A LATE CLASSIC MAYA LITHIC WORKSHOP AT COLHA, BELIZE

A Thesis

by

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ABSTRACT

A Late Classic Maya Lithic Workshop at Colha, Belize.

(May 1984)

Erwin Roemer, Jr., B.A., The University of Texas at Austin

Chairman of Advisory Committee: Dr. Harry J. Shafer

This thesis examines material evidence from one stone tool manufacturing area at the ancient Maya site of Colha in northern Belize, Central America. A detailed study is made of the chert manufacturing debris excavated from a huge archaeological deposit that accumulated at a Late Classic architectural platform (work operation 2007). The major aim is threefold: 1) to establish the archaeological context, 2) to depict the technological processes behind the stone tool production, and 3) to interpret the "craft specialist" behavior assumed to have been practiced at the site.

Analysis of the manufacturing debris is conducted by describing the material and then making technological inferences based on certain observed attributes on artifacts that represent various "stages" of manufacturing. Simple reduction models are offerred for two major tool classes: oval bifaces and stemmed blades. Descriptive statistics are part of the morphological data used to support this part of the analysis.

Craft specialization is interpreted by applying the insight of lithic technology and archaeological context to several predicates of expected behavior. In the course of defining the subject, previous studies of craft specialization are reviewed. One general predicate is that the workshop activities took place in a context of a civilized society. Two other specific predicates of craft specialization relate to: (a) standardization in manufacturing behavior and product morphology,and (b) efficiency in manufacturing. These predicates are generally supported by the evidence. Strict testing in terms of defined thresholds of measurement was not possible. This problem and others, along with some broader interpretations, are discussed in the concluding chapter.

DEDICATION

To my parents Mildred E. Connor and Erwin Roemer, Sr.

ACKNOWLEDGEMENTS

My involvement in archaeology could never have occurred without the encouragement my family has given me: my wife Kathy, son Tres, sister Rosiland, and parents. Too many times I was absent or unsociable because of this thesis.

At Colha, the families of John and Herbert Masson provided hospitality and aid in the work which can never be fully repaid.

On the professional basis, I thank my committee members for their patience in what became a drawn out study. Also, Thomas R. Hester, Colha Project director (UTSA), helped me from the start. Jack D. Eaton, associate project director, provided valuable guidance. Janet Ann Stock, Daniel R. Potter, Fred Oglesby, Barton Kuntsler, and Gene Rainwater, to name a few, helped in the 1980 field excavation or laboratory processing related to this material. Artifact measurements were coded at Texas A&M with the aid of Ben Olive, Esther Crane, and Jane Hauschild. My wife took time from her own projects to draft some of the illustrations, while Roger Coleman did the flow charts. David L. Carlson (TAMU Archeological Research Lab.) provided substantial support in giving to me both flexible employment and crucial instruction in the use of computers. Finally, I thank David L. Dibble (UT Austin) for my first sustained exposure to archaeology.

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CHAPTER I

INTRODUCTION

> Open the door!
> I will not open it.
> Wherefore not?
> The knife is in the meat, and the drink is in the horn, and there is revelry in Arthur's hall; and none may enter therein but the son of a king of a privileged country, or a craftsman bringing his craft.
>
> from the Red Book of Hergest,
> 14th century Welsh Bardic manuscript

Introduction

This thesis concerns the investigation of an ancient Maya stone tool workshop deposit at the site of Colha in northern Belize. There is unprecedented evidence of stone tool manufacturing at the site. Maya people lived in this community and exploited abundant local chert resources as much as 2,500 years ago, but the workshop studied here is of the Late Classic period (ca. A.D. 700-900). The discrete location of production is a small platform arrangement (*plazuela*) .5 km southwest of Colha's monumental center. The word "Colha" is a modern psuedo-Maya name given to ruins along Rancho Creek in northern Belize. Field work for this thesis was conducted in the spring of 1980 chiefly under the auspices of The University of Texas at San Antonio.

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

The Problem

The aim of my thesis is to describe the technological processes behind this workshop's evidence _and_ to interpret some notions of the "craft specialist" behavior thought to be represented. Objectively, the study problem may be considered in three parts below.

Objective 1

Establishment of the archaeological context.

This includes a review of the regional setting, environment, culture and chronology, previous archaeological studies, and description of the fieldwork which provided the data. Chapters II and III address this goal.

Objective 2

Morphological description and technological explanation of the stone tool evidence.

The former must precede the later, which is the more important part of this objective. Chapter V accounts for this effort. Although context is important, my study here is primarily based on laboratory examination of the voluminous chipping debris collected. Stone tool manufacturing rather than utilization created the bulk of the artifacts. Several major classes of stone tools were produced at the workshop, and trajectories of reduction are traced via simple flow chart models. An estimation of tool production is offered.

Objective 3

Interpretation of the activities represented by the workshop evidence.

Craft specialization is studied here because this label of work behavior has often been applied to Colha workshops. It is the most logical avenue of investigation, and one in need of better understanding. A significant portion of my thesis (Chapter IV) was required to adequately portray the subject. The interpretation of craft specialization is completed in Chapter VI. Here certain predicates of craft specialization behavior are taken from Chapter IV for consideration in view of the descriptive evidence. Under the general proposition that craft specialization was present at the workshop, three predicates are considered:

1) The workshop functioned within a context of civilization or urbanism.
2) The flintknappers worked in a standardized manner to produce standardized tools (i.e. products),
3) The flintknappers were efficient in their manufacturing behavior.

I earlier hoped to use quantified attributes in formal hypothesis testing, but this could not be done for reasons explained in Chapter VII, the concluding statements. This final chapter continues the reconstruction of conjectured events at the Late Classic workshop, and various problems of analysis are identified.

The Status of Current Research

The study of ancient craft specialization has only recently become a popular topic of study for archaeologists. The same can be said for lithic technology, at least in Mesoamerica. The background for general archaeological studies in Mesoamerica and Belize which has influenced work at Colha is provided by Chapter II. As stated before, craft specialization is extensively examined in Chapter IV. A brief background of the study of lithic technology introduces Chapter V. To my knowledge, no Late Classic chert workshop like that to be described has been previously reported.

Research Method

Explanation of research method follows the three objectives listed above. First, the context of time, space, and material evidence is described from examination of field notes, published and unpublished information, and personal communications with various researchers.

Second, the technological analysis follows more documentary research, an examination of the collected material, and descriptive measurements. The SAS (1982) computer program is used as a descriptive aid here. Inferences based on these measurements and other information are used to reconstruct the technological system(s) once in effect.

Third, the interpretations of craft specialization are based on more documentary research (for defining the phenomenon), and comparison of behavioral statements to the technological data. Neither strict hypothesis testing or complex statistical tests are conducted (see Chapter VII).

Importance of the Work

The value of the following study is two-fold. First, descriptive information is provided that has not been previously reported in Mesoamerica. The technological information comes from a site that Don Crabtree, "dean" of American flintknappers, believed to be one of the most significant stone tool production localities in the world. Second, I have concentrated on examination of craft specialist behavior to portray the rudiments of this activity (and concept). I have not been able to formulate the technological information of the lithic collection into formal tests of craft specialization. Problems I identify with this effort may be the most important contribution of the thesis. Hopefully, these problems are discussed well enough to challenge future researchers to solve them.

CHAPTER II

REGIONAL, ARCHAEOLOGICAL, AND SITE BACKGROUND

> Mesoamerica ... "was largely self-defined, and to it participants it represented all the world they wished to care about." Blanton, Kowalewski, Feinman, and Appel 1981:245.

Introduction

This chapter provides a regional and cultural background which starts from general levels to end at the research site. Four areas of decreasing size are described: Mesoamerica, the Maya Lowlands, Northern Belize, and the site of Colha. The background of Northern Belize is examined in detail because it is a useful intermediate point of reference. Here a review of previous archaeological research is given.

Mesoamerica

Mesoamerica includes southern Mexico from its central highlands to the Yucatan peninsula, all of Guatemala, El Salvador, and Belize, and also parts of Honduras, Nicaragua and Costa Rica (Figure 1). Lehmann (1921), Kirchoff (1943), and Willey and others (1964) have defined the entity based largely on cultural traits such as linguistics and technology.

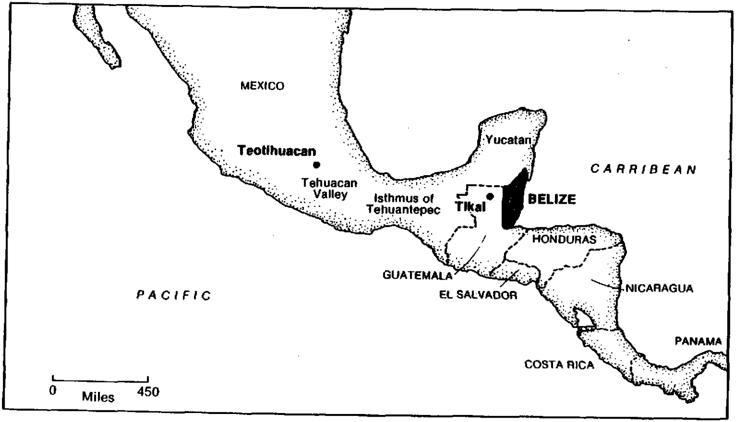


Figure 1. Regional map including Mesoamerica and Belize.

Environment

The area is characterized by compact physical diversity (Adams 1977a:11). Landforms range from the highland valleys of Mexico and Guatemala, separated by the constriction of the Isthmus of Tehuantepec, to the massive, flat plain of Yucatan (Figure 1). Coastal regions vary from firm sandy beaches to mangrove swamps. Three formal natural regions are: the drylands, tropical highlands, and tropical lowlands (West 1964a:365). Active volcanoes affect Mesoamericans today as in ancient times (Sheets 1979). Although most of the area is tropical, humidity and rainfall vary with local altitude and relief. Humid coastal plains and rain-forests are juxtaposed with cool alpine conditions. Mesoamerica is botanically complex. Many important food plants have a long history here: maize, cotton, chile, beans, cacao, squash, and avacodoes. Useful trees include mahogany, chicle, and the cieba. Terrestrial fauna is plentiful. Deer, rabbits, peccaries, monkeys, tapirs, cats, and oppossums are examples. Crocodiles, and various turtles, lizards, and snakes thrive in the lowlands. Birds are numerous and varied. Coastlines, lakes, and streams provide abundant aquatic resources. A compilation edited by West (1964b) details the natural background of Mesoamerica, and archaeologists frequently emphasize the physical resource base (cf. Harrison and Turner 1978).

Culture

More than anything, the people of Mesoamerica are what define the entity. This is true both for historic and ancient times. In opposition to areas northward, southward, and in the Caribbean, Mesoamerica exhibits (more so before European contact) distinctive kinds of agriculture, writing and numerics, linguistics, economic exchange, human sacrifice, social and religious organization, and technology (Kirchoff 1943; Weaver 1981:9-14). Millions of people in Mesoamerica at least partly retain these trends observed by the early Spaniards (Coe 1980:11). Distinctive aboriginal languages prevail in Mesoamerica, with two major divisions: the Uto-Aztecan strain generally north and west of the Isthmus of Tehuantepec, and the Macro-Maya language to the south and east (Wolf 1959).

It is a basic assumption that in ancient Mesoamerica, a complex set of social systems existed ranging from emerging chiefdoms to empire-states (cf. Blanton et al. 1981:246). Further, a major dichotomy in most groups had two social classes: the priviledged elite and the ruled masses. While this theme may be overemphasized in some research, archaeological evidence such as burial patterns and epigraphic information supports this notion. Regardless of particular circumstances, certain pan-Mesoamerican practices appear to have been mutually understood among the elite if not the majority of Mesoamericans: rank status and religious symbols, writing and calendrics, the ritual ball game, sacrifice, ancestor veneration, and funeral ritual (Blanton et al. 1981:247-248). The economic exhange of people, goods, and information in Mesoamerica was also largely controled by the elite. Prestige goods - often small, lightweight, and of rare materials - seem to have been moved the greatest distances (Blanton et al. 1981:248-249). Agricultural techniques, including systems of raised fields and canal irrigation, were sophisticated. The non-elite Mesoamericans were apparently well manipulated by their leaders. Great numbers of people provided the basic material goods and power (e.g. warriors) needed for the maintenance of society. No large "middle class" existed. A minority of "low level" elites were bureaucrats, traders, priests, cadres, and full-time craft specialists.

Chronology

Table 1 gives a broad chronological sequence for ancient Mesoamerica. Although this may be construed as a culture history scheme, it is better to consider its divisions as independent periods of time rather than stages (Rowe 1962). This chronology is refined for later discussions of the Maya Lowlands and Northern Belize. Archaic. The earliest Mesoamericans were probably hunter-gatherers who conducted a relatively flexible strategy of food collecting, scavenging, and incipient agricultural practices. There is very early, though meagre, evidence from the Basin of Mexico that human occupation is dated in Mesoamerica to about 19,000 B.C. (Tolstoy 1978:249). This is based on environmental data and a few radiocarbon samples. The Tehuacan Valley, Mexico, excavations of MacNeish (Byers 1967) are a landmark study that identified human utilization of maize at 5,000 B.C. Other Mexican cultigens are of similar or greater antiquity (Weaver 1981:Table 1).

