
1978 *Analytical Archaeology* (second edition). New York: Columbia University Press.

Clutton-Brock J.
1979 The mammalian remains from the Jericho tell. *Proceedings of the Prehistoric Society* 45: 135-157.

Cobb C.R.
1993 Archaeological approaches to the political economy of nonstratified societies. In M.B. Schiffer (ed.), *Archaeological Method and Theory* 5: 43-100. Tucson, University of Arizona Press.
1996 Specialization, exchange, and power in small-scale societies and chiefdoms. In B.L. Isaac (ed.), *Research in Economic Anthropology* 17: 251-294. Greenwich, CT, JAI Press, Inc.

COHMAP Members
1988 Climatic changes of the last 18,000 years: observations and model simulations. *Science* 241: 1043-1052.

Coinman N.R., Clark G.A., and Donaldson M.L.
1989 Aspects of structure in an Epipaleolithic occupation site in west central Jordan. In D.O. Henry and G.H. Odell (eds.), *Alternative Approaches to Lithic Analysis*: 213-235. Archaeological Papers of the American Anthropological Association 1. Washington, American Anthropological Association.

Collins M.B.
1973 Observations on the thermal treatment of chert in the Solutrean of Laugerie Haute, France. *Proceedings of the Prehistoric Society* 39: 461-466.

Contenson H. De
1971 Tell Ramad, a village of Syria of the 7th and 6th millennia B.C. *Archaeology* 24.3: 278-285.
1993 Ramad dans le Néolithique du Levant. *Paléorient* 19.1: 29-31.

Copeland L.
1989 Flint and obsidian artifacts of Tell Sabi Abyad. In P.M.M.G. Akkermans (ed.), *Excavations at Tell Sabi Abyad*: 237-284. Balikh Valley Archaeological Project Monograph 1. British Archaeological Reports - Intern. Series 468. Oxford, B.A.R.

Coqueugniot E.
1994 L'industrie lithique de Dja'de el Mughara et le début P.P.N.B. sur l'Euphrate Syrien (sondages 1991 et 1992). In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 313-330. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Costin C.L.
1986 *From Chiefdom to Empire State: Ceramic Economy Among the Prehistoric Wanka of Highland Peru*. University of California, Los Angeles: Unpublished PhD. Dissertation.
1991 Craft specialization: issues in defining, documenting, and explaining the organization of production. In M. Schiffer (ed.), *Archaeological Method and Theory* 3: 1-56. Tucson, University of Arizona Press.

Crabtree P.J.
1991 Gender hierarchies and the sexual division of labor in the Natufian culture of the southern Levant. In D. Walde and N.D. Willows (eds.), *The Archaeology of Gender*: 384-391. Proceedings of the Twenty-Second Annual Conference of the Archaeological Association of the University of Calgary. Calgary, University of Calgary.

Crabtree D.E.
1968 Mesoamerican polyhedral cores and prismatic blades. *American Antiquity* 33: 446-478.
1972 The cone fracture principle and the manufacture of lithic materials. *Tebiwa* 15.2: 29-42.
1982 *An Introduction to Flintworking*. Occasional Papers of the Idaho Museum of Natural History 28. Pocatello, Idaho Museum of Natural History.

Cross J.R.
1983 Twigs, branches, trees, and forests: problems of scale in lithic analysis. In J.A.Moore and A.S. Keene (eds.), *Archaeological Hammers and Theories*: 87-106. New York, Academic Press.
1993 Craft specialization in nonstratified societies. In B.L. Isaac (ed.), *Research in Economic Anthropology* 14: 61-84. Greenwich, CT, JAI Press, Inc.

Crowfoot J.
1935 Notes of the flint implements of Jericho 1935. *Liverpool Annals of Archaeology and Anthropology* 22: 174-184.

Crowfoot Payne J.
1983 The flint industries of Jericho. In K.M. Kenyon and T.A. Holland (eds.), Excavations at Jericho 5: 622-759. London: British School of Archaeology in Jerusalem, The British Academy.

Deal M. and Hayden B.
1987 The persistence of Pre-Columbian lithic technology. In B. Hayden (ed.), *Lithic Studies Among the Contemporary Highland Maya*: 233-331. Tucson, University of Arizona Press.

Demars P-Y. and Laurent P.
1989 *Types D'Outils Lithiques du Paleolithique Superieur en Europe.* Cahiers du Quaternaire 14. Paris, Éditions du Centre National de la Recherche Scientifique.

Di Lernia S., Fiorentino G., Galiberti A., and Basili R.
1995 The early Neolithic mine of Defensola "A" (I 18): flint exploitation in the Gargano area. *Archaeologia Polona* 33: 119-132. Wroclaw, Instytut Historii Kultury Materialnej, Polska Akademia Nauk.

Dibble H.
1984 Interpreting typological variation of Middle Paleolithic scrapers: function, style, or sequence of reduction? *Journal of Field Archaeology* 11: 431-436.
1987 The interpretation of Middle Paleolithic scraper morphology. *American Antiquity* 52: 109-117.
1995 Middle Paleolithic scraper reduction: background, clarification, and review of the evidence. *Journal of Archaeological Method and Theory* 2.4: 299-368.

Dickson F.P.
1977 Quartz flaking. In R.V.S. Wright (ed.), *Stone Tools as Cultural Markers*: 97-103. Prehistory and Material Culture Series 12. Canberra, Australian Institute of Aboriginal Studies.

Ducos P.
1993 Proto-élevage et élevage au Levant Sud au VII^{e} millénaire B.C. Les données de la Damascène. *Paléorient* 19.1: 153-173.

Dunnell R.C., McCutcheon P.T., Ikeya M., and Toyoda S.
1994 Heat treatment of Mill Creek and Dover cherts on the Malden Plain, southeast Missouri. *Journal of Archaeological Science* 21: 79-89.

Edwards P.C.
1989 Problems of recognizing earliest sedentism: the Natufian example. *Journal of Mediterranean Archaeology* 2.1: 5-48.
1991 Wadi Hammeh 27: an early Natufian site at Pella, Jordan. In O. Bar-Yosef and F.R. Valla (eds.), *The Natufian Culture of the Levant*: 123-148. Archaeological Series 1. Ann Arbor, International Monographs in Prehistory.

Edwards P.C. and Edwards W.I.
1990 Heat treatment of chert in the Natufian period. *Journal of Mediterranean Archaeology* 3: 1-5.

Elston R.G. and Kuhn S.L. (eds.)
2002 *Thinking Small: Global Perspectives on Microlithization*. Archaeological Papers of the American Anthropological Association 12. Washington, American Anthropological Association.

Ericson J.E.
1982 Production for obsidian exchange in California. In J.E. Ericson and T.K. Earle (eds.), *Contexts for Prehistoric Exchange*: 129-148. New York, Academic Press.

Evans R.
1973 *Craft Specialization in the Chalcolithic Period of the Eastern Portion of the Balkan Peninsula*. University of California, Los Angeles: Unpublished PhD. Dissertation.
1978 Early craft specialization: an example from the Balkan Chalcolithic. In C.L. Redman, M.J. Berman, E.V. Curtin, W.T. Langhorne Jr., N.M., Versaggi, and J.C. Wanser (eds.), *Social Archeology: Beyond Subsistence and Dating*: 113-129. New York, Academic Press.

Fedick S.L.
1991 Chert tool production and consumption among Classic Period Maya households. In T.R. Hester and H.J. Shafer (eds.), *Maya Stone Tools: Selected Papers from the Second Maya Lithic Conference*: 103-118. Monographs in World Archaeology 1. Madison, Prehistory Press.

Ferembach D.
1970 Étude anthropologique des ossements humains néolithiques de Tell-Ramad, Syrie (Campagnes 1963-1966). *l'Anthropologie* 74: 247-254.

Ferembch D. and Lechevallier M.
1973 Découverte de crânes surmodelés dans une habitation du VII[e] millénaire, à Beisamoun, Israël. *Paléorient* 1.2: 223-230.

Fladmark K.R.
1982 Microdebitage analysis: initial considerations. *Journal of Archaeological Science* 9: 205-220.

Flannery K.V.
1969 Origins and ecological effects of early domestication in Iran and the Near East: a comparative study. In P.J. Ucko and G.W. Dimbleby (eds.), *The Domestication and Exploitation of Plants and Animals*: 73-100. Chicago, Aldine.

Flenniken J.J.
1981 *Replicative Systems Analysis: A Model Applied to the Vein Quartz Artifacts from the Hoko River Site*. Reports of Investigations 59. Pullman, Laboratory of Anthropology, Washington State University.

Flenniken J.J. and Wilke P.J.
1989 Typology, technology, and chronology of Great Basin dart points. *American Anthropologist* 91: 149-158.

Fowler W.R., Jr.
1991 Lithic analysis as a means of processual inference in southern Mesoamerica: a review of recent research. In T.R. Hester and H.J. Shafer (eds.), *Maya Stone Tools: Selected Papers from the Second Maya Lithic Conference*: 1-19. Monographs in World Archaeology 1. Madison, Prehistory Press.

Fried M.
1967 *The Evolution of Political Society: An Essay in Political Anthropology.* New York: Random House.

Gallagher J.P.
1977 Contemporary stone tools in Ethiopia: implications for archaeology. *Journal of Field Archaeology* 4: 407-414.

Garfinkel Y.
1987 Burnt lime products and social implications in the Pre-Pottery Neolithic B villages of the Near East. *Paléorient* 13.1: 69-76.
1993 The Yarmoukian culture in Israel. *Paléorient* 19.1: 115-134.