Preclassic. Beginning at ca. 2,500 B.C. a period of sedentism known as the Preclassic (or Formative) initiated the pattern of culture that has come to distinguish Mesoamerica. Why and how this occurred is not well understood, but agricultural practices, social organization, and general population growth were likely causes. The Olmec culture of the Veracruz area is believed to be one of the earliest such groups to exhibit sophisticated technology and symbolism which evolved over numerous generations. More fully developed

Table 1. Chronological periods discussed for Mesoamerica, the Maya Lowlands, Northern Belize, and Colha.

GREGORIAN CALENDAR	MESOAMERICA	MAYA LOWLANDS AND NORTHERN BELIZE	PROVISIONAL CERAMIC COMPLEXES AT COLHA
	European Contact	European Contact	
ca. A.D. 1500			
	Postclassic	Late Postclassic	
		A.D. 1250	
		Early Postclassic	SAN ANTONIO
A.D. 900			
	Classic	Late Classic	MASSON (Op. 2007)
		A.D. 700-800	BOMBA
		Middle Classic	
		A.D. 400	COBWEB
		Early Classic	
A.D. 250			
	Preclassic	Late Preclassic	BLOSSOM BANK
		400 B.C.	CHIWA
		Middle Preclassic	BOLAY
		1000 B.C.	
		Early Preclassic	
2500 B.C.		2000 B.C.	
	Archaic	Archaic	

Preclassic times include: monumental structures, writing and calendar systems, elaborate burials for the elite, highly planned centers of at least temporarily great population densities, intensive agriculture, a hierarchical social structure, and refined artifacts such as well made pottery (Adams 1977b; Weaver 1981:66-84).

Classic. The Classic Period of Mesoamerican culture (ca. A.D. 250-900) is identified with a slight hiatus following the Preclassic, followed by an outstanding refinement and increase of material expression (Weaver 1981:185-189). The great Mexican city of Teotihuacan dominated much of Mesoamerica within this period. Archaeological evidence such as a halt in monument building and the razing of many sites indicates that this social system failed or underwent drastic changes about A.D. 900. Numerous theories have been offered to account for this collaspe (Culbert 1973). To name a few they include climatic change, warfare, environmental resource depletion, and religious fatalism. The material this thesis examines is from this terminal portion of Classic times.

Postclassic. The time after A.D. 900 until the arrival of the Spanish under Cortes at A.D. 1519 is termed the Postclassic. Militarism, which had origins at least as early as Classic times, was sustained or increased. This combined with what has been considered a "decadence" in artifact styles, and what may have been a relative breakdown in cohesion of broad social groups. As documented by the Spanish (Tozzer 1941), long distance economic relationships existed between people of what is now central Mexico and the Yucatan. For example, the island of Cozumel was an important maritime trading point for Postclassic Mesoamerica. This period might be summarized as a greatly modified continuity of Mesoamerican traditions still linked to Preclassic times. The Aztecs (Mexica) are one popular stereotype of Postclassic society.

The Maya Lowlands

The term Maya Lowlands pertains to an environmental and cultural zone within Meosamerica. It is centered on the low coastal plains - primarily the Yucatan peninsula - eastward of the continental divide in southern Mesoamerica. This is a major part of the Maya culture area, which extends to the mountainous areas of Chiapas and Guatemala, and the Pacific coast. I discuss the lowlands here because this broad area takes in the the Colha locality. The Maya people were (and are) a major cultural entity of Mesoamerica. Their language is most distinctive of the group. Most of the qualities earlier listed for Mesoamerica are (were) present, with finer distinctions indicative of the Maya.

Environment

The Maya Lowlands cover the entire Yucatan peninsula continuing south through the Peten of Guatemala, most of Belize, and western Honduras. The Lowlands consist of a massive sedimentary platform extending northeastward from the older metamorphic uplands. Of two important stone tool resources, chert infrequently outcrops from limestone in certain localities. The second, obsidian, must be imported from the adjacent highlands. Large areas of rainforest or scrub growth cover the lowlands. In general, the greatest rainfall (up to 180 cm) and most of the rivers and lakes are found in the southern Maya Lowlands: Tabasco, Chiapas, Peten, and Belize. Karstic topography is common elsewhere, especially in the northern part of the Yucatan peninsula. The land is flatest here and xerophytic plants are common. Low lying mangrove swamps are often found along the coasts of the Maya Lowlands.

Culture

The culture previously described for Mesoamerica generally portrays the Lowland Maya, but certain important differences exist. The basic language of the Maya is possibly the major distinction relative to other Mesoamericans. Adams and Culbert (1977:4-6) specifically list features which define the ancient Lowland Maya. Among the material evidence is: 1) cut-stone, mortar, and masonary architectural with the corbeled arch, 2) a generally 2-D art style with specific conventions, 3) art media that includes specific kinds of sculpture, murals, ceramics, and the like, 4) a writing and calendrical system that could be expressed as art, 5) elaborate burials for a minority of the people, 6) urban centers usually with certain patterns of courtyard groups and public art, and 7) the possibility that the preceding evidence could occur in any combination and on a small scale in areas away from the major urban centers (Adams and Culbert 1977:4-5). Functional, infered features include: 1) a hierarchical society ruled by hereditary elite whose supporters included numerous craft specialists, 2) social status which was legitimized through the use of temples, palaces, and ball courts, 3) urban density populations at some centers, 4) permanent high density rural populations at least in the Late Classic, and 5) political regions controled by kinship alliances (Adams and Culbert 1977:5-6). Sanders (1973:348) points out that the extremely elaborate emphasis on burial ritual may indicate that Maya temples were centers of ancestor cult worship rather than places of the "high gods" in the Mexican sense. There are minor physical differences that have been used to identify and sub-divide the modern Maya (Hammond 1982b:90-91). The Lowland Maya have never been overly isolated from highland people or coastal travelers. In fact, much of Lowland Maya society seems to have been affected at one time or another by outsiders. A prime example is the architectural and graphic evidence of Teotihuacan (Mexican) influence at Chichen Itza. No single urban center or cohesive group of Maya dominated the Maya Lowlands. There seem to have been "many socio-political systems in close juxtaposition (Blanton et al. 1981:177)."

Chronology

Table 1 gives a combined chronological scheme for the Maya Lowlands including Northern Belize, the sub-region of this thesis's focus. Developmental aspects are much the same as explained before for Mesoamerica. Here I briefly review the chronology as a way of highlighting major sites and events of the Lowland Maya past. Much of this discussion follows Hammond (1982b).

Archaic. The earliest evidence indicates aceramic, pre-agricultural people between ca. 9000 and 2000 B.C. in the Lowland area. This is based on survey findings of Richard MacNeish along the coast of Belize, and excavation in Loltun cave in Yucatan. In both cases stone tools and tool making debris constitute most of the artifacts. As yet there is no firm evidence to permit inference that these hunter-gatherers were (or were not) distinctly Maya.

Preclassic. The earliest identified Maya occupation is at ca. 2000 to 1000 B.C., the Early Preclassic. Excavations at Cuello in Northern Belize have recently established this early beginning for the Maya. Here over thirty radiocarbon samples were retrieved in good context with a series of architectural and midden deposits. The style of building, stone tools, and early pottery all indicate Maya trends. Also in these times, the earliest known jade artifacts were imported to the Lowlands. The Middle Preclassic period (ca. 1000-400 B.C.) is associated with a major new pottery form generally called Mamon and first defined at Uaxactun in the Peten. It is uniform, widespread, and soley utilitarian. Many Lowland sites of durable occupation had their beginnings in the Middle Preclassic: Tikal, Dzibilchaltun in the Yucatan, and Altar de Sacrificios at the Peten-Chiapas border. The first obsidian imports of much quantity are known from the early part of this period. Outside cultural influences include the Pacific coast area peoples and the Olmec of the Gulf coast. Olmec style artifacts and petroglyphs occur - though rarely - in the Maya Lowlands. The Late Preclassic (ca. 400 B.C.-A.D. 100) is again defined largely on the basis of ceramics, in particular a Uaxactun type called Chicanel which is even more widespread and numerous. A substantial human population increase is suggested by this material which is found at practically all sites. By this time specific ceremonial precincts are usually present, burials are elaborate, and sophisticated architecture exists at sites such as Tikal, Cerros, and Lamanai. This and other evidence supports the widely held agreement that the Maya had now achieved a complex level of civilization.

Classic. There is much similarity between the Late Preclassic and what is termed the Classic, although definite changes occurred. An example of what may have become a competitive social environment is the fortification of various sites in the Rio Bec area. The most important formal criteria is that of certain calendric inscriptions known as the Long Count. Based on fieldwork and analysis, correlation from Maya symbols often found on carved stelae indicates a span from about A.D. 250 to 900. Some Preclassic sites flourished into this period, while others did not. The Early and Late Classic divisions are derived from the same studies of Uaxactun pottery. The Middle Classic period was later suggested as an interim where Teotihuacan extended much influence on the Maya. For example, Teotihuacan-like architecture exists at Tikal from this time. In the Late Classic, the first major decline in Maya material culture began about A.D. 800, where various major ceremonial sites were abandoned and the stelae records became markedly less frequent. Within a hundred years these activities were largely non-existent, although some sites continued to be inhabited. The theories of this decline have been previously mentioned. The southern Maya Lowlands were most severely depleted, while northern Yucatan had less of a population decrease.

Postclassic. The halt of the Long Count and a dramatic change in pottery styles in part initiated Postclassic times, although as before, there was a cultural transition in other aspects. In the Early Postclassic (ca. A.D. 900-1250), the major site of Chichen Itza spans this change. A trend toward secularization and militarism is noted in this area, but trade also flourished. Northern Yucatecans began to migrate into the "vacated" southern Lowlands of the Peten and Northern Belize. The Late Postclassic (ca. A.D. 1250-contact) is associated with Mayapan, another site of northern Yucatan which came to replace Chichen Itza. Trading of a variety of goods continued, especially up and down the east coast of Yucatan. Cozumel Island is one outstanding example of a combination religious and trading center. As an arbitrary period, the Postclassic may be considered to end at Spanish contact. Ponce de Leon sighted Yucatan in 1513. Although the Spanish attempted to develop the Maya area, in reality the native culture persisted little changed for many years thereafter. The ineffective Catholic mission at Lamanai, not so far from Colha, is a good example of this. As late as the 1800s the Maya of Quintana Roo were quiet independent and belligerent to Europeans.

Northern Belize

Northern Belize is discussed below as a useful background interface between Mesoamerica and Colha. The environment, culture-chronology, and previous research is presented. The emphasis on previous research is because many recent studies have occurred here, and most sites are so near Colha that important connections likely existed in ancient times. As a sub-region of the Maya Lowlands, Northern Belize can be viewed in two ways. First, as part of Belize, it is a political area where fate has decreed that foreign (i.e. U.S.) archaeologists have been encouraged to turn their efforts. Second, it can be viewed as a contained physiographic area _if_ one wishes to view the Rio Hondo, Carribean, and Belize River as northern, eastern, and southern boundaries, respectively, with a western boundary arbitrarily cutting along the Peten of Guatemala (Figure 2). Southern Belize, with its mountains, higher rainfall, and other resources, could be justified as sufficiently different. At any rate, Northern Belize now connotes an immediate geographic and cultural meaning to many Lowland Maya researchers. It may come to be an areal concept much like what the Southwest is to North American archaeologists: an intensively studied region which has traditional boundaries (i.e. the U.S.-Mexican border along Arizona) not necessarily meaningful to the big picture.

Environment

Northern Belize is part of the southern Yucatan platform (West 1964a:7-73) where marine clastics and limestones make up a flat plain with a few sluggish rivers and both coastal and inland swamps (Rice 1974:12,26). The eastern flowing Belize River valley of central Belize is a convenient southern border for the area, while the Rio Hondo and Caribbean Sea respectively form northwestern and eastern boundaries. The region is roughly 97 km (60 miles) east-west and the same north-south.

Knowledge of geology is useful for understanding lithic evidence from sites of Northern Belize. This low shelf exhibits 250,000,000 years of landform evolution (Bushong 1961:8). While the Maya Mountains of southern Belize uplifted in the Paleozoic Era, Northern Belize was generally an inland sea (Rice 1974:10). A limestone cover was deposited upon the northern lowlands during the late Mesozoic Era (Flores 1952:409). This Cretaceous Period limestone remains in Northern Belize today, selectively eroded, exposed, or covered with thin

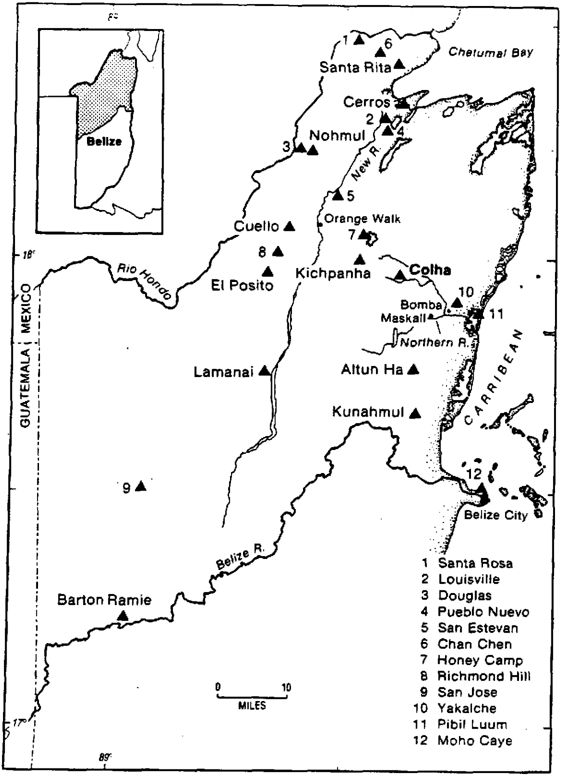


Figure 2. Archaeological sites in Northern Belize.

Pleistocene Epoch alluvial deposits. Rock forming processes originating in the Paleozoic have retained a notable northeast-southwest strike in their present outcrops (Rice 1974:11). These deposits are unevenly patterned (e.g. the above mentioned strike has deposits that may have affected settlement patterns). The limestone provided raw material for the Maya in the form of flint (or chert) for chipped stone artifacts and, limestone and marl for building purposes. In Belize, marl is a fine calcarous clay associated with the formation of limestone (cf. American Geological Institute 1976:269). Finally, a major barrier reef formation exists along the Belizean coast. This reef and cay network is the largest unbroken barrier reef in the Western Hemisphere (Atlas of Belize 1979:36), and it has protected both ancient and modern mariners.

Climate in Northern Belize is the tropical savanna type (Aw classification, Koeppen and Geiger 1930-1939). Wright and others (1959) classify it as lowland dry tropical with an annual range of 10^{o} to 35^{o} C temperature. Rainfall is generally about 178 cm (70 inches) per year, with a winter dry season between November and April (Atlas of Belize 1979:27). Two predominent wind patterns affect the climate: the Southeast Trades between February and September, and mild Northers from October through January (Rice 1974:7). Although Belize is west of the major hurricane tracks, such storms remain a serious threat especially in June and July (Wright et al. 1959:21). Another extreme is the "mauger" season in August, a period of dry, calm conditions "characterized by oppressive heat, still air, and life made miserable, night and day, by noxious insects (Setzekorn 1981:70)."

The flora and fauna of Northern Belize relate to a major environmental zone, the Dry Tropical classification of Wright and others (1959:28). Vegetation is complex but can be summarized as coastal swamps with extensive mangroves, inland swamps and marshes with grasses and trees such as cypress, and low pine ridges. The term "ridge" (i.e. Cohune Palm ridge) is often used colloquially in Belize to refer as much to a stand of trees as to a rise in elevation (Setzekorn 1981:73). A quasi-rain forest of variable make-up (see Wright et al. 1959) blends into the swamps and ridges (Rice 1974:17). Of several hundred species of deciduous hardwoods and softwoods which favor the soils associated with limestone, the more notable include Mahogony or Caobal (Swietenia macrophylla), the Zapote or Sapodilla (Acgras zopota), and the Chacah or Gumbo Limbo (Bursera smaruba). The later tree is useful because its inner bark sap provides the antidote to the poison tree, Chechem (Metopium brownii), and the two always grow in association. Of interest, Setzekorn (1981:73) incorrectly states Chechem to be "innocuous". A stately Ceiba tree (Ceiba pentandra), sacred to the ancient and modern Maya, remains at Colha. In deeper soils that permit a higher canopy and thicker growth, a remarkably dense hardwood known as Axmaster (Krugiodenror ferrum) tends to occur. Lignum vitae (Guaiacum sanctum) and iron wood (Dialium guianense) of similar density are found near Colha. Cohune, or Corozo, palms (Orbignya cohune) also occur along streams (Rice 1974:17). This tree has small edible nuts which can produce a useful oil (Cox 1979:140; Setzekorn 1981:74). The nuts are too difficult to process for large scale commercial efforts, but Maya are reported to extract the oil for cooking purposes (Bailey 1943:428).

For fauna, I again refer to the work of Wright and others (1959) where observations were made of many mammals, reptiles, fish, and fowls throughout Belize. Setzekorn (1981:75-83) gives a brief listing which includes animals that can be observed near the research site. This includes savannah deer (*Odocoileus truei*), crocodiles (*Crocodylus moreletii*), Tomigoff snakes (*Bothrops mummifer*, *Bothrops atrox*), iguanas, kinkajous (*Potos flavus*), the rare jaguar (*Felis onca*), and so on. Unfortunately, many animals in Belize are scarce due to hunting and land development.

Culture/Chronology

The ancient inhabitants of Belize are considered to have been Maya or Maya-related people whose culture fits within the earlier discussions of the Lowland Maya. Probably the most important aspect of cultural development in Belize is that we now know it displays evidence not only of the oldest identified settled existence in the Maya Lowlands (Hammond 1977), but for very early hunting and gathering lifeways. This is good progress in view that not many years ago most researchers thought Maya civilization originated in the highlands to the west and diffused into the lowlands (Hammond 1974:180). A re-itemization of the culture and chronology of Northern Belize would be redundant in view of the earlier discussions. Hammond (1982c) provides one appropriate synthesis for the area. Instead, a review of archaeological research in Northern Belize is offered below to elucidate significant studies and data. The studies are grouped into early and recent times of research.

Early Studies

In one span from the earliest research in Belize through about 1970, I will review archaeological research in Northern Belize. Among the earliest documented explorers of Belize are Patrick Walker and John Caddy (Pendergast 1967) and, inadvertently, John L. Stephens (1841). The latter, along with artist Frederick Catherwood, entered Belize in 1839 to head for Copan, Honduras, and eventually Palenque, Mexico. Their popular account of Incidents of Travel in Central America, Chiapas, and Yucatan continues to sell as re-issued originals. Walker and Caddy - Belize City's version of the duo - raced across the southern fringe of Northern Belize to beat Stephenson and Catherwood to Palenque. Their report, however, was unauthorized by English authorities. It was unpublished until recently (Pendergast 1967; Setzekorn 1981:161-165).

A most prolific investigator of Northern Belize from the late 1890s until about 1940 was Thomas W.F. Gann, a medical officer turned archaeologist by his fasination with Mayan culture and artifacts. His field notes and excavation strategies left a bit to be desired, and it sometimes seems to modern workers that every Maya mound in Northern Belize sustained his probes. But for his time, he was a relatively typical investigator who at least published most of his quests. The list of important Northern Belize sites that Gann excavated are Santa Rita (1900,1897-98,1918,1911, 1939), Pueblo Nuevo (Gann 1918), Nohmul (Gann and Gann 1939), Lamanai (Gann 1926), Honey Camp and Douglass (Gann 1911,1914-16), and others. These sites are distributed mainly north and west of Colha. Of special note, Santa Rita was an impressive site of over 30 mounds where important Postclassic frescoes were preserved on one building (Gann 1900; Rice 1974:104, 106-114).

Other work that took place in Northern Belize before 1970 includes that at San Jose (Thompson 1939), at Louisville (Haberland 1958), at San Estevan (Bullard 1965), in the Belize River valley (Willey et al. 1965), and at Altun Ha (Pendergast 1979). With the exception of Louisville, these sites are southern fringe locations within Northern Belize. These projects reflect the more modern approach in archaeology. For example, San Jose was favored for excavation because Thompson believed that the largest and most impressive sites were not necessarily representative of Maya society as a whole (Thompson 1939:9). Excavations at this modest-sized site of four mound groups permitted ceramic sequences to be constructed for Preclassic through Classic times (Thompson 1939:Fig. 38). Despite the site's local character, trade goods were abundant (Rice 1974:101). A growing sophistication was reflected by this orientation away from purely descriptive efforts.

At Louisville, between the New River and Rio Hondo, stucco relief heads and Preclassic pottery were recovered from burial mounds (Gann 1943:13-16; Haberland 1958:128-129). San Estevan is a small center - 19 mounds, three plazas, and a ball court - just east of the New River. Bullard (1965,1963) spent one season here to stratigraphically test several structures at one plaza. The ceramic chronology portrayed Preclassic to Late Classic times (Bullard 1965:Fig. 48), while the general site area is known to have abundant Postclassic remains (Rice 1974:118).

The Belize River valley work of Willey and others (1965) is along the southern periphery of Northern Belize. This was one of the first substantial settlement pattern surveys in Mesoamerica, with extensive work at the site of Barton Ramie. The context and function of Maya social patterns over a large area away from ceremonial centers was sought. The ceramic sequence established by this project has comparative use for Northern Belize.

Altun Ha is the major Classic period site of southern Northern Belize. Now a major tourist attraction, it was excavated from the mid 1960s until 1974 by David Pendergast (1969a,1971,1979). A number of impressive caches here included an alloyed gold bead and the largest single jade artifact known for the Maya: a sun god head (Kinich Ahau) weighing 4.4 kg (9.75 pounds). These items caused Mesoamerican archaeologists to reconsider the Maya Lowlands as a region of influence - not isolation (Rice 1974:104; Pendergast 1969).

Other sites of Northern Belize investigated before 1970 are described by Rice (1974:86,123-124). Among these, two more sites in the eastern Belize River valley deserve comment. One, New Boston, is a small site of stone tool manufacturing workshops (Gann 1911; Guthe 1922). The second, Moho Caye, was apparently a specialized location at the mouth of the river. It is believed that trade and maritime food processing but no sustained habitation took place here (Franks 1876; Gann 1911, 1925). Finally, I should mention that Thompson (1981:9) states Bullard (1960:363-364) documented the first identified lithic workshop in the Maya Lowlands at Santa Rosa, Belize. In fact, Gann had noted stone tool "factories" at sites like Kunahmul (Gann 1911,1918; Shafer and Hester 1983:532).

Recent Studies

After 1970, archaeological studies in Northern Belize greatly increased. As I earlier discussed, government policy encouraged this growth. General political stability in Belize has also been a factor. According to Marcus (1983), little changed in the design of fieldwork in Northern Belize until the 1970s. Research of interdisciplinary or ecological aims was seldom undertaken. Although it is pre-1970, the work of Willey and others (1965) in the Belize River valley might be an appropriate transition mark for the first highly improved investigations.

Two major archaeological projects of Northern Belize in the 1970s focused respectively on the site of Cerros, east of Corozal on Chetumal Bay, and at Cuello, near Orange Walk Town (Figure 2). Cerros is well known for its carefully studied architectural decoration on Late Preclassic pyramids (Freidel 1976,1977,1978, 1979,1981; Scarbrough et al. 1982). Long lipped and blunt snouted "dragons" typical of Lowland Maya convention were molded in stucco wall masks on one structure (Freidel 1981:207-223;1977). Major occupation in the Late Preclassic suggests it was an important regional site interpretated to have been part of an information and commodity exchange network (Freidel 1979). The work of Cliff (1982) and Garber (1981) are examples of recent dissertations to come from the Cerros Project. The former work examines functional implications of the site's settlement density, while the later provides a descriptive presentation of artifacts.

Cuello is an early Preclassic site located just west of the New River near Orange Walk Town. Important excavations took place in a portion of the site from 1978 to 1980 (Hammond 1978,1980) where the earliest securely dated evidence for recognizable Lowland Maya traits was retrieved (Hammond et al. 1976,1977a,1977b; Hammond and Miksicek 1981). Here a large flat structure with a small pyramid was associated with numerous radiocarbon samples. Associating these samples with distinctive artifact and building feature styles, a formal phase of the Early Preclassic is defined to begin at about 2,000 B.C. - a startling date in terms of previously known chronology (Hammond et al. 1976). Well made and distinctive pottery, imported luxury itmes and tools, and subsistence evidence related to both wild and cultivated plants were also documented for this early phase, the Swasey (Hammond et al 1979; Miksicek et al. 1981).

The site of Cuello was identified for testing during an important general survey, the Corozal Project (Hammond 1973, 1974, 1975, 1976a). The project examined and retested sites known from previous work in the area (e.g. San Estavan, Nohmul, Santa Rita, San Luis). New sites were also recorded including that of this thesis, Colha. It was believed at the time that Maya settlement density tended to increase in western Northern Belize. The Corozal Project surveyed the distribution, variety, and antiquity of sites with this problem in mind. The study of environmental factors was also stressed (Hammond 1974:180).

Concurrently, a more specialized survey which sought evidence of ancient raised fields and canals had begun to the west along the Rio Hondo (Puleston 1976,1977; Siemens 1974,1977). Important findings included pollen samples from ancient canals which indicated that cotton and maize were grown by the Maya (Puleston 1976:29). Also, a stone axe hafted in a wooden handle was retrieved from a waterlogged context (Puleston 1976:29). The axe was associated with cut wooden objects radiocarbon dated to 1110 B.C. +- 230, within the Preclassic Period. The examination of the intensive agricultural practices of the ancient Maya permitted new estimates on the character of ancient populations. Another direction for archaeology in Northern Belize had begun.

Work with similar aims to locate such features occurred several years later. R.E.W. Adams (1980; Adams et al. 1981) conducted a remote sensing study which covered the Peten and the northern part of Northern Belize. Ancient buildings, roads, and canals were identified by airborne modified synthetic aperture radar. A rank ordering and sizing of Maya sites was also aided by this inspection.

Artificial canals and raised fields were again an object of study by a major late 1970's project at Pulltrouser Swamp just north of Orange Walk Town. Extensive field work was directed to the agricultural features and associated habitation sites (Turner et al. 1980; Turner and Harrison 1981).

While the "earliest" Maya were being studied at Cuello, speculation also began that Northern Belize might disclose even earlier human evidence. The Richmond Hill site near Orange Walk Town consisted of controversial stone tools (or naturally chipped stone, depending on one's position) with no ceramic associations (Puleston 1975; Miller 1976). Other nonceramic sites were later located by Hester and others (1980) and MacNeish (1981,1982; MacNeish et al. 1980; MacNeish and Nelken-Turner 1983). Some of these sites, such as the Lowe Ranch site 20 miles northwest of Belize City, definitely appear as early affiliations of hunter-gatherer evidence which may date as much as 10,000 years in age (Hester et al. 1980; MacNeish 1981, 1982; MacNeish et al. 1980). A transition from these Archaic times to early Maya civilization has not yet been established in terms of field evidence or theory (cf. Marcus 1983:459).