Garrard A., Baird D., Colledge S., Martin L., and Wright K.
1994 Prehistoric environment and settlement in the Azraq Basin: an interim report on the 1987 and 1988 excavation seasons. *Levant* 26: 73-109.

Garrard A., Byrd B., Harvey P., and Hivernel F.
1985 Prehistoric environment and settlement in the Azraq Basin: a report on the 1982 survey season. *Levant* 17: 1-28.

Garrard A.N. and Stanley Price N.P.
1975-77 A survey of prehistoric sites in the Azraq Basin, eastern Jordan. *Paléorient* 3: 107-126.

Garstang J.
1935 Jericho: city and necropolis (fifth report). *Liverpool Annals of Archaeology and Anthropology* 22: 143-184.

Gebel H.G.
1984 Das Akeramische Neolithikum Vorderasiens. *Beihefte zum Tübinger Atlas des Vorderen Orients, Reiche B* (*Geisteswissenschaften*) 52.

1994 Neolithic primary production in the southern and central Levant. In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 393-394. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Gebel H.G., Muheisen M.Sh., and Nissen H.J.
1988 Preliminary report on the first season of excavations at Basta. In A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan: The State of Research in 1986*: 101-134. British Archaeological Reports - Intern. Series 396.1. Oxford, B.A.R.

Gebel H.G.K.
1996 Chipped lithics in the Basta craft system. In H.G.K. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent and their Contemporaries in Adjacent Regions*: 261-270. Studies in Early Near Eastern Production, Subsistence, and Environment 3. Berlin, ex oriente.
2004 Central to what? The centrality issue of the LPPNB mega-site phenomenon in Jordan. In H.-D. Bienert, H.G.K. Gebel, and R. Neef (eds.) *Central Settlements in Neolithic Jordan. Proceedings of a Symposium held in Wadi Musa, Jordan 21st-25th July, 1997*: 1-19. Studies in Early Near Eastern Production, Subsistence, and Environment 5, 1998. Berlin, ex oriente.

Gebel H.G.K., Bienert H.-D. (with contributions by Kramer T., Müller-Neuhof B., Neef R., Timm J., and Wright K.)
1997 Ba‘ja hidden in the Petra mountains. In H.G.K. Gebel, Z. Kafafi, and G.O. Rollefson (eds.), *Prehistory of Jordan II: Perspectives from 1997*: 221-262. Studies in Early Near Eastern Production, Subsistence, and Environment 4. Berlin, ex oriente.

Ginter B.
1974 The extraction, production and distribution of raw material and flint products at the Late Palaeolithic in the northern part of central Europe (Polish with English summary). *Przeglad Archeologiczny* 22: 5-122.

Goldberg P. and Bar-Yosef O.
1990 The effect of man on geomorphological processes based upon evidence from the Levant and adjacent areas. In S. Bottema, G. Entjes-Nieborg, and W. Van Zeist (eds.), *Man's Role in the Shaping of the Eastern Mediterranean Landscape. Proceedings of the INQUA/BAI Symposium on the Impact of Ancient Man on the Landscape of the Eastern Mediterranean Region and the Near East, Groningen, Netherlands, 6-9 March 1989*: 71-86. Rotterdam, A.A. Balkema.

Goldberg M.C. and Weiner E.R.
1989 The science of luminescence. In M.C. Goldberg (ed.), *Luminescence Applications in Biological, Chemical, Environmental, and Hydrological Sciences*: 1-22. Symposium Series 383. Washington, American Chemical Society.

Gopher A.
1989 *Flint Assemblages of Munhata (Israel)*. Les Cahiers du Centre de Recherche Français de Jérusalem 4. Paris, Association Paléorient.
1993 Sixth - fifth millennia B.C. settlements in the coastal plain in Israel. *Paléorient* 19.1: 55-63.
1994 *Arrowheads of the Neolithic Levant: A Seriation Analysis*. Winona Lake, Indiana, Eisenbrauns.

Gopher A. and Gophna R.
1993 Cultures of the eighth and seventh millennia BP in the southern Levant: a review for the 1990s. *Journal of World Prehistory* 7: 297-353.

Goring-Morris A.N.
1987 *At the Edge: Terminal Pleistocene Hunters-Gatherers in the Negev and Sinai.* British Archaeological Reports - Intern. Series 361.1, 2. Oxford, B.A.R.
1991 A PPNB settlement at Kfar HaHoresh in lower Galilee: a preliminary report of the 1991 season. *Mitekufat Haeven, Journal of the Israel Prehistoric Society* 24: 77-101.

1993 From foraging to herding in the Negev and Sinai: the early to late Neolithic transition. *Paléorient* 19.1: 65-89.
1994 Aspects of the PPNB lithic industry at Kfar HaHoresh, near Nazareth, Israel. In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 427-444. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Gould R.A.
1977 Ethno-archaeology; or, where do models come from? A closer look at Australian aboriginal lithic technology. In R.V.S. Wright (ed.), *Stone Tools as Cultural Markers: Change, Evolution and Complexity*: 162-168. Prehistory and Material Cultural Series 12. Canberra, Australian Institute of Aboriginal Studies.
1981 Brandon revisited: a new look at an old technology. In R.A. Gould and M.B. Schiffer (eds.), *Modern Material Culture: The Archaeology of Us*: 269-281. New York, Academic Press.

Gourdin W.H. and Kingery W.D.
1975 The beginnings of pyrotechnology: Neolithic and Egyptian lime plaster. *Journal of Field Archaeology* 2: 133-150.

Hassan F.A.
1977 The dynamics of agricultural origins in early Palestine: a theoretical model. *In*: C. Reed (ed.), *Origins of Agriculture*: 589-610. The Hague, Mouton.

Hauptmann A., Begemann F., Heitkemper E., Pernicka E., and Schmitt-Strecker S.
1992 Early copper production at Feinan, Wadi Araba, Jordan: the composition of ores and copper. *Archeomaterials* 6: 1-33.

Hayden B.
1987 Traditional metate manufacturing in Guatemala using chipped stone tools. In B. Hayden (ed.), *Lithic Studies Among the Contemporary Highland Maya*: 8-119. Tucson, University of Arizona Press.

Healan D.M.
1992 A comment on Moholy-Nagy's "The misidentification of lithic workshops." *Latin American Antiquity* 3: 240-242.

Healan D.M., Kerley J.M., and Bey G.J.
1983 Excavation and preliminary analysis of an obsidian workshop in Tula, Hidalgo, Mexico. *Journal of Field Archaeology* 10: 127-145.

Hecker H.
1982 Domestication revisited: its implications for faunal analysis. *Journal of Field Archaeology* 9: 217-136.

Henry D.O.
1983 Adaptive evolution within the Epipaleolithic of the Near East. *Advances in World Archaeology* 2: 99-160.
1989a *From Foraging to Agriculture: The Levant at the End of the Ice Age*. Philadelphia, University of Pennsylvania Press.
1989b Correlations between reduction strategies and settlement patterns. In D.O. Henry and G.H. Odell (eds.), *Alternative Approaches to Lithic Analysis*: 139-155. Archaeological Papers of the American Anthropological Association 1. Arlington, American Anthropological Association.

Henry D.O. (ed.)
1995 *Prehistoric Cultural Ecology and Evolution: Insights from Southern Jordan*. New York, Plenum Press.

Henry D.O. and Leroi-Gourhan A.
1976 The excavation of Hayonim Terrace: an interim report. *Journal of Field Archaeology* 3: 391-406.

Hester T.R. and Shafer H.J.
1992 Lithic workshops revisited: comments on Moholy-Nagy. *Latin American Antiquity* 3: 243-248.

1994 The ancient Maya craft community at Colha, Belize, and its external relationships. In G.M. Schwartz and S.E. Falconer (eds.), *Archaeological Views from the Countryside: Village Communities in Early Complex Societies*: 48-63. Washington, Smithsonian Institution Press.

Hillsman M.J.
1991 *Evolution of Visible and Ultraviolet-Excited Attributes of Some Texas and Macroscopically Similar New Mexico Cherts*. Portales, Eastern New Mexico University: Unpublished M.A. Thesis.

Hodder I. and Orton C.
1976 *Spatial Analysis in Archaeology*. Cambridge, Cambridge University Press.

Hofman J.L., Todd L.C., and Collins M.B.
1991 Identification of central Texas Edwards chert at the Folsom and Lindenmeier sites. *Plains Anthropologist* 36: 297-308.

Hole F.
1977 *Studies in the Archaeological History of the Deh Luran Plain: the Excavation of Chagha Sefid*. Memoir 9. Ann Arbor, Museum of Anthropology, University of Michigan.
1983 The Jarmo chipped stone. In L.S. Braidwood, R.J. Braidwood, B. Howe, C.A. Reed, and P.J. Watson (eds.), *Prehistoric Archeology Along the Zagros Flanks*: 233-284. Oriental Institute Publications 105. Chicago, Oriental Institute, University of Chicago.
1984 A reassessment of the Neolithic revolution. *Paléorient* 10.2: 49-60.
1986 Chipped-stone tools. In K.V. Flannery (ed.), *Guilá Naquitz: Archaic Foraging and Early Agriculture in Oaxaca, Mexico*: 97-139. Orlando, Academic Press.
1994 Interregional aspects of the Khuzistan Aceramic-Early Pottery Neolithic sequence. In H.G. Gebel and Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 101-116. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Hole F., Flannery K.V., and Neely J.A.
1969 *Prehistory and Human Ecology of the Deh Luran Plain: An Early Village Sequence from Khuzistan, Iran*. Memoir 1. Ann Arbor, Museum of Anthropology, University of Michigan.