Lamanai (Indian Church), a major site on the western edge of New River Lagoon about 40 km west of Altun Ha, has been the focus of 13 years of fieldwork since 1974 (Pendergast 1981, 1977, 1975; Lambert and Arnason 1978). One of the few sites in Northern Belize that probably has its true name - "submerged crocidile" - based on numerous motifs and linguistic affiliation, this site has the largest securely dated Preclassic structure in the Maya area (33 m height, Pendergast 1981:32,41). Much of the Classic period and all of the Postclassic is represented including occupation through the 1500s, when the Spanish built an isolated, ill-fated mission at the site (Pendergast 1981:29-31,51-52). As a river port of trade, Lamanai very likely had extensive cultural influence. This is thought to be shown by the presence of Late Preclassic architecture and building masks much like those of Cerros, and by Postclassic ceramic affiliations far north into Yucatan (Pendergast 1981:39,42,49).

A University of The Americas team excavated at El Pozito from 1974 to 1976 (Neivens and Libbey 1976:137; Hester and Hammond 1976:vi). El Pozito was found to have evidence of a strong Late Classic occupation (Neivens 1976), and an obsidian workshop area here is the first reported for Belize (Neivens and Libbey 1976).

Since 1979, a number of sites in Northern Belize have been recorded and tested by the Colha Project (cf. Hester 1979:3; Hester et al. 1980:4). Sites with lithic workshops or possible trading locations for stone tools were sought. The following review has much bearing on the site of Colha, which is later described.

Kichpanha (Kate's Lagoon) is a site 12 km northwest of Colha. It was previously surveyed by Hammond (1981a, b). Additional work here by the Colha Project (Kelly and Valdez 1979a; Kelly 1980) determined the site's area and chronology to be greater than previously believed (i.e. Preclassic through Postclassic evidence is now known). Because few stone tool workshops are identified at Kichpanha, it is believed that this was a major staging point for the distribution of stone tools made at nearby Colha (Gibson and Shafer 1982; Marcus 1983:477).

Several sites exist southeast of Colha near the Northern River's coastal outlet. Yakalche (Pendergast et al. 1968; Kelly 1980:51-56) is a small site about 12 km north of Bomba at the river. Although chert was used in structures, no stone tool workshops were observed, and the site is thought to have been a "way station" for the exchange of Colha products to the coast and beyond (Kelly 1980:55). Pendergast and others (1968) earlier had tested one structure at Yakalche to recover a probable ceremonial offering of 379 human teeth from a Postclassic context. A second site at the Northern River Lagoon on the coast was examined by Kelly and Valdez (1979a) and Kelly (1980). The Northern River Lagoon site (Pibil Luum, Kelly 1980:61) is a small but unusual site which may also have been an important trading location (Kelly 1980:65-61; Kelly and Valdez 1979). A dense ceramic deposit, well preserved faunal material, and a small amount of stone tools (including obsidian) were associated with an isolated structure and midden (Kelly 1980:56-61; Kelly 1982:89-92). Additional small sites were recorded near Bomba and south to Nago Bank (Kelly 1982:87-89). Further west on the Northern River, Gibson (1982a) tested a small mound near Maskall.

Substantial survey in the Altun Ha vicinity (Rockstone Pond) by the Colha Project identified a number of workshop mounds assumed to have serviced Altun Ha in the Classic (Kelly et al. 1979; Kelly 1980:61-63; Kelly 1982:94-95).

Kunahmul (alias New Boston or Canton Ranch) is a Late Classic site 6 km northeast of a sharp bend in the Belize River ca. 8.5 km from the coast. Besides Altun Ha, this is possibly the only other monumental center in this southeastern part of Northern Belize (Kelly 1982:96). Workshop mounds are present (Kelly 1979; 1980:64-65) and Taylor (1980) conducted excavations. Additional known Maya sites have been revisited by the Colha Project: Progresso, Honey Camp, and others (cf. Kelly 1980:66; Kelly 1982:92).

Of special note, Colha workers first documented some of the most important preceramic evidence in Belize. At the sites of the Lowe Ranch property, Sand Hill, and Ladyville (all south of Kunahmul and just north of the Belize River), distinctive projectile points, unifacial tools, large blades, and stone bowels were discovered (Hester et al. 1980b, Hester 1982a:39-41; Kelly 1982:95; Shafer et al. 1980). The Belize Archaic Archaeological Reconnaissance project has carried out further investigations at these and other preceramic sites throughout Belize (MacNeish et al. 1980; MacNeish 1981, 1982; MacNeish and Nelken-Turner 1983).

The Site of Colha

Introduction

Colha is located in east-central Northern Belize about 53 km north-northwest of Belize City and 24 km from the coast. It is shown as Rancho Creek at the old Northern Highway on many maps. Most of the site has long been owned by the congenial and archaeologically protective Masson family, who have cleared large portions of it for ranching. A recently booming hamlet, Santa Marta, now occupies the northwestern fringe of the site.

Colha is a modest archaeological ruin in terms of monumental structures: one ballcourt and 5 to 7 courtyards (Hammond 1973). However, the site has been recognized since the early 1970s for its numerous and massive stone tool workshop deposits (cf. Hammond 1982:66). My thesis examines material from one of the workshops of about 100 now known. Three well identified major periods of site activity and tool production are known at Colha: the Preclassic, the Late Classic, and the Early Postclassic. These periods are identified with provisional ceramic complexes (Table 1; Valdez and Adams 1982). About 3.5 km west of the site, a minor but perennial stream, Rancho Creek, originates. This stream bisects the archaeological site to join massive Cobweb Swamp, which forms an eastern site boundary. Although difficult to trace, Rancho Creek traverses this marshy region to meet Quashie Banner Creek, and thence the Northern River and Caribbean.

Previous Work at the Site

Because Colha is split by the Northern Highway (which is now bypassed with an improved route parallel to the west), it has been known to local inhabitants and travelers for years. Although Thomas Gann probably visited the site, Norman Hammond and the Corozal Project (Cambridge University-British Museum) began the first investigations. The site was recorded in 1973 (Hammond 1973), with surveying and mapping in that season and later (Hammond 1975). In 1976 the site was further examined and two structures were tested: an elevated walkway (sacbeob) and one lithic workshop deposit (Wilk 1973,1976a).

At this point, Hammond joined with Thomas Hester (UTSA) to organize a field symposium in Northern Belize in 1976. The purpose of this gathering was: "(1) to make an on-site inspection of Colha, to view the chert-working loci and vast exposure of workshop debris, and (2) to present a series of papers, followed by extensive discussion, in which the status of lithic research in the region could be assessed" (Hester and Hammond 1976:v). In essence, the 1976 symposium emphasized that research pertaining to the stone technology of the Maya was in a nascent but contributive stage, and that Colha deserved attention as "one of the most important lithic sites in the world" (Hester and Hammond 1976:vi, quote of Don E. Crabtree).

In the 1979 "dry" season, a major archaeological undertaking began at Colha. The Colha Project has been conducted under the auspices of The University of Texas at San Antonio, Center for Archaeological Research, with Thomas R. Hester as project director. In association with the Centro Studi e Richerche Ligabue (Venice) and Texas A&M University, the site was visited again in 1980, 1981, and 1983 (with more field work planned for 1984). Associate directors have included Jack D. Eaton (UTSA), Harry J. Shafer (TAMU), R.E.W. Adams (UTSA), Giancarlo Ligabue (Venice), and the late Robert F. Heizer (U. of California, Berkeley). Three interim reports presently constitute the major references for this fieldwork (Hester 1979; Hester et al. 1980c; Hester et al. 1982a). The reader is referred to these publications for information too lengthy to repeat here. The research designs from two of the reports have direct bearing on this thesis, and they are listed below.

The 1979 Field Season. Some of the most important findings, especially in terms of the lithic workshops, resulted from the first season of work at Colha. This interim report (Hester 1979) perhaps remains the best in terms of portraying what the project's essential goals and findings have involved. It consists of five summary papers, 12 excavation reports and special studies, and five survey reports.

The effective research design had objectives which guided efforts beyond the 1979 season:

> 1. test the lithic workshops for suspected qualitative differences and variability; 2. determine the temporal span of the workshops and evaluate the relative importance of lithic production at the site during various periods; 3. test a sampling strategy designed to handle the vast quantities of debitage from the workshops; 4. devise a classification and typological system to handle both debitage and lithic artifacts from the workshops and from other contexts at the site; 5. formulate substantive statements regarding craft specilization based on data from the workshop excavations; and 6. test other types of structures at the site, carry out ecological studies and conduct additonal site survey and mapping--all necessary components in our effort to provide an overall perspective from which to view the lighic production system(s) in cultural context [Hester et al. 1979:3].

Specifically, goals 1,2, and 5 above influenced the direction of fieldwork for my thesis in the following 1980 season.

The 1980 Field Season. The next season of work at Colha produced a report about 50% larger than the first (Hester et al. 1980). Included are four summary papers, 11 excavation reports, and 17 special studies and survey reports.

The research design was basically the same as before, with more specific goals in terms of work locations. The objectives were:

> 1) Excavation and testing of additional Preclassic, Classic and Postclassic workshops in order to increase our sample . . .; 2) Excavation in one, or possibly two, plazuela areas . . .; 3) Additional testing was necessary in the monumental center, . . .; 4) Survey and testing was needed [in] the 3000 and 4000 quadrants [southern part of the site] . . .; 5) Field surveys and limited testing were required in the Northern River Lagoon area, the Maskall and Bomba area, the Canton Farm area, the lithic workshops area near Altun Ha and the Kate's Lagoon (Kichpanha) area . . . [Hester 1980:3-4].

The work of my thesis was conducted under objectives 1 and 2 here. Because the fieldwork has been documented (Roemer 1980) and a fuller description is offered in Chapter III, here I will only comment on a few aspects of this Late Classic workshop. Operation 2007 refers to excavations that concentrated at a small, unimposing plazuela about a half kilometer south of the monumental center. Aguadas (water holes) are nearby east and west of the mound. One sizable plaza unit (untested) exists just south of Operation 2007, while a Preclassic workshop deposit (Op. 2006) and a Classic period plaza (Op. 2008) are about 100 m to the east. The initial importnce of Operation 2007 was in: 1) the nature of the lithic midden, which contained impressive Late Classic core-blade technology and 2) the workshop deposit's association with an elevated platform. At the time of discovery, these findings were unique for Colha. Now, two other similar situations are known (Ops. 3017,4026).

Besides the interim reports, two sources are recommended for detailed overviews of the known cultural sequence and traits of Colha. Both are already slightly out of date. The first is a survey of lithic evidence in Northern Belize (Hester 1982a), where most of the data cited is from Colha. The second source is an article which again unites information from Colha and the region (Shafer and Hester 1983).

Cultural Summary of Colha

Chronology. Colha is recognized to have three major periods of occupation: (1) the Middle to Late Preclassic (ca. 900 B.C.-A.D. 250 [Hester et al. 1983]), (2) the Late Classic (ca. A.D. 600-850 [Shafer and Hester 1983:521]), and (3) the Early Postclassic (ca. A.D. 850-1250 [Shafer and Hester 1983:531]). Evidence from other time periods exists but is poorly represented (cf. Hester 1982a:50, the Late Postclassic; Hester 1982a:47-48; Hammond 1982:68-69, the Early Classic). Chronological control has come from the association of numerous radio-carbon samples (Hester 1980b), distinctive regional ceramic types (Shafer and Hester 1983:519-520; Adams and Valdez 1980), building styles (Eaton 1982), and stratigraphic interpretations.

The Preclassic at Colha has recently been discussed by Hester and others (1983). Three chronological segments are identified: two of the Middle Preclassic (ca. 900-300 B.C.), and one of the Late Preclassic (ca. 300 B.C.-A.D. 250). The earlier Preclassic times at Colha are represented by domestic debris, features, and human burials in what later became the monumental area. The Bolay and Chiwa ceramic complexes (including Mamom) at Colha pertain to the Early or Middle Preclassic, while Blossom Bank ceramics (Chicanel) indicate the Late Preclassic (Valdez and Adams 1982:21-22). A small early village without a highly developed social structure is suggested (Hester et al. 1983:1-6). I believe three environmental factors especially attracted the Maya to settle at Colha in the Preclassic. Local chert resources are plentiful even after more than 2,000 years of exploitation. The presence of Rancho Creek was surely a consideration for potable water, transportation, and aquatic resources. Last, the site is located at an ecotone between a large marsh complex and better drained land. An increased variety of plants and animals were available because of this. Modification of the marsh for intensive agriculture may have occurred. Remote sensing studies (Adams et al. 1981) were conducted north of but missing the area. Although perhaps largely autonomous, Colha shows evidence of long distance trade relationships at this time (Hester et al. 1983:4). It is in the Late Preclassic that population growth and developement of civic and religious behavior is associated with monumental buildings and the great quantities of stone tool production waste (Hester et al. 1983:8-12; Eaton 1982:12). Craft specialization and the massive stone tool industry at Colha appear fully developed by the Late Preclassic (Shafer and Hester 1983). This might have surprised earlier Mayanists who associated craft specialization with the Late Classic (cf. Kidder 1950).