Holgate R.
1995 Neolithic flint mining in Britian. *Archaeologia Polona* 33: 133-161.

Howe B.
1983 Karim Shahir. In L. Braidwood, R.J. Braidwood, B. Howe, C.A. Reed, and P.J. Watson (eds.), *Prehistoric Archeology Along the Zagros Flanks*: 24-154. Oriental Institute Publications 105. Chicago, Oriental Institute, University of Chicago.

Hubert F.
1978 *L'Exploitation du Silex a Spiennes*. Archaeologicum Belgii Speculum 9. Bruxelles, Service National des Fouilles.

Ingersoll D., Yellen J.E., and MacDonald W. (eds.)
1977 *Experimental Archaeology*. New York, Columbia University Press.

Inizan M.-L.
1980 Sur les industries à lames de Qatar. *Paléorient* 6: 233-236.
1991 Le débitage par pression; des choix culturels. In *25 Ans d'Études Technologiques en Préhistoire: Bilan et Perspectives*: 267-377. Juan-les-Pins, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Inizan M.-L. and Lechevallier M.
1985 La taille du silex par pression a Mehrgarh, Pakistan: la tombe d'un tailleur? *Paléorient* 11.1: 111-118.
1990 A techno-economic approach to lithics: some examples of blade pressure debitage in the Indo-Pakistani

subcontinent. In M. Taddei (ed.), *South Asian Archaeology: 1987, Part 1*: 41-59. Rome, Instituto Italiano per il Medio ed Estremo Oriente.

Inizan M.-L., Roche H., and Tixier J.
1975-76 Avantage d'un traitement thermique pour la taille des roches siliceuses. *Quaternaria* 18: 1-18.
1992 *Technology of Knapped Stone*. Préhistoire de la Pierre Taillée 3. Meudon, Cercle de Recherches et d'Etudes Préhistoriques.

Jasnosz S.
1982 Materialy i Studia do Dziejow Osadnictwa Starozytnego i Wczesnosredniowiecznego Ziemi Obornicko-Rogozinskiej (Czesc 1). *Fontes Archaeologici Posnanienses* 31: 1-144. Poznan, Muzeum Archeologiczne w Poznaniu.

Jelinek A.
1981 The Middle Paleolithic in the southern Levant from the perspective of the Tabun Cave. In J. Cauvin and P. Sanlaville (eds.), *Préhistoire du Levant*: 265-280. Paris, Éditions du Centre National de la Recherche Scientifique.

Jenkins E. and Rosen A.
2007 The phytoliths. In B. Finlayson and S. Mithen (eds.), *The Early Prehistory of Wadi Faynan, Southern Jordan*: 429-436. Wadi Faynan Series 1, Levant Supplement Series 4. Oxford, Oxbow Books, and Council for British Research in the Levant.

Jochim M.A.
1989 Optimization and stone tool studies: problems and potentials. In R. Torrence (ed.), *Time, Energy and Stone Tools*: 106-111. Cambridge, Cambridge University Press.

Johnson J.K.
1979 Archaic biface manufacture: production failures: a chronicle of the misbegotten. *Lithic Technology* 8: 25-35.

Johnson L.L.
1978 The history of flint-knapping experimentation, 1838-1976. *Current Anthropology* 19: 337-372.

Johnson J.K. and Morrow C.A. (eds.)
1987 *The Organization of Core Technology*. Boulder, Westview Press.

Kafafi Z.
1986 White objects from 'Ain Ghazal, near Amman. *Bulletin of the American Schools of Oriental Research* 261: 51-56.
1993 The Yarmoukians in Jordan. *Paléorient* 19.1: 101-114.

Kalin, F.
1981 Flintknapping and Silicosis. *Flintknapper's Exchange* 4.2: 2-9.

Karnes J.D. and Quintero L.A.
2007 An MPPNB blade cache from 'Ain Ghazal, Jordan. In L. Astruc, D. Binder, and F. Briois (eds.), *Technical Systems and Near Eastern PPN Communities*: 311-316. Antibes, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Kaufman D.
1992 Hunter-gatherers of the Levantine Epipaleolithic: the socioecological origins of sedentism. *Journal of Mediterranean Archaeology* 5: 165-201.

Keeley L.H.
1982 Hafting and retooling: effects on the archaeological record. *American Antiquity* 47: 798-809.

Kelterborn P.
1981 A challenge for today's craftsmen: the Livre de Beurre method. *Flintknappers' Exchange* 4.3: 12-22.

Kenoyer J.M., Vidale M., and Bhan K.K.
1991 Contemporary stone beadmaking in Khambhat, India: patterns of craft specialization and organization of production as reflected in the archaeological record. *World Archaeology* 23: 44-63.

Kenyon K.M.
1957 *Digging Up Jericho*. London, Benn.
1960 *Archaeology in the Holy Land*. New York, Frederick A. Praeger.
1981 *The Architecture and Stratigraphy of the Tell*. Excavations at Jericho 3. London: British School of Archaeology in Jerusalem, The British Academy.

King E. and Potter D.
1994 Small sites in prehistoric Maya socioeconomic organization: a perspective from Colha, Belize. In G.M. Schwartz and S.E. Falconer (eds.), *Archaeological Views from the Countryside: Village Communities in Early Complex Societies*: 64-90. Washington, Smithsonian Institution Press.

Kingery W.D., Vandiver P.B., and Prickett M.
1988 The beginnings of pyrotechnology, Part II: production and use of lime and gypsum plaster in the Pre-Pottery Neolithic Near East. *Journal of Field Archaeology* 15: 219-244.

Kirkbride D.
1966 Five seasons at the Pre-Pottery Neolithic village of Beidha in Jordan. *Palestine Exploration Quarterly* 98: 8-72.
1967 Beidha 1965: An interim report. *Palestine Exploration Quarterly* 99: 5-13.

Kislev M.E.
1988 Desiccated plant remains, an interim report. In O. Bar-Yosef and D. Alon (eds.), *Nahal Hemar Cave*: 76-81. *'Atiqot* 18. Jerusalem, Israel Exploration Society.
1992 Agriculture in the Near East in the VIIth millennium bc. In P.C. Anderson (ed.), *Préhistoire de l'Agriculture: Nouvelles Approches Expérimentales et Ethnographiques:* 87-93. Monographie du Centre de Recherches Archéologiques 6. Paris, Éditions du Centre National de la Recherche Scientifique.

Kislev M.E., Nadel D., and Carmi I.
1992 Epipalaeolithic (19,000 BP) cereal and fruit diet at Ohalo II, Sea of Galilee, Israel. *Review of Palaeobotany and Palynology* 73: 161-166.

Kobusiewics M.
1967 Materialy do osadnictwa w epoce kamienia w powiecie obornickim. *Fontes Archaeologici Posnanienses* 18: 1-28. Poznan, Muzeum Archeologiczne w Poznaniu.

Köhler-Rollefson I.
1988 The aftermath of the Levantine Neolithic Revolution in light of ecological and ethnographic evidence. *Paléorient* 14.1: 87-93.
1989 Changes in goat exploitation at 'Ain Ghazal between the early and late Neolithic: a metrical analysis. *Paléorient* 15.1: 141-146.
1992 A model for the development of nomadic pastoralism on the Transjordanian plateau. In O. Bar-Yosef and A. Khazanov (eds.), *Pastoralism in the Levant*: 11-18. Madison, The Prehistory Press.

Köhler-Rollefson I., Gillespie W., and Metzger M.
1988 The fauna from Neolithic 'Ain Ghazal. In A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan: the State of Research in 1986*: 423-430. British Archaeological Reports - Intern. Series 396.1. Oxford, B.A.R.

Köhler-Rollefson I., Quintero L.A., and Rollefson G.O.
1993 A brief note on the fauna from Neolithic 'Ain Ghazal. *Paléorient* 19.2: 95-97.

Kozlowski S.K. and Sachse-Kozlowska E.
1976 The system of providing flint raw materials in the late palaeolithic in Poland. In *Second International Symposium on Flint, 8-11 Mei 1975 - Maastricht*: 66-69. Staringia 3. Nederlandse Geologische Vereniging.

Kuhn T.S.
1962 *The Structure of Scientific Revolutions*. Chicago, University of Chicago Press.

Kuijt I.
1995 *New Perspectives on Old Territories: Ritual Practices and the Emergence of Social Complexity in the Levantine Neolithic*. Cambridge, Harvard University: Unpublished PhD. Dissertation.
1996 Where are the microliths? Lithic technology and Neolithic chronology as seen from the PPNA occupation at Dhra‘, Jordan. *Neo-Lithics* 2: 7-8.

Kuijt I, and Goring-Morris N.
2002 Foraging, farming, and social complexity in the Pre-Pottery Neolithic of the southern Levant. A review and synthesis. *Journal of World Prehistory* 16: 361-440.

Kuijt I., Mabry J., and Palumbo G.
1991 Early Neolithc use of upland areas of Wadi el-Yabis: preliminary evidence from excavations of ‘Iraq ed-Dubb, Jordan. *Paléorient* 17.1: 99-108.