The Late Classic at Colha is known from final building modifications in the monumental center and a number of plaza groups and lithic workshops. The ceramic affiliation (Tepeu 3) for this time at Colha has been designated the Masson complex (Valdez and Adams 1982:27). Stone tool manufacturing had continuity from the Preclassic but it changed somewhat and stabilized or even decreased in production quantity (Shafer and Hester 1983:529-531). The monumental center retained its basic size (i.e. number of courtyards) of Preclassic times (Eaton 1982). This is a significant indication of maintenance rather than growth, and it is possible that the town's focus on stone tool manufacturing did not require substantial non-secular activities (Hammond 1982:68). There is also the viable suggestion that Colha came under the influence of Altun Ha, the major elite Late Classic site of southern Northern Belize (Shafer and Hester 1983; Hammond 1982:69). Extensive destruction and re-use of Classic period building material is typical of Colha (Eaton 1982a:13-14). This makes my interpretations difficult. Late Classic occupation at the site was ended by what is thought to have been the violent overthrow of the resident elite, as depicted by 28 to 30 decapitated human heads associated with terminal Classic vessels in a pit (Hester 1980:6; Steele et al. 1980). Bellicose invaders from the north possibly conducted this destruction (Hester et al. 1982:8).

The Early Postclassic is shown at Colha by both domestic middens (cf. Taylor 1980b), and workshops (cf. Shafer 1979). The formal ceramic complex is known as San Antonio (Valdez and Adams 1982:28). An unmistakable shift takes place in the evidence, including the stone tool industry (Hester 1982:49-50). In general, the Postclassic occupation was much reduced in size. Relatively superficial re-use was made of the older structures (Eaton 1982:14). There is the possibility that Yucatecan people lived at Colha during the Postclassic (Hammond 1982:69-70).

The Lithic Industries. The massive production of stone tools spanned a solid 1500 years at Colha. In that time, an intriguing blend of consistency and change occurred. The stone production evidence appears to favor the overall theme of continuity with subtle transitions, despite a contrast between the terminal Classic and Postclassic technologies. Although symbolic stone artifacts (eccentrics) were produced, the majority of effort and organization was apparently directed to stone tool manufacturing for the massive production of practical tools: axes, hoes, cutting or penentrating instruments, and so on. The best summary for the lithic industries of Colha again comes from Shafer and Hester (1983). Below I will comment on the nature of production and the kinds of artifacts made during each of the three distinct occupations of the site.

Preclassic stone tool manufacturing at Colha involves the earliest known efforts from the Middle Preclassic, where massive production and regional distribution was probably not stressed (Hester et al. 1983). However, these same traits were fully developed in Late Preclassic times (Shafer and Hester 1983:524-529). The Middle Preclassic tools are small oval bifaces - possibly used as axes, T-shaped bifaces - probably adzes, thick unifaces - possible scraping tools, and macroblades - large specialized flakes which often provided burin spalls, the detached slivers of macroblade cutting edges suitable for use as perforating tools. These burin spalls have been associated with shell bead making evidence at Operation 2012 (Potter 1980:180; Hester et al. 1983:6). Late Preclassic tools are of three classes: large oval bifaces, tranchet-bit tools, and macroblade tools. Both the large oval bifaces and tranchet-bit tools were produced by the hundreds of thousands (Shafer and Hester 1983). Based on studies in consumer areas (Shafer 1980), the oval bifaces were probably used as axes and mattocks. Puleston's (1976) hafted specimen is most similar to Preclassic Colha specimens. The tranchet bit tools were oval bifaces that had a special transverse flake removed at the wide end to produce a useful single faceted bit edge. The tranchet waste flakes, which are basically curved blades with prepared ridges, provide a basis for estimating the production numbers of tranchet bit tools (cf. Shafer and Oglesby 1980). Hester (1982b:4) gives one estimate that over 2,000,000 tranchet bit tools were produced during the Late Preclassic at Colha. Both oval bifaces and tranchet bit tools were made from macroflake blanks (huge flakes ca. 200-300 mm long), whose procurement origin is obscure (Hester and Shafer 1983:521-522,538). Macroblade tools are large blades (specialized flakes) from 150 to 300 mm long which were often made into stemmed "daggers". These implements and the rare biface eccentrics were sometimes placed in symbolic caches (Shafer and Hester 1983:524,535). The actual production evidence of macroblades is also generally scarce (Hester and Shafer 1983:529). Of interest, in 1983 Daniel Potter (Op. 2012) discovered two macroblades and a matching core in a ritual context. In sum, at least 32 workshops at Colha have been identified as Preclassic (Shafer and Hester 1983:524). Seven Late Preclassic workshops have been tested (Ops. 1001,2002,2006,2024,2032,4001,and 4030). These deposits, up to 350 m^2 in area and 1.75 m deep (Shafer and Hester 1983:524), are basically Late Preclassic although small amounts of Middle Preclassic debris may be present.

The Late Classic production of stone tools at Colha shows continuity from Preclassic times with some change in forms and decrease in output (Shafer and Hester 1983:529). This is the contex of my thesis's data. The three major tool forms of the Preclassic (large oval bifaces, tranchet bit tools, and macroblades) are found with some changes not yet well documented (Shafer and Hester 1983:52). For example, Late Classic oval bifaces are somewhat smaller, tranchet bit tools may be of diagnostic dimensions and finish, macroblades are rare, and so on. One definite new trend was the massive production of smaller blades which I describe in Chapter V (cf. Shafer and Hester 1983:529-531). is this Many of these blades were modified into stemmed projectile tools, although unmodified specimens were also potential tools (Shafer and Hester 1983:531). Another distinctive Late Classic tool at Colha is the so called "general utility biface" (Hester 1982:49; cf. Kidder 1947; Bullard and Bullard 1965:Figure 13a,b). This is a thick biface with a distinctive truncated end opposite a well finished bit end (Shafer and Hester 1983:530-531). At least 17 Late Classic workshop deposits have been found at Colha. Some of these are debitage mounds similar to the Preclassic deposits, while others are talus deposits associated with structures (Shafer and Hester 1983:529). Five Late Classic debitage locations have been tested (Ops. 1001, 2007 [this thesis], 3017, 4026, 4029).

The Early Postclassic at Colha has a complete break with the previous traditions of lithic technology (Hester 1982a:52). First, a different technique of percussion manufacturing was employed: use of the "soft hammer" technique. Second, the raw material was often chalcedony, a type of stone more plentiful at a distance from Colha (near Kichpanha, for example). Third, workshop debitage often was mixed with greater amounts of domestic garbage (Shafer and Hester 1983:531). Two temporal divisions for tools are seen within the Early Postclassic (Hester 1982a:49). The "early facet" assemblage consists of side notched projectile points (ca. 80 mm long), triangular bifaces assumed to be preforms for these points, and plano-convex triangular bifaces possibly used as adzes (Hester 1982a:50; Shafer

1979:35-41). Small deer antler tools used in flintknapping are often recovered in the "early facet" deposits (Hester 1982a:50). It is impressive that no large oval bifaces or blades were produced at Colha in the Postclassic. Of 12 identified Postclassic debitage and/or domestic middens at the site, four have been tested (Ops. 2001, 2003, 2010, and 2032).

Regional Perspective. Colha, like any other Mesoamerican community, cannot be viewed as an isolated site (cf. Weaver 1981:513-517). This is especially so in view of the lithic industry which produced enormous amounts of what were probably forestry/farming tools (the oval bifaces, etc.). The knowledge of exchange depicted by the production evidence at the site and indications of consumption in outlying areas may come to be one of the major benefits of the research at Colha. The best current documentation of the consumption and recycling of Colha tools is that of Shafer (1983). This kind of information should compliment established models such as the "interaction sphere" concept used for Cerros (Freidel 1979).

Massive distribution of lithic products began at Colha in the Late Preclassic (Shafer and Hester 1983:538). In Northern Belize, the sites of Cuello, Cerros, K'axob, Tilbaat, Kichpanha, and Nohmul all probably recieved Colha tools (Shafer and Hester 1983:538). Hester (1982a:47) suggests that Late Preclassic Colha-made tools possibly were distributed throughout Northern Belize and into the Peten. The secular eccentrics may have been distributed in a seperate exchange system, but in all cases Colha is assumed to have governed its own distribution systems (Shafer and Hester 1983:538). Poorly understood but viable transportation routes for lithic products include inland routes such as one via Kichpanha (Gibson and Shafer 1982), and the Rancho Creek-Northern River connection to the Caribbean and back inland, for example, to the Belize River (Hammond 1982a:68; Kelly and Valdez 1979a:169).

It has been suggested that although the major production of lithic artifacts continued at Colha in the Late Classic, the administration for distribution (i.e. redistribution) was located at Altun Ha ca. 25 km to the south (Shafer 1981). This is based on a decrease of workshops at Colha, scattered Late Classic workshops between Colha and Altun Ha, certain luxury goods known from Altun Ha, and an assumption that it was a regionally dominant site for these times (see also Hammond 1982a:69; Shafer and Hester 1983:540). The consumer area for Colha's Late Classic stone artifacts is poorly known, but claimed to be about the same as that for earlier times (Shafer and Hester 1983:537,541; Hester 1982a:49; Hammond 1982a:69).

The distribution of Early Postclassic Colha stone tools is also not well understood. This is due, in part, to a comparative paucity of Postclassic evidence at the site (Hammond 1982a:70). Also, if chalcedony was being imported to the site for reduction, this complicates the issue (Hester 1982:49). The system of Postclassic lithic production was apparently more informal than before (Shafer and Hester 1983:537), and this theme possibly carried over in distribution practices. Postclassic stone artifacts at Lamanai include types identical to those of Colha (Shafer and Hester 1983:538).

Conclusion

Colha is an important site for at least three major reasons. First, the sheer quantity of lithic artifacts and waste debris is unprecedented in Mesoamerica. Close analysis of this lithic material has not only improved knowledge of lithic technology but lead to the use of certain classes of Colha stone artifacts as horizon markers in establishing the chronologies of other sites (Hester 1982a:52; Hammond 1982a:70).

Second, the great amounts of lithic evidence add to our knowledge and understanding of craft specialization in Mesoamerica. With the durability of lithic evidence and the "industrial" quantities of it, Colha is generally regarded as an excellent example of large scale Maya craft specialization (Shafer and Hester 1983:539). The routine time flintknappers spent at production is not known but the process appears to have continued for generations (Shafer and Hester 1983:538). Stoneworking may have been conducted either on a part-time, seasonal, or full-time basis. Important complimentary crafts may have existed there but left no archaeological evidence. Shell-bead manufacturing has been noted at Colha (Hester 1982a:46), and ceramicists, weavers, woodworkers, and masons are only a few of the kinds of craft specialists possibly once also present.

Third, studies at Colha help explain the economic infrastructure of the ancient Maya. Massive quantities of stone tools were produced for what were surely the practical needs of a society greater than the modest population represented at Colha. Farming or other plant and land modification tasks were probably the most common activities of consumption, although on occasion stone tools were used in ceremonial contexts. As shown by work at nearby Pulltrouser Swamp, the area around

Colha can be chert-poor, and some manner of distribution or trade of Colha tools was in effect. In turn, Eaton (1982:17) points out that the Colha community likely imported foodstuffs.

CHAPTER III

CONTEXT OF FIELDWORK AND COLLECTION

> Readers of George Orwell's 1984 will recall the passage where O'Brien, the revolutionary leader, is about to offer a toast. "What shall it be?" he asks. "To the confusion of the Thought Police? To the death of Big Brother? To humanity? To the future?" "To the past," says the book's hero, Winston. And O'Brien agrees: "The past is more important." <u>Houston Chronicle</u> editorial, 1/22/84.

Introduction

The general nature and setting of the material under study is explained below. Discussion of stone tool manufacturing evidence is greatly expanded in Chapter V. Combined, this descriptive information is required for the interpretations of Chapter VI.

The data context relates primarily to a description of excavation at one small location within Colha. Discussed are: 1) the research design that prompted the work, 2) a description of the test area before excavation, 3) the field methods, 4) the sequence of excavations, 5) a summary of the architecture and non-lithic material, and 6) a summary of the initial interpretations made shortly after the fieldwork was completed.

Research Design

The research design used at Colha in 1979 largely directed the field work which produced this thesis's data in 1980. This plan is summarized below in terms of six goals derived from more extensive statements (Hester et al. 1979; Shafer and Hester 1979; see also Chapter

II). The goals were to:

> 1. test the lithic workshops for suspected qualitative differences and variablility;
> 2. determine the temporal span of the workshops and evaluate the relative importance of lithic production at the site during various periods;
> 3. test a sampling strategy designed to handle the vast quantities of debitage from the workshops;
> 4. devise a classification and typological system to handle both debitage and lithic artifacts from the workshops and from other contexts at the site;
> 5. formulate substantive statements regarding craft specialization based on data from the workshop excavations; and
> 6. test other types of structures at the site, carry out ecological studies and conduct additional site survey and mapping--all necessary components in our effort to provide an overall perspective from which to view the lithic production system(s) in cultural context. (Hester 1979:3).

The first, second, and fifth goals especially pertain to my thesis.

In 1980, more specific research objectives were stated to fit within the earlier goals. These objectives dealt mainly with work proposed at certain regional and site areas (Hester et al. 1980a:3-4). One objective which was temporally rather than spatially restrictive suited the recovery of the Classic period material under study:

> Excavation and testing of additional Preclassic, Classic, and Postclassic workshops in order to increase our sample (especially in the Classic) so that we could refine our data on typology and on craft specialization within the lithic production system; (Hester et al. 1980a:3).

The formal Colha research design of 1979 to 1980 might be characterized as a diversified, general framework with emphasis on lithic technology. The initial research situation was exploratory due to unique aspects of the site's character.

The workshop deposit which came to be tested was selected by the project directors Hester, Eaton, and Shafer. Dense chert blade manufacturing debris was visible upon the mound's surface. This material was not yet well known at the site. The directors also guided the placement of excavation units described below.

The Test Area Prior to Excavation

The regional and general site setting for the work area is described in Chapter II. The precise area of field work related to an eroded artificial platform about 20 m in diameter and 1.5 m above the natural ground surface. It was situated in a cultivated field approximately 450 m southwest of the monumental center, and 250 m east-northeast of the modern highway. Substantial aguadas were located roughly east and west of the mound. Significant larger mound arrangements were located 100 to 150 m east and south. One was the place of Operations 2006 and 2008 (Roemer 1979; Escobedo 1980a). The study mound itself was unimpressive in size and not readily distinguished from hundreds of others at Colha. Subtle rises upon the mound indicated remnants of upper platforms (Figure 3). Besides rubble and recent soil development, tree root depressions and areas of dense lithic manufacturing debris were visible. The lithic debitage was particularily concentrated in two areas along the northern part of the major mound. The upper platform rises were located in the southern mound area. As previously discussed, the original reason for testing here pertained to the character of the lithic debris, and the northeastern area of the mound was selected for subsurface inspection of the debitage.

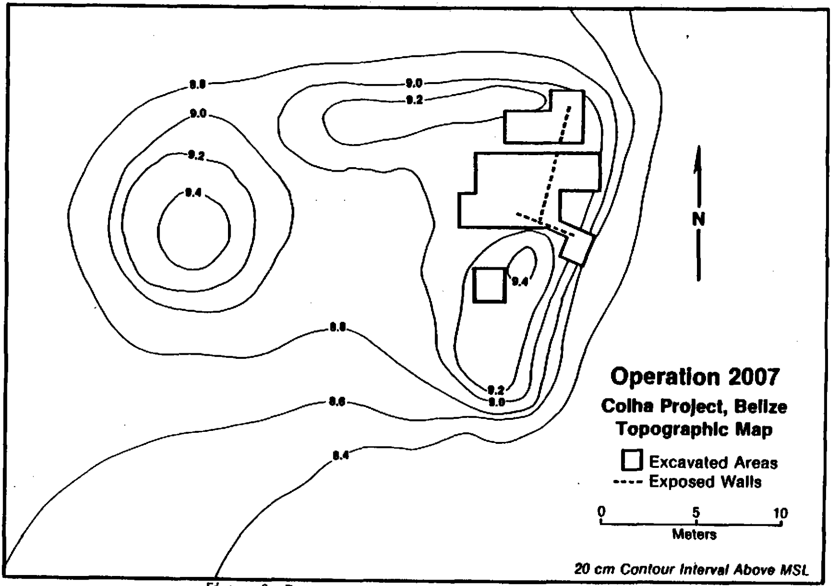


Figure 3. Topographic map for the Op. 2007 plazuela.

Field Methods

Because of the nature of the workshop deposits, techniques of excavation and recording used were a blend of traditional and improvised archaeological techniques. Most of the field work occurred between January 19 and March 3, 1980. Generally, two archaeologists and one laborer worked five and a half days per week.

The mound area was designated Operaton 2007, which labeled this as the seventh major excavation located in the northeastern quadrant of Colha's mapping grid (the "2000" sector). Discrete work units of varying configurations within the Op. 2007 limits were numbered as suboperations (Sub-ops.).

The suboperations were generally gridded 2x2 m areas, until later excavations followed irregular outlines to expose architecture. The majority of units also were aligned to cardinal directions via magnetic compass. The prime datum stake for areal control was located at site coordinates W 458, S 436. This is a reference point from the main site datum in the monumental center.

Elevation at the Op. 2007 datum stake was 9.1 m above mean sea level. Measurements below surface were made using the line level technique running from the highest unit corner stakes which had their position noted in respect to W 458, S 436. Excavation levels were recorded in centimeters negative to those same unit corner stakes.

When testing debitage, excavation was performed in 20 cm arbitrary levels. Stratigraphic breaks such as floors or basal clay also provided unit level boundaries. Standard record forms were completed for each suboperation's level (on file, UTSA).

Because soil content was minimal in the lithic debitage, artifacts were collected within the 20 cm levels by use of a field sorting table. Debitage was shoveled upon the table and sorted through by trowel and hand action (Figure 4). Mesh screening was infrequently used when soil was present such as in rubble mixtures or beginning and ending unit depths. Two persons usually table sorted as another excavated. Collected material included ceramics, shell, obsidian, hammerstones, groundstone, and what might be called the "parent/product" artifacts of chipped stone: cores, bifaces, and chert blades of any discernable form. Other waste flakes (i.e. biface thinning flakes) and unaltered rubble was not collected. To achieve complete debitage sampling, column samples were removed in 20x20x20 cm cubes corressponding to the arbitrary levels. This was done using two tic-marked vertical strings set parallel 20 cm apart. A woodstove type scooping tool worked best for removing the debitage. The fragile debitage also necessitated tapering excavation walls at about 75^0 to avoid collapse from work vibrations and changing moisture.

Other more traditional field techniques were completed involving sketches of completed unit profiles, the construction of a 20 cm interval contour map using a plane table and alidade (Figure 3), and photography.

All collected artifacts, except the column samples, were cleaned and labeled at the field laboratory. As other units were excavated in the course of exposing architecture of the plazuela, a total collection of nearly 300 bifaces (mainly fragments), over 100 blade cores, ca. 20 hammerstones, 114 stemmed blades, thousands of unmodified chert blades, a small number of pecked and ground stone fragments, and other artifacts were returned to Texas (estimated weight 1,000 kg).

Figure 4. View north of first work at Sub-op. 1, table-sorting.

Figure 5. View north of debitage (Sub-op. 1, right) and platform edge.

Excavations

Prior to excavation, surface collection was made of some artifacts such as blade cores, bifaces, a matate fragment, several obsidian blade fragments, and hammerstones. Observed disturbance in the area included recent bush burning, plowing, and palm tree root holes (often as much as 40 cm deep and wide).

Subop. 1 designated the initial 2x2 m test unit. It was placed high on the mound's eastern slope to sample a clear deposit of lithic debitage. The excavation revealed more than a meter's depth of relatively homogeneous lithic manufacturing debris. Artifacts which came to be commonly seen throughout later work were contained in this debitage deposit, which ended in Level 7 at a depth of 136 cm below the northwest corner datum. The artifacts included a large number of flakes, unmodified and modified blades, blade cores, bifaces, a small number of tranchet flakes, chert hammerstones, a small number of mollusc shells, and Late Classic period ceramics. Only a few bone fragments were noted. At the base of the debitage a mixture of marl, lithic debitage, and stone rubble existed, and this extended to a depth of 166 cm. Artifacts continued to occur within a marl and marl-clay martix until sterile marl was exposed at 182 cm. Testing ended at about 215 cm depth. Flake contours within the massive debitage deposit slanted downward to the east. This was later seen to indicate "spill" from a higher platform area, which was revealed here during retrieval of a column sample from the unit's western wall. As that area of debitage collasped and was trimmed back, the vertical face of a stone laid retaining wall (Wall 1, Figure 5) was exposed. It rested on basal clay which was slightly elevated above the a marl-artifact mixture of the excavation unit. This indicated that the Maya had performed minor excavations at the base of the retaining wall.

Subop. 2 was a 2x2 m test unit laid out upon the upper mound 5 m southwest of Subop. 1. It was hoped that a test here might provide architectural or other cultural information complimentary to the manufacturing debris. This testing encountered architectural rubble involving a complex series of structural fills. Most of the artifacts collected from this excavation were contained in rubble fill, which often was about 50% of the volume of any level. No large quantities or concentrations of lithic debitage were found. Profiles revealed the following: 1) in the southern profile a marl zone which was 10 cmn thick at 45 cm depth, 2) a zone of loosely packed, small rubble, mainly in the eastern profile at 50 to 110 cm, and 3) larger rubble in the western and northern profiles. Excavation stopped at a sterile, undulating marl surface.

Subop. 3 was a 2x2 m unit placed on the western side of Subop. 1. Wall 1 (Figures 6,7) was determined to be a lower retaining wall for a raised platform now oriented at 20° magnetically east of north. Floor 1 above this was a relatively soft marl-plaster surface (Figures 6,7). Concealed behind the retaining wall, debitage supported this flooring. A single layer stone alignment designated Wall 2 (Figure 7) laid upon Floor 1 and retained more debitage which had been scattered over Floor 1. At the upper level of Wall 2 over this thin layer of debris was another floor with a very hard lime-plaster surface which we labeled Floor 2 (Figure 7).

Subop. 4 continued the exposure of Wall 2 and Floor 2 in the form of a unit 2x2 m west of Subop. 3. This

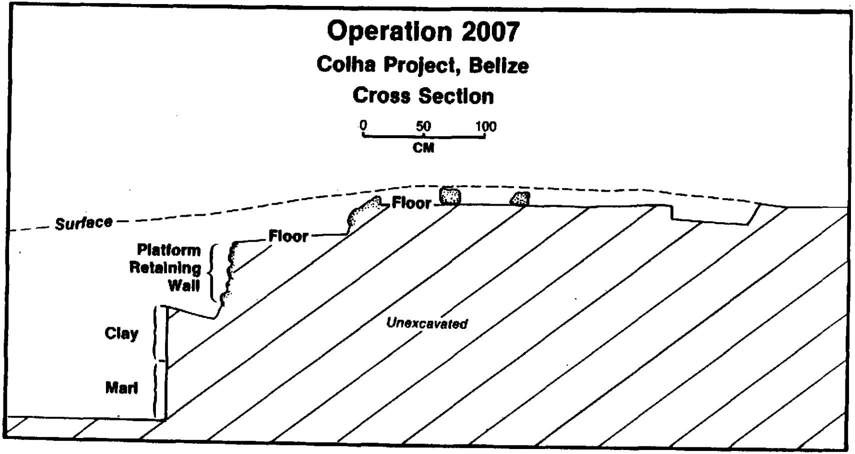


Figure 6. Cross section of excavations across platform (Floor 2 higher than Floor 1).

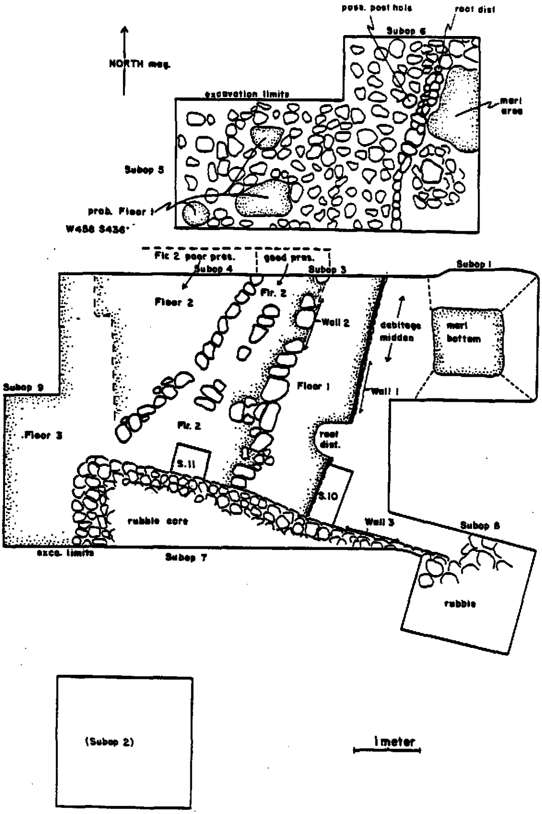


Figure 7. Plan of excavation at Op. 2007.

excavation revealed that the preservation of Floor 2 was poor and vaguely discernable in that area.

Subops. 5 and 6 expanded shallow excavations to the north, exposing more of Wall 1 and Floors 1 and 2. Floor preservation worsened, partly due to the downward contour of the mounds in that area. The northern limits of Subop. 6 were adjacent to the recently cultivated field. The debitage midden followed Wall 1 northward while diminishing in depth.

Subop. 7 was a 2.5 m extension to the south from Subops. 3 and 4, toward the upper mound of Subop. 2. This followed the projection of Walls 1 and 2 and Floors 1 and 2. Wall 3 was detected, rising about 25 cm above the floors and at a right angle to the former walls. This was where the distinct rise in the Subop. 2 area began. Wall 3 (Figure 7) was constructed of limestone and soft marlstone. Stone rubble and lithic tools and debitage continued through this testing. The debitage midden extended along Wall 1 to end at Wall 3 in a strip at least 1 m wide.

Subop. 8 was a trench that permitted Wall 3 to be traced to the east. A distinct corner for this structure was not found. Surface erosion probably was reponsible for this.

Subop. 9 related to exposure of the area along the western side of Subop. 7 where a corner for Wall 3 was recorded. Floor 2 became very deteriorated in the western area of the excavations. However, floor plaster recorded as Floor 3 existed in the westernmost unit area. This was at what might be the courtyard area of the plazuela. The plaster was about 20 cm lower than the general elevation of Floor 2, and 10 cm higher than Floor 1. It is also possible this was an extension of Floor 1, emerging from under Floor 2. Or, it may have

have been an eroded remnant of Floor 2.

Subop. 10 was a small excavation along the face of Wall 3. The bases of Walls 1 and 3 were identified here. The face of Wall 1 was 40 cm high at this point and rested on gray clay 65 cm below the surface.