Lech J.
1981 Flint mining among the early farming communities of Poland. In *Third International Symposium on Flint, 24-27 Mei 1979 - Maastricht*: 39-45. Staringia 6. Nederlandse Geologische Vereniging.
1987 Mining and distribution of siliceous rocks among the first farming communities in eastern central Europe. A review. In J.K. Kozlowski and S.K. Kozlowski (eds.), *Chipped Stone Industries of the Early Farming Cultures in Europe*: 369-380. Archaeologia Interregionalis. Warsaw, Wydawnictwa Uniwersytetu Warszawskiego.

Lechevallier M.
1978 *Abou Gosh et Beisamoun: Deux Gisements du VII^{e} Millénaire Avant l'Ère Chrétienne en Israel*. Memoires et Travaux du Centre de Recherches Préhistoriques Française de Jérusalem 2. Paris, Association Paléorient.

Lemonnier P.
1983 L'etude des systemes techniques, une urgence en technologie culturelle. *Techniques et Culture* 1: 11-34.

Leroi-Gourhan A.
1993 *Gesture and Speech*. Cambridge, MIT Press. (English translation by Anna Bostock Berger of *Le Geste et la Parole I: Technique et Language*, 1964. Paris, Albin Michel.)

Luedtke B.E.
1992 *An Archaeologist's Guide to Chert and Flint*. Archaeological Research Tools 7. Los Angeles, Institute of Archaeology, University of California.

Luz B.
1982 Palaeoclimatic interpretations of the last 20,000 yr. record of deep-sea cores around the Middle East. In J. Bintliff and W. Van Zeist (eds.), *Palaeoclimates, Palaeoenvironments and Human Communities in the Eastern Mediterranean Region in Later Prehistory*: 41-61. British Archaeological Reports - Intern. Series 133.1, 2. Oxford, B.A.R.

MacNeish R.S., Nelken-Terner A., and Johnson I.W.
1967 *The Prehistory of the Tehuacan Valley 2, Noncermaic Artifacts*. Austin, University of Texas Press.

Magne M.
1989 Lithic reduction stages and assemblage formation processes. In D.S. Amick and R.P. Mauldin (eds.), *Experiments in Lithic Technology*: 15-31. British Archaeological Reports - Intern. Series 528. Oxford, B.A.R.

Magne M. and Pokotylo D.
1981 A pilot study in bifacial lithic reduction sequences. *Lithic Technology* 10: 34-47.

Mallory J.K.
1986 "Workshops" and "specialized production" in the production of Maya chert tools: a response to Shafer and Hester. *American Antiquity* 51: 152-158.

Mandel R.D. and Simmons A.H.
1988 Preliminary assessment of the geomorphology of 'Ain Ghazal. In A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986*: 431-435. British Archaeological Reports - Intern. Series 396.2. Oxford, B.A.R.

Mandeville M.D.
1973 A consideration of the thermal pretreatment of chert. *Plains Anthropologist* 18: 177-202.

Marks A.E. and Kaufman D.
1983 Boker Tachtit: the artifacts. In A.E. Marks (ed.), *Prehistory and Paleoenvironments in the Central Negev III. The Avdat/Aqev Area, Part 3*: 69-126. Dallas, Southern Methodist University.

Marks A.E. and Volkman P.
1983 Changing core reduction strategies: a technological shift from the Middle to the Upper Paleolithic in the southern Levant. In A. Trinkaus (ed.), *The Mousterian Legacy: Human Biocultural Change in the Upper Pleistocene*: 13-33. British Archaeological Reports - Intern. Series 164. Oxford, B.A.R.

Mauldin R.P. and Amick D.S.
1989 Investigating patterning in debitage from experimental bifacial core reduction. In D.S. Amick and R.P. Mauldin (eds.), *Experiments in Lithic Technology*: 67-88. British Archaeological Reports - Intern. Series 528. Oxford, B.A.R.

McCorriston J.
1994 Acorn eating and agricultural origins: California ethnographies as analogies for the ancient Near East. *Antiquity* 68: 97-107.

McCorriston J. and Hole F.
1991 The ecology of seasonal stress and the origins of agriculture in the Near East. *American Anthropologist* 95: 46-69.

Mellaart J.
1975 *The Neolithic of the Near East*. London, Thames and Hudson.

Michaels G.H.
1989 Craft specialization in the early Postclassic of Colha. In P. McAnany and B.L. Isaac (eds.), *Prehistoric Maya Economies of Belize*: 139-183. Research in Economic Anthropology - Supplement 4. Greenwich, JAI Press, Inc.

Miller R.
1983 Heat treatment of flints at Jericho. In K.M. Kenyon and T.A. Holland (eds.), *The Pottery Phases of the Tell and Other Finds*: 759. Excavations at Jericho 5. London: British School of Archaeology in Jerusalem, The British Academy.

Mithen S. and Finlayson B.
2007 WF16 and the Pre-Pottery Neolithic A of the southern Levant. In B. Finlayson and S. Mithen (eds.), *The Early Prehistory of Wadi Faynan, Southern Jordan*: 470-486. Wadi Faynan Series 1, Levant Supplement Series 4. Oxford, Oxbow Books, and Council for British Research in the Levant.

Moholy-Nagy H.
1990 The misidentification of Mesoamerican lithic workshops. *Latin American Antiquity* 1: 268-279.

Molist M., Mateu J., and Palomo T.
1994 Étude préliminaire sur les industries lithiques du PPNB moyen et récent de Tell Halula (Haute Vallée de l'Euphrate, Syrie). In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 349-362. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Montet-White A.
1988 Raw-material economy among medium-sized Late Paleolithic campsites of Central Europe. In H.L. Dibble and A. Montet-White (eds.), *Upper Pleistocene Prehistory of Western Eurasia*: 361-373. Monograph 54, University Museum Symposium Series 1. Philadelphia, University Museum, University of Pennsylvania.

Montet-White A. and Holen S. (eds.)
1991 *Raw Material Economies Among Prehistoric Hunter-Gatherers*. Publications in Anthropology 19. Lawrence, University Press of Kansas.

Moore A.M.T.
1973 The late Neolithic in Palestine. *Levant* 5: 36-68.
1975 The excavation of Tell Abu Hureyra in Syria: a preliminary report. *Proceedings of the Prehistoric Society* 41: 50-77.
1981 North Syria in Neolithic 2. In J. Cauvin and P. Sanlaville (eds.), *Préhistoire du Levant: Chronologie et Organization de l'Espace Depuis les Origines Jusqu'au VI^e Millénaire*: 445-456. Colloques Internationaux 598. Paris, Éditions du Centre National de la Recherche Scientifique.
1982 A four-stage sequence for the Levantine Neolithic *ca.* 8500-3750 B.C. *Bulletin of the American Schools for Oriental Research* 246: 1-34.
1983 The first farmers of the Levant. In T.C. Young, P.E.L. Smith, and P. Mortensen (eds.), *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia*: 91-111. Studies in Ancient Oriental Civilization 36. Chicago, Oriental Institute, University of Chicago.
1985 The development of Neolithic societies in the Near East. *Advances in World Archaeology* 4: 1-69.

Morala A. and Turq A.
1991 Relations entre matières premières lithiques et technologie: l'exemple du Paléolithique entre Dordogne et Lot. In *25 Ans d'Études Technologiques en Préhistoire: Bilan et Perspectives*: 159-168. Juan-les-Pins, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Mortensen P.
1970 A preliminary study of the chipped stone industry from Beidha: an early Neolithic village in southern Jordan. *Acta Archaeologica* (Denmark) 41: 1-54.
1988 A note on a small box with flint blades and arrowheads from Beidha - and its implications. In A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986*: 199-207. British Archaeological Reports - Intern. Series 396.1. Oxford, B.A.R.

Mueller-Wille C. and Dickson D.
1991 An examination of some models of late Pleistocene society in southwestern Europe. In G.A. Clark (ed.), *Perspectives on the Past: Theoretical Biases in Mediterranean Hunter-Gatherer Research*: 25-55. Philadelphia, University of Pennsylvania Press.

Muheisen M., Qadi N., and Gebel H.G.K.
2004 Raw materials of the flint and ground stone implements. In H.J. Nissen, M. Muheisen, and H.G.K. Gebel (eds.), *Basta I: the Human Ecology*: 129-154. bibliotheca neolithica Asiae meridionalis et occidentalis, and Yarmouk University, Monograph of the Faculty of Archeology and Anthropology 4. Berlin, ex oriente.

Murray P.
1980 Discard location: the ethnographic data. *American Antiquity* 45: 490-502.

Nadel D.
1989 Flint heat treatment at the beginning of the Neolithic period in the Levant. *Mitekufat Haeven, Journal of the Israel Prehistoric Society* 22: 61-67.
1990 Ohalo II - a preliminary report. *Mitekufat Haeven, Journal of the Israel Prehistoric Society* 23: 48-59.

Nelson L.L.
1968 *The Effect of Annealing on the Properties of Edwards Plateau Flint.* Denver, University of Denver: Unpublished M.A. Thesis.

Nelson M.C.
1991 The study of technological organization. In M.B. Schiffer (ed.), *Archaeological Method and Theory* 3: 57-100. Tucson, University of Arizona Press.

Neuville R.
1934 Le préhistorique de Palestine. *Revue Biblique* 43: 237-259.

Newcomer M.H.
1975 "Punch technique" and Upper Paleolithic blades. In E. Swanson (ed.), *Lithic Technology: Making and Using Stone Tools*: 97-102, Pl. ii, iii. The Hague, Mouton.

Nicholson B.A.
1983 A comparative evaluation of four sampling techniques and the reliability of microdebitage as a cultural indicator in regional surveys. *Plains Anthropologist* 28.102.1: 273-281.

Nishiaki Y.
1993 Lithic analysis and culture change in the Late Pre-Pottery Neolithic of north Syria. *Anthropological Science: Jurnal of the Anthropological Society of Nippon* 101.1: 91-109.
1994 The naviform method at Douara Cave II, Palmyra, Syria. In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 363-378. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.
2000 *Lithic Technology of Neolithic Syria*. British Archaeological Reports - Intern. Series 840. Oxford, Archaeopress.

Nissen H.J., Muheisen M.S., and Gebel H.G.
1987 Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities of Jordan* 31: 79-119.
1991 Report on the excavations at Basta. *Annual of the Department of Antiquities of Jordan* 35: 13-34.

Noy T., Schuldenrein J., and Tchernov E.
1980 Gilgal, a Pre-Pottery Neolithic A site in the lower Jordan Valley. *Israel Exploration Journal* 30.1-2: 63-82.

Odell G.H., Hayden B.D., Johnson J.K., Kay M., Morrow T.A., Nash S.E., Nassaney M.S., Rick J.W., Rondeau M.F., Rosen S.A., Shott M.J., and Thacker P.T.
1996 Some comments on a continuing debate. In G.H. Odell (ed.), *Stone Tools: Theoretical Insights into Human Prehistory*: 377-392. New York, Plenum Press.

Ohnuma K.
1988 *Ksar Akil, Lebanon: A Technological Study of the Earlier Upper Palaeolithic Levels of Ksar Akil, III: Levels XXV-XIV, with contributions by C.A. Bergman and M.H. Newcomer.* British Archaeological Reports - Intern. Series 426. Oxford, B.A.R.
1997 Chronology of the "Proto-Neolithic" of Iraq and Syria: a hypothetical view. *Al-Rafidan* 18: 45-58. Tokyo, Institute for Cultural Studies of Ancient Iraq, Kokushikan University.

Ohnuma K. and Bergman C.
1988 Experimental studies in the determination of flaking mode. In K. Ohnuma (ed.), *Ksar Akil, Lebanon: A Technological Study of the Earlier Upper Palaeolithic Levels of Ksar Akil, III: Levels XXV-XIV, with*

contributions by C.A. Bergman and M.H. Newcomer: 329-338. British Archaeological Reports - Intern. Series 426. Oxford, B.A.R.

Olausson D.S.
1983 Experiments to investigate the effects of heat treatment on use-wear on flint tools. *Proceedings of the Prehistoric Society* 49: 1-13.

Olszewski D.
1988 The north Syrian late Epipaleolithic and its relationship to the Natufian complex. *Levant* 20: 127-137.
1991 Social complexity in the Natufian? Assessing the relationship of ideas and data. In G.A. Clark (ed.), *Perspectives on the Past: Theoretical Biases in Mediterranean Hunter-Gatherer Research*: 322-340. Philadelphia, University of Pennsylvania Press.
1993 Subsistence ecology in the Mediterranean forest: implications for the origins of cultivation in the Epipaleolithic southern Levant. *American Anthropologist* 95: 420-435.

Parry W.J. and Kelly R.L.
1987 Expedient core technology and sedentism. In J.K. Johnson and C.A. Morrow (eds.), *The Organization of Core Technology*: 285-304. Boulder, Westview Press.

Patterson L.
1990 Characteristics of bifacial-reduction flake-size distribution. *American Antiquity* 55: 550-558.

Peacock D.P.S.
1981 Archaeology, ethnology, and ceramic production. In H. Howard and E.L. Morris (eds.), *Production and Distribution: A Ceramic Viewpoint*: 187-194. British Archaeological Reports - Intern. Series 120. Oxford, B.A.R.

Pelegrin J.
1985 Réflexions sur le comportement technique. In M. Otte (ed.), *La Signification Culturelle des Industries Lithiques: Actes du Colloque de Liège du 3 au 7 Octobre 1984*: 72-91. Studia Praehistorica Belgica 4. British Archaeological Reports - Intern. Series 239. Oxford, B.A.R.
1990 Prehistoric lithic technology: some aspects of research. *Archaeological Review from Cambridge* 9.1: 116-125.
1991a Aspects de démarche expérimentale en technologie lithique. In *25 Ans d'Études Technologiques en Préhistoire: Bilan et Perspectives*: 57-63. Juan-les-Pins, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.
1991b Sur une recherche technique experimental des techniques de debitage laminaire. In *Archeologie Experimentale, Tome 2 – La Terre: L'os et la Pierre, la Maison et les Champs*: 118-128. Actes du Colloque International: "Expérimentation en Archéologie: Bilan et Perspectives," Tenu à l'Archéodrome de Beaune les 6, 7, 8, et 9 avril 1988. Paris, Éditions Errance.

Pelegrin J., Karlin C., and Bodu P.
1988 « *Chaînes opératoires* »: un outil pour le préhistorien. In J. Tixier (ed.), *Journée d'Études Technologiques en Préhistoire*: 55-62. Notes et Monographies Techniques 25. Paris, Éditions du Centre National de la Recherche Scientifique.

Perlès C.
1991 Introduction. In *25 Ans d'Études Technologiques en Préhistoire: Bilan et Perspectives*: 7-10. Juan-les-Pins, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.
1992 Systems of exchange and organization of production in Neolithic Greece. (English translation by Nora Scott.) *Journal of Mediterranean Archaeology* 5: 115-164.

Perlès C. and Phillips J.
1991 The Natufian conference - discussion. In O. Bar-Yosef and F.R. Valla (eds.), *The Natufian Culture of the Levant*: 637-644. Archaeological Series 1. Ann Arbor, International Monographs in Prehistory.

Perrot J.
1952 Les industries lithiques Palestinnes de la fin du mesolithique à l'age du bronze. *Israel Exploration Journal* 2.2: 73-81.
1966 Le gisement natoufien de Mallaha (Eynan), Israël. *L'Anthropologie* 70: 437-484.
1968 La préhistoire Palestinienne. *Dictionnaire de la bible - supplément* 8: 286-446.
1993 Remarques introductives. *Paléorient* 19.1: 9-21.

Phillips J.L.
1991 Refitting, edge-wear and *chaînes opératoires*: a case study from the Sinai. In *25 Ans d'Études Technologiques en Préhistoire: Bilan et Perspectives*: 305-317. Juan-les-Pins, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Pitzer J.M., Hester T.H., and Heizer R.F.
1974 Microblade technology of the Channel Islands: a preliminary report. *Masterkey* 48: 124-135.

Pope M. and Pollock S.
1995 Trade, tools, and tasks: a study of Uruk chipped stone industries. In B.L. Isaac (ed.), *Research in Economic Anthropology* 16: 227-265. Greenwich, CT, JAI Press, Inc.

Prentice G.
1983 Cottage industries: concepts and implications. *Midcontinental Journal of Archaeology* 8: 17-48.

Purdy B.A.
1974 Investigations concerning the thermal alteration of silica minerals: an archaeological approach. *Tebewa* 17.1: 37-66.

Quennell A.M.
1954 *Geologic Map of Jordan (East of the Rift Valley). Sheet 1, Amman*. Scale 1:250,000. Amman, Department of Lands and Surveys of Jordan.

Quintero L.A.
1996 Flint mining in the Pre-Pottery Neolithic: preliminary report on the exploitation of flint at Neolithic 'Ain Ghazal in highland Jordan. In H.G.K. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent and their Contemporaries in Adjacent Regions*: 233-242. Studies in Early Near Eastern Production, Subsistence, and Environment 3. Berlin, ex oriente.
1997 Lithic industrial behavior at 'Ain Ghazal: a study of MPPNB debitage loci. *Neo-Lithics* 1: 11-14.

Quintero L.A. and Hintzman M.
2007 Woodworking implements from Neolithic 'Ayn Ghazal: tools of change. In F. Al-Khraysheh (ed) *Studies in the History and Archaeology of Jordan IX, Cultural Interaction throughout the Ages*: 193-203. Amman, Department of Antiquities of Jordan.

Quintero L.A., Rollefson G.O., and Wilke P.J.
2004 Highland towns and desert settlements: origins of nomadic pastoralism in the Jordanian Neolithic. In H.-D. Bienert, H.G.K. Gebel, and R. Neef (eds.), *Central Settlements in Neolithic Jordan. Proceedings of a Symposium Held in Wadi Musa, Jordan 21st-25th July, 1997*: 201-213. Studies in Early Near Eastern Production, Subsistence, and Environment 5, 1998. Berlin, ex oriente.

Quintero L.A. and Wilke P.J.
1995 Evolution and economic significance of naviform core-and-blade technology in the southern Levant. *Paléorient* 21.1: 17-33.

Quintero L.A., Wilke P.J., and Waines J.G.
1997 Pragmatic studies of Near East Neolithic sickle blades. In H.G.K. Gebel, Z. Kafafi, and G.O. Rollefson (eds.), *Prehistory of Jordan II: Perspectives from 1997*: 263-286. Studies in Early Near Eastern Production, Subsistence, and Environment 4. Berlin, ex oriente.

Redman C.
1978 *The Rise of Civilization: From Early Farmers to Urban Society in the Ancient Near East*. San Francisco, W.H. Freeman and Co.
1982 The Çayönü chipped stone industry: the 1968 and 1970 excavation seasons. In L.S. Braidwood and R.J. Braidwood (eds.), *Prehistoric Village Archaeology in South-Eastern Turkey: The Eighth Millennium B.C. Site at Çayönü: Its Chipped and Ground Stone Industries and Faunal Remains*: 17-72. British Archaeological Reports - Intern. Series 138. Oxford, B.A.R.
1983 Regularity and change in the architecture in an early village. In T.C. Young, P.E.L. Smith, and P. Mortensen P. (eds.), *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia*: 189-206. Studies in Ancient Oriental Civilization 36. Chicago, Oriental Institute, University of Chicago.