Subop. 11, a test into Floor 2, was dug along the face of Wall 3. The small test revealed the debitage fill of the platform's interior. Floor 2 here was 7 cm of marl-plaster, laid upon a base of almost pure debitage 10-12 cm thick. Floor 1 was a more substantial marl-plaster flooring about 10-12 cm in thickness. Debitage 45 cm depth underlaid this floor, and in turn it rested upon a clay base.

Architecture and Non-lithic Artifacts

A summary of archaeological evidence other than the lithic tool debris is described here. The brevity of this discussion is not intended to portray a lack of importance for the structural and non-lithic evidence. As described, the research design was oriented toward lithic technology. Architectural exposure might have been more extensive and features such as burials possibly existed below the exposed floors. Non-lithic portable artifacts were indeed scarce relative to the lithic debitage.

Architectural evidence consisted of six structural features: Floors 1,2, and 3, and Walls 1,2, and 3. All floors consisted of marl-plaster construction. Marl, such as that at the bottom of Subop. 1, is a white clay substance that is excellent for building purposes. Floor 2 was the upper most platform floor only a short distance below the modern surface (Figures 8,9). The floor's surface had a flat, hard finish which was best preserved between alignments of cobbles (Wall 2). The

Figure 8. View south of Floor 2 and aligned rubble (workers at Wall 3).

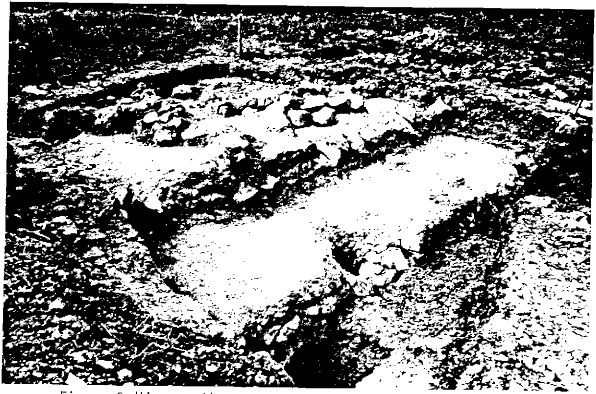


Figure 9. View northwest of exposed platform (note root hole).

surface literally could make trowels ring. This surface grout was part of a friable marl layer about 7 cm thick. This floor rested on about 10 cm or more of lithic debitage which apparently was recycled or leveled to serve this purpose. Floor 1 (Figures 6,7) was the lower marl floor which capped the lower retaining wall (Wall 1) and ran below Floor 2 (based on Subop. 11's findings). This floor was somewhat thicker than Floor 2 and rested upon more debitage. Because of deterioration and an ambiguous elevation, Floor 3 was an extension of Floor 1 exposed toward the center of the main mound, or, this was a remnant of Floor 2. In either case, a central plaza area floor was possibly represented here.

Of three recorded walls at Op. 2007, two were retaining facades and one was probably some form of wall base alignment. Wall 1 was the major platform retaining wall first exposed in Sob-op. 1. Its thickness was not probed but it was assumed to be a single stone width of about 15 cm. Wall material here was mainly chert cobbles with white cortex. Some evidence of mortar and possible debitage chinking was present. Set on grey-brown clay, its height averaged about 50 cm (tapering out to the north at Subop. 6), and its recorded length was 7 m at 20° east of north. Wall 2 was a nominal description for the alignment of large cobbles along the eastern edge of Floor 2 (Figures 7,8). This alignment was either the base of a stone or organic wall, or perhaps a protective edging for Floor 2. The later conjecture is possibly more likely to be true because a second associated cobble alignment was parallel and inset about 1 m from "Wall" 2 (Figures 7,8). The other alignment may have been the eastern edge of a basal outline for a now perished superstructure. Interpretations are complicated by the building stone recycling which was a pervasive activity at Colha, especially in the Late Classic (Jack Eaton, personal communication). Wall 3 was another retaining wall that supported the northern face of the upper rubble mound tested by Subop. 2. This wall was at a right angle to Wall 1 and preceded its construction. Individual stones varied from 10-20 cm in size, with possible traces of mortar. Some soft marl stones possibly were trimmed in placement. Wall 3's maximum height at its eroded surface was 55 cm, with a preserved length of 5.5 m.

Only a few limestone cobbles in the rubble of Op. 2007 had cut and tenoned forms. Although the Late Classic builders of Colha utilized this type of stone, the recycling and razing mentioned above apparently has resulted in their sporadic, displaced occurence.

Ceramic material at Op. 2007 was always in the form of vessel sherds. One near complete but shattered vessel was collected as Feature 1 in Subop. 2's rubble. The debitage deposit elsewhere had a steady but modest amount of ceramics. These sherds included both well abraded and unabraded examples. I think but cannot prove that a bit more ceramics occurred in the rubble over Floors 1 and 2. The major ceramic assemblage collected throughout excavations was interpreted to be that of the Late Classic Tepeu 2-3 phase (A.D. 800-900), based on analysis by R.E.W. Adams and Fred Valdez (personal communication). Two very similar modified sherds came from Subop. 7. They were fragments of perforated discs about 2-3 cm in diameter.

Charcoal fragments and small flecks were noted throughout the debitage fill. Several combined samples were taken including one from an area sealed below Floor 2 in Subop. 11. Unfortunately, the single sample eventually radio-carbon tested indicated a highly aberrant date. Repeated burning of the mound's surface in recent times and continual water leaching may have been detrimental factors here. One area of Floor 2's surface appeared to have been thermally altered in ancient times.

Bone was rarely found at Op. 2007, which was surprising considering its relatively good (albeit deteriorated) preservation at Colha. A possible fragment of a deer antler came from wall slump in Subop. 1, and small amounts tortoise and fish bone was collected from debitage elsewhere. Other small fragments were probably missed in table sorting, Close inspection of debitage column samples revealed only a few very small fragments of bone. Wet screening the matrix might have improved recovery, but large amounts of bone appear to have simply not been present at Op. 2007. This is in contrast to other locations at the site, especially Postclassic middens.

Molluscan remains existed in small amounts throughout the excavated fill. A Pomacea concentration in the form of a lense was noted in the debitage of Subop. 10. This situation has been noted at other Colha debitage deposits (cf. Roemer 1979). Other shells at Op. 2007 were marine specimens, Turbinella and Anadara, terrestrial Neocyclotus and Orthalicus, and fresh water Nephronais. Modified shell included the marine specimens, one of which had holes cut into it (Roemer 1980:Figure 9). Another worked shell was a small, angular, incised object, an "L" shape ca. 30 mm in height. Lawrence Feldman (cf. 1980) is conducting analysis of Colha molluscs.

Initial Interpretations

During and soon after the fieldwork at Op. 2007, certain interpretations were inferred from the experience. These ideas effected the formation of objectives for this thesis.

This appeared to by yet another of the Colha lithic workshops where intensive, massive stone tool production took place. The major trajectories appeared to be oval bifaces and stemmed blades. These products were represented by hundreds of near completed but rejected tool forms and thousands (if not millions) of waste flakes. Comparatively modest amounts of utilized stone tools and domestic waste in the form of ceramic sherds were present. The flake contours of the debitage indicated a deposit which had spilled down from the floors to engulf Wall 1 in the Subop. 1 area. This, coupled with the consistent Late Classic pottery identifications, seemed to indicate that the workshop operated within a relatively short time on the archaeological scale (ca. 200 years or so). The nature of the lithic debitage on top of Floor 2 was basically no different from material coming from deep in Subop. 1. This too supported the notion that debitage nearly covered the platform from a continuous activity of manufacturing, with abandonment at the termination of the Late Classic. Concerning the platform's original construction, two traits were apparent. The Maya used lithic debitage for the interior platform fill and base of Floor 2, and marl (for plaster) and chert were possibly mined just below the platform's base. Because of the way Wall 3 preceded Wall 1, it was possible that the massive fill inside Wall 1 (the bulk of the Floor 1 and 2 platform) was lithic debitage that was discarded from manufacturing elsewhere at the Op. 2007 plazuela (perhaps in the vicinity of Subop. 2 and the western plazuela area). If this is true, the lithic midden of Subop. 1 was only a final episode of Late Classic workshop production. An artist's perspective of one possible scenario for Op. 2007 was constructed by Jack D. Eaton (Figure 10). The existence of a perishable superstructure was hinted at by the alignments of stone on Floor 2 (Figure 7). This stone may have served as basal trim from a wooden-thatch hut.

Another major interpretation influenced by other evidence at Colha was that this workshop represented craft specialization behavior. One objective of this thesis is to refine this assumption. At the time excavations closed, the field workers at Op. 2007 (including myself) might have been hard pressed to argue for this condition beyond pointing to the awesome volume of debitage that had been encountered. Was this the prime behavioral expression of craft specialists? Could basic attributes of the lithic technology observed qualify the presence of craft specialization?

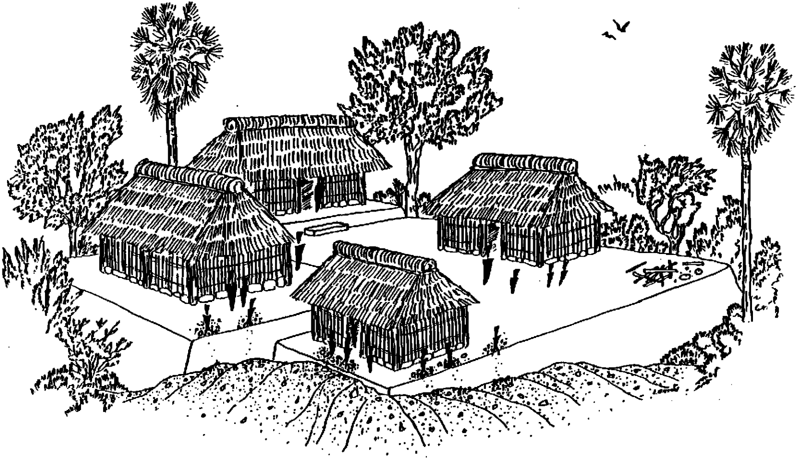


Figure 10. Reconstructed scenario for the Op. 2007 plazuela (from Eaton 1981:Figure 3).

Chapter IV

CRAFT SPECIALIZATION

> In small towns the same workman makes chairs and ploughs and tables, and often this same artisan builds houses, and even so he is thankful if he can only find employment enough to support him. And it is, of course, impossible for a man of many trades to be proficient in all of them. In large cities, on the other hand, inasmuch as many people have demands to make upon each branch of industry, one trade alone, and very often even less than a whole trade, is enough to support a man . . . .
>
> Xenophon's Cyropaedia
> (VIII,2,5)

Introduction

This chapter is an explanative statement for craft specialization. First, craft specialization is defined. Second, three parts of the defintion are discussed. The terms standardization and efficiency, crucial to the research proposition of Chapter VI, are defined. Third, I review some previous studies involving craft specialization. This is important background for a complex topic my thesis only partially examines. Again note that craft specialization is assumed to have been present at the site and workshop under study.

Craft Specialization Defined

For this thesis, craft specialization is the markedly efficient and standardized production of a given class of artifacts which is distributed to consumers. The products are not necessarily used by the producer(s), whose subsistence is provided directly or indirectly by the consumers. The above definition is derived from my interpretation of the essence of craft specialization following the work of Childe (1936,1942) and White (1949,1959), the refinement of scholars like Rice (1981), and other studies. I am emphasizing efficiency and standardization, and not addressing other possible distinctions (see below). Efficiency and standardization are associated with a context of incipient or developed civilization, such as that of the ancient Maya. While craft specialization may exist in partial, variable degrees for primitive contexts like those of hunter-gatherers, the institutional craft specialization (Arnold 1984) of societies at least as complex as chiefdoms is the way the term is used here.

In anthropological research, the concept of craft specialization is used frequently. However, few studies focus on it and no formal, consistent definition exists to my knowledge. A variety of terms are commonly interchanged: "occupational specialization", "economic specialization", "division of labor", and so on. A list of associated terms I have encountered includes a range of material and abstract entities: massive replication/production volume, work-time (part or full-time), division of labor/differentiation, technology/work/energy, trade/consumption, limited/controled workspace and resources, etc. All of the above can be argued to variably suit the cause, being, or effect of craft specialization. To attempt incorporation of these (and other) aspects for my definition of craft specialization would be an ad hoc activity pointless to what I wish to study: efficiency and standardization. Below I discuss these terms and the context of civilized societies.

Standardization

Standardization is restriction of behavior or material form to some rule of comparison (Webster 1968:1772). Uniformity or lack of variation is also implied by the term. Division of labor, the repetitive motions of tool use, and the higher precision in assembly and function of complex products all contribute to standardization (Wagner 1960:93,220-221). This process is assumed to develop through the stimulus of various socio-economic factors. For example, according to Mumford (1963:83-94) early historic European warfare promoted standardization and mass production.

Some standardization in human behavior likely preceded the presence of craft specialization (Singer 1960:259-260). Lithic technology has been interpreted as standardized and repetitive in its earliest developments (Braidwood 1961), while Hocart (1933) points to the relationship between standardization and ritual. Archaeologists tend to focus on the material evidence. For example, Sheets (1978a) identifies consistency in products and manufacturing debris with craft specialization. Yet a warning familiar to anthropologists is the way that standardization (or lack of it) in artifact form may or may not relate to that same trait in function. For example, it is a popular axiom among North American prehistorians that highly stylized dart points were actually multi-use tools for hunter gatherers.