Renfrew C.
1977 Alternative models for exchange and spatial distribution. In T.K. Earle and J.E. Ericson (eds.), *Exchange Systems in Prehistory*: 71-90. New York, Academic Press.

Renfrew C. and Dixon J.
1977 Obsidian in western Asia: a review. In G. de G. Sieveking, I.H. Longworth, and K.E. Wilson (eds.), *Problems in Economic and Social Archaeology*: 137-150. Boulder, Westview Press.

Rhotert H.
1938 *Transjordanien: Vorgeschichtliche Forschungen*. Stuttgart, Verlag Strecker und Schröder.

Rice P.M.
1991 Specialization, standardization, and diversity: a retrospective. In R.L. Bishop and F.W. Lange (eds.), *The Ceramic Legacy of Anna O. Shepard*: 257-279. Boulder, University of Colorado Press.

Rick J.W.
1978 *Heat-Altered Cherts of the Lower Illinois Valley: An Experimental Study in Prehistoric Technology*. Prehistoric Records 2. Evanston, Northwestern Archeological Program, Northwestern University.

Rick J.W. and Chappell S.
1983 Thermal alteration of silica materials in technological and functional perspective. *Lithic Technology* 12: 69-80.

Rigaud J.-F.
1978 The significance of variability among lithic artifacts: a specific case from southwestern France. *Journal of Anthropological Research* 34: 299-310.

Robins G.V., Seeley N.J., Symons M.C.R., and McNeil D.A.C.
1981 Manganese (II) as an indicator of ancient heat treatment in flint. *Archaeometry* 23.1: 103-107.

Rollefson G.O.
1983 Ritual and ceremony at Neolithic ‘Ain Ghazal (Jordan). *Paléorient* 9.2: 29-38.
1986 Neolithic ‘Ain Ghazal (Jordan): ritual and ceremony, II. *Paléorient* 12.1:45-51.
1987a Observations on the Neolithic village in Wadi Shu‘eib. *Annual of the Department of Antiquities of Jordan* 32: 521-524.
1987b Local and external relations in the Levantine PPN period: ‘Ain Ghazal (Jordan) as a regional center. In A. Hadidi (ed.), *Studies in the History and Archaeology of Jordan III, Trade, Communications and International Relations throughout the Ages*: 29-32. Amman, Department of Antiquities of Jordan.
1989a The late Aceramic Neolithic of the Levant: a synthesis. *Paléorient* 15.1: 168-173.
1989b The Aceramic Neolithic of the southern Levant: the view from ‘Ain Ghazal. *Paléorient* 15.1: 135-140.
1990a Neolithic chipped stone technology at ‘Ain Ghazal, Jordan: the status of the PPNC phase. *Paléorient* 16.1: 119-124.
1990b The uses of plaster at Neolithic ‘Ain Ghazal, Jordan. *Archeomaterials* 4: 33-54.
1992 Neolithic settlement patterns in northern Jordan and Palestine. In M. Zaghloul, K. ‘Amr, F. Zayadine, R. Nabeel, and N.R. Tawfiq (eds.), *Studies in the History and Archaeology of Jordan IV, Sites and Settlement in Jordan*: 123-135. Amman, Department of Antiquities of Jordan.

1993 The origins of the Yarmoukian at ‘Ain Ghazal. *Paléorient* 19.1: 91-100.
1996 The Neolithic devolution: ecological impact and cultural compensation at ‘Ain Ghazal. In J.D. Seger (ed.), *Retrieving the Past: Essays on Archaeological Research and Methodology in Honor of Gus W. Van Beek*: 219-229. Winona Lake, Eisenbrauns.
1997 Neolithic ‘Ayn Ghazal in its landscape. In G. Bisheh, M. Zaghloul and I. Kehrberg (eds.), *Studies in the History and Archaeology of Jordan VI, Landscape Resources and Human Occupation in Jordan throughout the Ages*: 241-244. Amman, Department of Antiquities of Jordan.
2004 The character of LPPNB social organization. In H.-D. Bienert, H.G.K. Gebel, and R. Neef (eds.) *Central Settlements in Neolithic Jordan. Proceedings of a Symposium held in Wadi Musa, Jordan 21st-25th July, 1997*: 145-155. Studies in Early Near Eastern Production, Subsistence, and Environment 5, 1998. Berlin, ex oriente.

Rollefson G.O., Kafafi Z., and Simmons A.
1991 The Neolithic village of ‘Ain Ghazal, Jordan: Preliminary report on the 1988 season. *Bulletin of the American Schools of Oriental Research, Supplement* 27: 95-116.

Rollefson G.O. and Köhler-Rollefson I.
1989 The collapse of early Neolithic settlements in the southern Levant. In I. Hershkovits (ed.), *People and Culture in Change: Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic, and Neolithic Populations of Europe and the Mediterranean Basin*: 73-89. British Archaeological Reports - Intern. Series 508.1. Oxford, B.A.R.
1993 PPNC adaptations in the first half of the 6th millennium B.C. *Paléorient* 19.1: 33-42.

Rollefson G.O., Quintero L.A., and Wilke P.J.
2007 Purple-pink flint flint sources in Jordan. In C. Delage (ed.), *Chert Availability and Prehistoric Exploitation in the Near East*: 55-67. British Archaeological Reports - Intern. Series 1615. Oxford, John and Erica Hedges.

Rollefson G.O. and Simmons A.H.
1987 The life and death of ‘Ain Ghazal. *Archaeology* 40.6: 38-45.

Rollefson G.O., Simmons A., and Kafafi Z.
1992 The Neolithic cultures at ‘Ain Ghazal, Jordan. *Journal of Field Archaeology* 19: 443-470.

Ronen A. and Kaufman D.
1976 Epi-Palaeolithic sites near Nahal Hadera, central coastal plain of Israel. *Tel Aviv* 3: 16-30.

Roodenberg J.J.
1986 *Le Mobilier en Pierre de Bouqras: Utilisation de la Pierre dans un Site Néolithique sur le Moyen Euphrate (Syrie)*. Leiden, Nederlands Historisch-Archaeologisch Instituut te Istanbul.
1989 Hayaz Höyük and the Final PPNB in the Taurus foothills. *Paléorient* 15.1: 91-101.

Rosen S.A.
1986 The analysis of trade and craft specialization in the Chalcolithic period: comparisons from different realms of material culture. *Michmanim* 3: 21-32.
1989 The origins of craft specialization: lithic perspectives. In I. Hershkovits (ed.), *People and Culture in Change: Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic, and Neolithic Populations of Europe and the Mediterranean Basin*: 107-114. British Archaeological Reports - Intern. Series 508.1. Oxford, B.A.R.
1997 *Lithics After the Stone Age. A Handbook of Stone Tools from the Levant*. Walnut Creek, AltaMira Press.

Rossignol-Strick M.
1993 Late Quaternary climate in the eastern Mediterranean region. *Paléorient* 19.1: 135-152.

Rust A.
1943 *Die Alt-und Mittelsteinzeitlichen Funde Von Stellmoor*. Holstein, Karl Wachholta Verlag Neumünster.

Sabloff J.A.
1981 When rhetoric fades: a brief appraisal of intellectual trends in American archaeology during the past two decades. *Bulletin of the American Schools of Oriental Research* 242: 1-6.

Sackett J.R.
1981 From de Mortillet to Bordes: a century of French Paleolithic research. In G. Daniel (ed.), *Towards a History of Archaeology*: 85-99. London, Thames and Hudson.
1991 Straight archaeology French style: the phylogenetic paradigm in historic perspective. In G.A. Clark (ed.), *Perspectives on the Past: Theoretical Biases in Mediterranean Hunter-Gatherer Research*: 109-139. Philadelphia, University of Pennsylvania Press.

Santley R.S.
1984 Obsidian exchange, economic stratification, and the evolution of complex society in the basin of Mexico. In K. Hirth (ed.), *Trade and Exchange in Early Mesoamerica*: 43-86. Albuquerque, University of New Mexico Press.

Santley R.S., Kneebone R.R., and Kerley J.
1985 Rates of obsidian utilization in Central Mexico and on the south Gulf Coast. *Lithic Technology* 14. 107-119.

Sappington R.L.
1984 Procurement without quarry production: examples from southwestern Idaho. In J.E. Ericson and B.A. Purdy (eds.), *Prehistoric Quarries and Lithic Production*: 23-34. Cambridge, Cambridge University Press.

Sauer J.D.
1993 *Historical Geography of Crop Plants: A Select Roster*. Boca Raton, CRC Press.

Sayej G.
2004 *The Lithic Industries of Zahrat adh-Dhra' and the Pre-Pottery Neolithic Period of Southern Jordan*. British Archaeological Reports - Intern. Series 1329. Oxford, Archaeopress.

Schiffer M.B.
1974 Nomothetic aspects of chipped-stone experiments. *Newsletter of Lithic Technology* 3: 46-50.
1976 *Behavioral Archaeology*. New York, Academic Press.
1987 *Formation Processes of the Archaeological Record*. Albuquerque, University of New Mexico Press.

Schild R.
1980a Introduction to dynamic technological analysis of chipped stone assemblages. In R. Schild (ed.), *Unconventional Archaeology: New Approaches and Goals in Polish Archaeology*: 57-85. Wrocław, Instytut Historii Kultury Materialnej, Polska Akademia Nauk.

Schild R. (ed.)
1980b *Unconventional Archaeology: New Approaches and Goals in Polish Archaeology*. Wrocław, Instytut Historii Kultury Materialnej, Polska Akademia Nauk.

Schmandt-Besserat D.
1990 Accounting in the prehistoric Middle East. *Archeomaterials* 4: 15-23.

Schmid E.
1973 Die reviere urgeschichtlichen silexbergbaus in Europa. *Der Anschnitt* 25.4: 12-15.

Schuldenrein J. and Clark G.
1994 Landscape and prehistoric chronology of west-central Jordan. *Geoarchaeology: An International Journal* 9: 31-55.

Schyle, D.
2007 *Ramat Tamar and Metzad Mazal: The Early Neolithic Economy of Flint Mining and Production of Bifacials Southwest of the Dead Sea*. bibliotheca neolithica Asiae meridionalis et occidentalis. Berlin, ex oriente.

Sellet F.
1993 *Chaîne opératoire*: the concept and its application. *Lithic Technology* 18: 106-112.

Service E.
1962 *Primitive Social Organization: An Evolutionary Perspective*. New York, Random House.

Shafer H.J. and Hester T.R.
1983 Ancient Maya chert workshops in northern Belize, Central America. *American Antiquity* 48: 519-543.
1986 Maya stone-tool craft specialization and production at Colha, Belize: reply to Mallory. *American Antiquity* 51: 158-166.

Sheets P.D.
1975 Behavioral analysis and the structure of a prehistoric industry. *Current Anthropology* 16: 369-391.

Shott M.J.
1994 Size and form in the analysis of flake debris: review and recent approaches. *Journal of Archaeological Method and Theory* 1: 69-110.

Sieveking G. De G., Bush P., Ferguson J., Craddock P.T., Hughes M.J., and Crowell M.R.
1972 Prehistoric flint mines and their identification as sources of raw material. *Archaeometry* 14.2: 151-176.

Simmons A.H., Rollefson G.O., Kafafi Z., Köhler-Rollefson I., Durand K.R., Mandel R.D., al-Nahar M., and Cooper J.
2001 Wadi Shu'eib, a large Neolithic community in central Jordan: final report of test investigations. *Bulletin of the American Schools of Oriental Research* 321: 1-39.

Simmons A.H., Boulton A., Butler C.R., Kafafi Z., and Rollefson G.O.
1990 A plastered human skull from Neolithic 'Ain Ghazal, Jordan. *Journal of Field Archaeology* 17: 107-110.

Simmons A.H. and Kafafi Z.
1988 Preliminary report on the 'Ain Ghazal archaeological survey, 1987. *Annual of the Department of Antiquities of Jordan* 32: 27-39.

Simmons A.H., Köhler-Rollefson I., Rollefson G.O., Mandel R., and Kafafi Z.
1988 'Ain Ghazal: a major Neolithic settlement in central Jordan. *Science* 240: 35-39.

Smith P.E.L. and Young T.C.
1972 The evolution of early agriculture and culture in greater Mesopotamia. In B. Spooner (ed.), *Population Growth: Anthropological Implications*: 1-59. Cambridge, MIT Press.

Smith S.
2007 The use wear analysis of chipped stone points. In B. Finlayson and S. Mithen (eds.) *The Early Prehistory of Wadi Faynan, Southern Jordan*: 284-318. Wadi Faynan Series 1, Levant Supplement Series 4. Oxford, Oxbow Books, and Council for British Research in the Levant.

Solecki R.L. and Solecki R.S.
1983 Late Pleistocene-early Holocene cultural traditions in the Zagros and the Levant. In T.C. Young, P.E.L. Smith, and P. Mortensen (eds.), *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia*: 123-137. Studies in Ancient Oriental Civilization 36. Chicago, Oriental Institute, University of Chicago.

Sonneville-Bordes D. de
1954 Lexique typologique du Paléolithique supérieur: outillage lithique: I grattoirs - II outils solutréens. *Bulletin de la Societé Préhistorique Française* 51: 327-335.

Spence M.W.
1981 Obsidian production and the state in Teotihuacan. *American Antiquity* 46: 769-788.

Speth J.
1988 Lithic analysis and the reconstruction of prehistoric foraging economies: comments on *At the Edge: Terminal Pleistocene Hunter-Gatherers in the Negev and Sinai* by A. Nigel Goring-Morris. *Mitekufat Haeven, Journal of the Israel Prehistoric Society* 21: 68-78.

Stapert D.
1976 Some natural surface modifications on flint in the Netherlands. *Palaeohistoria* 18: 7-41.

Stech T.
1990 Neolithic copper metallurgy in southwest Asia. *Archeomaterials* 4: 55-61.

Stekelis M.
1972 *The Yarmoukian Culture of the Neolithic Period*. Jerusalem, Magnes Press.

Strouhal E.
1973 Five plastered skulls from Pre-Pottery Neolithic B Jericho. *Paléorient* 1.2: 231-247.

Sullivan A.P. and Rozen K.C.
1985 Debitage analysis and archaeological interpretation. *American Antiquity* 50: 755-779.

Suzuki C. and Akazawa T.
1971 Manufacturing technique of the stone artifacts from Palmyra, Syria. *Anthropological Science: Journal of the Anthropological Society of Nippon* 79.2: 105-127.

Tanno K. and Wilcox G.
2006 How fast was wild wheat domesticated? *Science* 311: 1886.

Taute W.
1994 Pre-Pottery Neolithic flint mining and flint workshop activities southwest of the Dead Sea (Ramat Tamar and Messad Mazzal). In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 495-509. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.

Tchernov E.
1981 The biostratigraphy of the Middle East. In J. Cauvin and P. Sanlaville (eds.), *Préhistoire du Levant*: 67-98. Paris, Éditions du Centre National de la Recherche Scientifique.
1984 Commensal animals and human sedentism in the Middle East. In J. Clutton-Brock and C. Grigson (eds.), *Animals in Archaeology 3: Early Herders and Their Flocks*: 91-115. British Archaeological Reports - Intern. Series 202. Oxford, B.A.R.

Tixier J.
1974 *Glossary for the Description of Stone Tools: With Special Reference to the Epipalaeolithic of the Maghreb.* Newsletter of Lithic Technology - Special Publication 1. (English translation by M.H. Newcomer.) Pullman, Washington State University.

Tixier J., Inizan M.L., and Roche H.
1980 *Préhistoire de la pierre taillée, 1, Terminologie et technologie.* Antibes, Cercle de Recherches et d'Études Préhistoriques.

Tomka S.A.
1989 Differentiating lithic reduction techniques: an experimental approach. In D.S. Amick and R.P. Mauldin (eds.), *Experiments in Lithic Technology*: 137-161. British Archaeological Reports - Intern. Series 528. Oxford, B.A.R.

Torrence R. (ed.)
1989 *Time, Energy and Stone Tools*. Cambridge, Cambridge University Press.

Tosi M.
1984 The notion of craft specialization and its representation in the archaeological records of early states in the Turanian Basin. In N. Spriggs (ed.), *Marxist Perspectives in Archaeology*: 22-52. Cambridge, Cambridge University Press.

Tubb K.W. and Grissom C.A.
1995 ‘Ayn Ghazal: a comparative study of the 1983 and 1985 statuary caches. In K. ‘Amr, F. Zayadine, and M. Zaghloul (eds.), *Studies in the History and Archaeology of Jordan V, Art and Technology throughout the Ages:* 437-447. Amman, Department of Antiquities of Jordan.

Unger-Hamilton R.
1989 The Epi-Palaeolithic southern Levant and the origins of cultivation. *Current Anthropology* 30: 88-103.
1991 Natufian plant husbandry in the southern Levant and comparison with that of the Neolithic periods: the lithic perspective. In O. Bar-Yosef and F.R. Valla (eds.), *The Natufian Culture of the Levant*: 483-520. Archaeological Series 1. Ann Arbor, International Monographs in Prehistory.

Valde-Nowak P.
1995 Stone sources from the North-Carpathian province in the Stone and Early Bronze Ages. *Archaeologia Polona* 33: 111-118.

Valla F.R.
1981 Les établissements natoufiens dans le nord d’Israel. In J. Cauvin and P. Sanlaville (eds.), *Préhistoire du Levant*: 409-420. Paris, Éditions du Centre National de la Recherche Scientifique.
1984 *Les Industries de Silex de Mallaha (Eynan) et du Natoufien dans le Levant.* Mémoires et Travaux du Centre de Recherche Français de Jérusalem 3. Paris, Association Paléorient.
1995 The first settled societies - Natufian (12,500 - 10,200 BP). In T.E. Levy (ed.), *The Archaeology of Society in the Holy Land*: 169-185. New York, Facts on File.

Van Zeist W.
1985 Past and present environments of the Jordan Valley. In A. Hadidi (ed.), *Studies in the History and Archaeology of Jordan II, Jordanian Environment: Geographical and Historical*: 199-204. Amman, Department of Antiquities of Jordan.

Van Zeist W. and Bottema S.
1982 Vegetational history of the Eastern Mediterranean and the Near East during the last 20,000 years. In J.L. Bintliff and W. Van Zeist (eds.), *Palaeoclimates, Palaeoenvironments, and Human Communities in the Eastern Mediterranean Region in Later Prehistory*: 277-323. British Archaeological Reports - Intern. Series 133.2. Oxford, B.A.R.

Voigt M.
1990 Reconstructing Neolithic societies and economies in the Middle East. *Archeomaterials* 4: 1-14.

Volkman P.
1983 Boker Tachtit: core reconstructions. *In*: Marks A.E. (ed.), *Prehistory and Paleoenvironments in the Central Negev III, The Avdat/Aqev Area 3*: 127-190. Dallas, Southern Methodist University.

Wain H.C.
1965 *The Story of Fluorescence*. Stafford Springs, Raytech Industries.

Wattenmaker P.
1994 State formation and the organization of domestic production at third-millennium B.C. Kurban Höyük, southeast Turkey. In G.M. Schwartz and S.F. Falconer (eds.), *Archaeological Views from the Countryside: Village Communities in Early Complex Societies*: 109-120. Washington, Smithsonian Institution Press.

Waychunas G.A.
1988 Luminescence, x-ray emission, and new spectroscopies. In F.C. Hawthorne (ed.), *Spectroscopic Methods in Mineralogy and Geology*: 639-698. Reviews in Minerology 18. Washington, Mineralogical Society of America.

Wilke P.J.
1996 Bullet-shaped microblade cores of the Near Eastern Neolithic: experimental replicative studies. In H.G.K. Gebel and S.K. Kozłowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent and their Contemporaries in Adjacent Regions*: 289-310. Studies in Early Near Eastern Production, Subsistence, and Environment 3. Berlin, ex oriente.

Wilke P.J. and Quintero L.A.
1994 Naviform core-and-blade technology: assemblage character as determined by replicative experiments. In H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Berlin 1993*: 33-60. Studies in Early Near Eastern Production, Subsistence, and Environment 1. Berlin, ex oriente.
1996 Neolithic millstone production: insights from research in the arid southwestern United States. In H.G.K. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent and their Contemporaries in Adjacent Regions*: 243-260. Studies in Early Near Eastern Production, Subsistence, and Environment 3. Berlin, ex oriente.

Wilke P.J., Quintero L.A., Rollefson G.O., and Gebel H.G.K.
2007 The naviform core-and-blade industry in orthoquartzite at ‘Ain Jamman, Jordan. In L. Astruc, D. Binder, and F. Briois (eds.), *Technical Systems and Near Eastern PPN Communities*: 193-201. Antibes, Association pour la Promotion et la Diffusion des Connaissances Archéologiques.

Wylie A.
1985 The reaction against analogy. In M. Schiffer (ed.), *Advances in Archaeological Method and Theory* 7: 63-111. New York, Academic Press.

Yakar R. and Hershkovitz I.
1988 Nahal Hemar Cave: The modelled skulls. In O. Bar-Yosef and D. Alon (eds.), *Nahal Hemar Cave*. *‘Atiqot* 18: 59-63. Jerusalem, Israel Exploration Society.

Yerkes R.W.
1989 Mississippian craft specialization of the American Bottom. *Southeastern Archaeology* 8: 93-106.

Yerkes R.W. and Kardulias P.N.
1993 Recent developments in the analysis of lithic artifacts. *Journal of Archaeological Research* 1: 89-119.

Zohary D.
1989 Domestication of the Southwest Asian Neolithic crop assemblage of cereals, pulses, and flax: the evidence from the living plants. In D.R. Harris and G.C. Hillman (eds.), *Foraging and Farming: The Evolution of Plant Exploitation*: 358-373. One World Archaeology 13. London, Unwin Hyman.
1992 Domestication of the Near Eastern crop assemblage. In P.C. Anderson (ed.), *Préhistoire de l’Agriculture: Nouvelles Approches Expérimentales et Ethnographiques*: 81-86. Monographie du Centre de Recherches Archéologiques 6. Paris, Éditions du Centre National de la Recherche Scientifique.

ex oriente e.V.

Early Near Eastern Production, Subsistence, and Environment

Studies in Early Near Eastern Production, Subsistence, and Environment

Editors-in-Chief: Hans Georg K. Gebel and Reinder Neef

bibliotheca neolithica Asiae meridionalis et occidentalis

Editors-in-Chief: Hans Georg K. Gebel and Gary O. Rollefson

Jebel Abu Thawwab (Er-Rumman), Central Jordan. The Late Neolithic and Early Bronze Age I Occupations
by Zeidan Kafafi, with contributions by Nizar Abu-Jaber, Bo Dahl Hermansen, Ilse Koehler-Rollefson, Reinder Neef, Nabil Qadi, Raeda Quraan, Ziad al-Sa'ad, Danielle Stordeur, & Hisahiko Wada
bibliotheca neolithica Asiae meridionalis et occidentalis (2001) *& Monographs of the Institute of Archaeology and Anthropology, Yarmouk University* 3 (2001) (with 7 specialist contributions, XIII + 222 pages, 2 colour plates, 77 figures, 42 plates, 23 tables, hardcover - 78 Euro) [ISBN 978-3-9804241-7-2]

Gesher: A Pre-Pottery Neolithic A Site in the Central Jordan Valley, Israel. A Final Report
by Yosef Garfinkel and Doron Dag, with contributions by Shoshana Ashkenazi, Shmuel Belitzky, Gaelle Le Dosseur, Liora K. Horwitz, Mordechai E. Kislev, Yoel Melamed, Henk K. Mienis, Orit Simchoni.
bibliotheca neolithica Asiae meridionalis et occidentalis (2006) (with 11 contributions, XIV + 230 pages, 12 colour plates, 158 figures, 33 tables, hardcover - 85 Euro) [ISBN 978-3-9807578-6-7]

Ramat Tamar and Metzad Mazal. The Early Neolithic Economy of Neolithic Flint Mining and Production of Bifacials Southwest of the Dead Sea, by Daniel Schyle. bibliotheca neolithica Asiae meridionalis et occidentalis (2007) (XIV+ 220 pages, 48 figures, 48 tables, 94 plates. hardcover – 72 Euro) [ISBN 978-3-9807578-7-4]

Basta I. The Human Ecology, edited by Hans J. Nissen, Mujahed Muheisen and Hans Georg K. Gebel, with contributions by Maria Thaís Crepaldi Affonso, Cornelia Becker, Hans Georg K. Gebel, Andreas Hauptmann, Bo Dahl Hermansen, Ulrich Kamp, Mujahed Muheisen, Reinder Neef, Hans J. Nissen, Ernst Pernicka and Nabil Qadi
bibliotheca neolithica Asiae meridionalis et occidentalis (2004) & *Yarmouk University, Monograph of the Faculty of Archaeology and Anthropology* 4 (2004) (with 10 specialist contributions, XV + 310 pages, 69 figures, 34 plates, 63 tables/ diagrams/ appendices, hardcover - 98 Euro) [ISBN 978-3-9807578-0-5]

Basta II. The Architecture and Stratigraphy, by Hans Georg K. Gebel, Hans J. Nissen and Zaydoon Zaid, with a contribution by Moritz Kinzel. bibliotheca neolithica Asiae meridionalis et occidentalis (2006) & *Yarmouk University, Monograph of the Faculty of Archaeology and Anthropology* 5 (2006) (XVI + 306 pages, 56 figures, 72 plates, 6 tables, 6 appendices, 2 stratigraphical charts, 2 fold-up top plans as insertions, hardcover – 115 Euro) [ISBN 978-3-9807578-4-3]

Basta IV.3. The Ground Stone and Bone Industries, by Cornelia Becker, Wajeeh Karasneh, Nabil Qadi and Hans Georg K. Gebel. bibliotheca neolithica Asiae meridionalis et occidentalis (2010) & *Yarmouk University, Monograph of the Faculty of Archaeology and Anthropology* (2010) (forthcoming) [ISBN 978-3-9811888-5-1]

'Ain Ghazal Excavation Reports 2: Evolution of Lithic Economies in the Levantine Neolithic: Development and Demise of Naviform Core Technology, as Seen at 'Ain Ghazal, by Leslie A. Quintero. bibliotheca neolithica Asiae meridionalis et occidentalis (2010) & Yarmouk University, Monograph of the Faculty of Archaeology and Anthropology (2010). (XIV+ 184 pages, 7 figures, 51 plates, 10 tables. hardcover – 72 Euro) [ISBN 978-3-9811888-4-4]

* * * * * *

NEO-LITHICS. The Newsletter of Southwest Asian Neolithic Research

edited by Gary O. Rollefson and Hans Georg K. Gebel

since 1994: general contributions, field reports, special Topic Issues, information on gatherings and conferences, research news, recent theses and publications, upcoming meetings, *etc.* (minimum subscription of three years = 6 issues, 40-50 pages plus per issue, postage included - 66 Euro; back issues available) [ISSN 1434-6990]

* * * * * *

Modesty and Patience. Archaeological Studies and Memories in Honor of Nabil Qadi, "Abu Salim"

edited by Hans Georg K. Gebel, Zeidan Kafafi, and Omar al-Ghul

Yarmouk University, Monograph of the Faculty of Archaeology and Anthropology (2009) & ex oriente, Berlin (2009)
(IX+ 218 pages, 95 figures, 5 tables. softcover – 28 Euro) [ISBN 978-3-9811888-1-3]

Orders please send to:
ex oriente e.V., Hüttenweg 7, 14195 Berlin, Germany
Fax 0049 30 98 311 246, Email: ex-oriente@gmx.net, or via www.exoriente.org