Based on an examination of Webster (1968:398), the notion of control (or restriction) is a behavioral term related in two ways to standardization. First, it is a way to consider the conformity described above as a regulatory measurement. This may be either in terms of a normative value (e.g. an "ideal" tool 100 mm long), or as a means of restraint (e.g. an "ideal" tool may not exceed 100 mm length). The second way to view "control" is in the sense of a system governed by its human participants. This is the manner that Torrance (1981:175-180) uses the term to portray ancient Aegean ownership of access for obsidian. A context of civilization (see below) would be most appropriate here. Finally, I stress that great variation in archaeological evidence is the negation of standardization. Researchers may choose which extreme to emphasize, with the effect of biasing emphasis on the opposite condition.

Efficiency

Efficiency, as an economic term, may vary somewhat in definition (Christenson 1982). I prefer to use Schneider's (1974:234) definition of economizing as an equivalent term: "In the process of relating one's means to one's ends, selecting that combination of means and ends which maximizes utility... ." This is in part similar to statements of "minimax" behavior, which Christenson (1982) concisely discusses as a concept sometimes poorly used by anthropologists. A second definition that balances "economizing" efficiency and completes the minimax concept is the "ability to produce the desired effect with a minimum of effort, expense, or wastes; (Webster 1968:578)." Absolute efficiency, in terms of technology, is a type of rationality - "the one best way" to do something (Ellul 1964:xxv; Winner 1977:180). In general, efficiency in craft specialization does not mean that rates of improvement are consistent or unidirectional (again, this depends on particular measurements [Christenson 1982:422]). Ratios of efficiency are possible, but the precise identification and control of time, energy, and material input-output is required (Christenson 1982:420-422).

Sheets (1974,1978) provides one example of the use of efficiency in archaeological research. Here error rates in Mesoamerican obsidian manufacturing debris are argued to portray efficiency. Specific evidence such as hinge-terminated blades is examined. On the other hand, Torrance (1981:180-183,286-295) provides an abstract reasoning for efficiency (calling on Systems Theory, the Principle of Nonproportional Change, etc.) and then looks at similar kinds of evidence to reach no firm conclusion. This is largely because no absolute scale for efficency (and standardization) exists for "industrial organization" (Torrance 1981:295). Interpretive shortcomings in Chapter VI of this thesis support this belief, although it would seem that pertinent scales could be defined for specific contexts of proper, abundant data.

Civilization

Civilization is at once the most pervasive and yet nebulous of terms. Although many anthropologists would be quick to point out that "craft specialization" is not restricted to this level of social organization, I have encountered the term most often in studies within this context. Further, the concept of institutional craft specialization segregates this kind of craft specialization from the other end of the continuum. The greatest quantities of craft specialists may indeed occur under the influence of "higher civilizations

(Naroll 1956:687)."

Civilization is a broad concept embracing what is known as the state, the presence of written communication, and the existence of towns (Khazanov 1978:89; Childe 1957:37). A more specific definition (of many) for civilization is that of Robert M. Adams (Lamberg-Karlovsky 1972:134), where "interrelated sets of social institutions" are:

> 1. Class stratification, each stratum marked by a highly different degree of ownership or control of the main productive resources.
> 2. Political and religious hierarchies complementing each other in the administration of territorially organized states.
> 3. Complex division of labor, with full-time craftsmen, servants, soldiers, and officials existing alongside the great mass of primary, peasant producers.

The state is "a number of people, a certain delimited territory, and a specific type of government (Claessen and Skalnik 1978)." States involve stratified societies where social classes often equate certain occupations (Trigger 1972:578; Caplow 1964:12). A stratified society is "one in which members of the same sex and equivalent age status do not have equal access to the basic resources that sustain life (Fried 1967:186)." Unless factors such as mobility and the like moderate this unequal access, craft specialists may thrive in terms of stability and productivity under such rigid social systems. Management by an administrative class is often required. These bureaucrats and others such as religious "specialists" must form symbiotic relationships with the lower classes who actually produce food, procure raw work materials, and so on - some of whom could also be rationalized as specialists (Chang 1975:216; Caplow 1964:19). Social stratification can exist without the state (Fried 1967:185), but the two are most often associated.

Although substratification (or hierarchies) within a group of craft specialists may exist (Hopkins 1978: 473), there is an important solidarity or cohesion for almost any organization (Durkheim 1949:60-64). This is shown by the early formation of guilds: the voluntary association of craft specialists. Early guilds of Rome were both religious cults and secular groups for mutual aid (Mosse 1969:103). Sixth Century European monasteries functioned as specialized centers of industry, although the merchant guilds of the later Medieval period are better known (Boissonnade 1927; Gras 1922). Guilds came to monopolize certain industries and greatly influence lifestyles. Administrative control fluctuated. For example, the making of coins and arms was closely controled while other products were not (Mosse 1969:106-111). Trade apprenticeship in guilds often required long years.

The concept of status (Fried 1967:29-32) also relates to the social ranking of craft specialists and the state. In ancient history craft specialists appear to have often occupied levels of status higher than the masses of unskilled or multi-skilled workers such as farmers. But they also were usually below the elite bureaucrats - the "mental" specialists (Glotz 1926; Boissonnade 1927; Adams 1977a:34). Craft specialists have been no more than servants in many times and places, and this is a recurring theme (cf. Sjoberg 1960:185). Ancient Greeks and Romans viewed mechanical arts as degrading and of low status. Even work of creative artists was held in low esteem (Taylor 1968:3-4; Sjoberg 1960:401-402). To bring goods or manufacturing skills to the consumer, craft specialists sometimes took the status of strangers even within their own culture. Traveling merchants could achieve rewards including higher status (Caplow 1984:12; Becker 1940). The Aztec pochteca are a well known example of this in Mesoamerica. Medieval European peasants considered craft specialization a necessary but dangerous role in society (i.e. the amoral and rootless traveling salesman; Handlin 1967:461-464).

Craft specialists must be supported - at least in part, directly or by trade - by the food producers of their society. It is reasonable to infer that as craft specialists tend to settle near a resource, production area, or distribution point, more people can practice craft specialization and more people can support it. Communities form, and the cycle continues. Childe (1974) provides a definition of what constitutes an early town or city (i.e. urbanism). He lists traits including a dense population numbering in the thousands, workers who did not directly procure their own food, monumental public buildings, science, writing, imported raw materials, and a ruling class of civil, military, and religious leaders. Of note, full-time craft specialists and other specializations are emphasized (Childe 1974:10-13). Childe (1936) also stressed agriculture as a factor in the emergence of civilization and general population growth. The work of Harrison and Turner (1978) is confirming the kind of labor intensified farming that might have supported Maya craft specialists such as the flintknappers at Colha. The nucleation of urban communities is an aspect of civilization that appears linked to craft specialization. Nucleation is a complex term with both active (processual) and static meanings (Cliff 1982:13-15). It can refer to an actual change in habitation for any defined area over time, involving an increase in human density. Or, it is a more abstract term depicting settlement at a specific time (Cliff 1982). Concerning increased settlement size, Naroll (1956:689) has proposed an allometric relationship to pertain to craft specialization (cf. Renfrew 1975:27-29; Carneiro 1967). Specifically, an index number is constructed for measuring cultural developement of various ethnographically known societies. Quantification occurs under details of three broad indicators: craft specialization, "organizational ramification" (settlement size), and urbanization. Naroll's research was largely an exercise in methodology.

Review of Craft Specialization

The following review covers a portion of numerous published studies, primarily in archaeology, that deal with craft specialization from a variety of perspectives. However, the number of focused examinations of the subject is not large. I have divided the review into two major sections: works outside and works within Mesoamerica. In each section the works most related to craft specialization are first discussed, followed in sequence by those with relatively less concern for the topic. Some ethnographic studies are also cited.

Studies of Craft Specialization Outside Mesoamerica

Five dissertations which examine problems in craft specialization not set in Mesoamerica are reviewed below. The subject of craft specialization is a major component of each. After this, a few examples are given of the more common limited references to craft specialization. I do not comment on ethnographic studies. These usually deal with modern craft specialization in third world settings. Of historic interest, Adam Smith and Frederick Taylor of the 19th Century may be the earliest students of craft specialization (Taylor 1968:21).

Robin Torrance's dissertation, Obsidian in the Aegean: Towards a Methodology for the Study of Prehistoric Exchange, is probably the most specific and well reasoned research available showing what can be done with archaeological material (obsidian artifacts) and assumptions of craft specialization. The main purpose of her work is to evaluate two theories of exchange: commercial production and indirect redistribution *versus* non-commercial, reciprocal exchange and direct procurement of resources. Obsidian resources, manufacturing debris, and products are the medium of evidence. Torrance's criteria for craft specialization are reprinted in Tables 2 and 3. Craft specialization is assumed to involve traits of "control over access" and a "highly efficient system for extraction and production" (Torrance 1981:176), which existed only when commercial marketing took place. To do this evidence from three Neolithic-Bronze Age sites at Melos is examined. One, Phylakopi, had long been in question as to its possible role as a redistributive center over two quarry sites, Sta Nychia and Demenegaki. From a regional analysis of obsidian distribution, based on fall-off curves and regression, Torrance concludes that direct access - not commercial redistribution - took place (Torrance 1981:Chapter IV). Next, based on a study of on-site context and the technological and morphological attributes of obsidian, it is reasoned that the obsidian was extracted and processsed in an

Table 2. Torrance's (1981:193) Archaeological Expectations.

Eight Archaeological Expectations For Craft Specialists in A Commercial Economy:

1. very high degree of skills utilized;
2. low incidence of errors;
3. small quantities of industrial waste per unit of manufacture;
4. end product comprised of a minimum amount of raw material;
5. technology which minimizes the inputs of time, effort and raw material;
6. use of standardized techniques of manufacture; consequently,
7. standardization in the types of errors made and in methods for recovery from errors;
8. a high degree of consistency in the size and shape of both the products and the waste materials.

Table 3. Torrance's Trait Checklist for Ethnographic Research (Torrance 1981: after Table 11, 237-240).

Stone Working Traits of Craft Specialists Known by Ethnography:

-Access to resource/Ownership
-Access to technological knowledge/Apprenticeships
-Boundary markers at sources
-Defensive structures at sources
-Other structures
-Sustained exploitation for most of year
-Sophisticated or complex technology
-Specialized toolkit
-Careful choice of raw material
-Differentiation in use of space
-Craft Specialization
-Division of labor
-High degree of skill employed
-Low error rates
-Small quantities of waste per product
-Standardized technology
-Standardized products
-Standardized by-products
-Specialized waste deposits

"unorganized, expedient, and inefficient" way (Torrance 1981:423). In short, Torance believes that commercial trade was not in effect for the quarries, but that variable direct access took place. Of pertinence to my research, Torrance devotes much discussion to what standardization and efficiency mean for the production of lithic artifacts. Efficiency and standardization are not clearly seperated in the text, but efficiency determines standardization, and product morphology becomes uniform (Torrance 1981:184). Unfortunately, theoretical and ethnographic review here is not joined by overly convincing evidence because "absolute scales of industrial organization using efficiency and standardization as measures have never been constructed" (Torrance 1981:295, see also p. 434). This dissertation is probably the most thorough archaeological study to date of craft specialization. One criticism is that theoretical, technical, or experimental justification for numerous assumptions of the lithic analysis itself is not made. For example, Mexican metateros, British gunflint manufacturers, and others of greatly varied times and cultures are assembled without discussion of how such a large variety of lithic materials and techniques can be viewed as a common-ground for craft specialist behavior (Torrance 1981:193-195).

In a second archaeological dissertation, Evans (1973) investigates graphite-decorated pottery from the eastern portion of the Balkan Peninsula of Europe to show that craft specialization was a possibility for the Balkan Chalcolithic (ca. 5,000-3,500 B.C.). In a later article (Evans 1978), he reiterates this theme with the consideration of pottery production, copper and gold working, flintknapping, figurine making, shell bracelt manufacturing, and weaving. Evan's definition of craft specialization and research hypotheses (Evans 1973,1978) are provided in Table 4. As it is offered, I believe his definition is oversimplified. For a core statement in building his definition of craft specialization, Evans (1978:115) cites another anthropologist to say: "a specialist is an individual who holds a position or vocation because he controls a set of skills that most of his communal fellows do not control. It is obvious that this defintion depends on the societal or communal context (emphasis added, Rodgers 1966:410)". Yet the social impact of craft specialization on Balkan Chalcolithic communities (or vice versa) is not well explained in terms of its material context. Supportive archaeological evidence is minimal at best. Much of it was gathered from the inspection of secondary collections, rather than original field context. For example, the best example of a flint workshop from a site in Romania (Dumitrescu 1965) is "14 axes, 13 cores, and more than 60 large pieces of flint. There were also 4 hammerstones . . . (Evans 1978:121)". The "large pieces" and knapping debitage are undescribed.

A third archaeological dissertation examines the relationship between site differentiation and specialized function for a "third line" community site of the Cahokia settlement area in North America (Gregg 1975). Although an ecological approach and terms such as "production" are well discussed (Gregg 1975:1-5), no explicit definition of specialization is presented (Gregg 1975:86,337). A site, however, is "characterized by specialized production when the artifactual remains at the site locale indicate that the extraction and/or synthesis of a particular item or items is a dominant cultural activity of the site. Mining, lumbering, fishing, farming, and industrial communities are

Table 4. Evan's (1973,1978) Conception of Craft Specialization.

Four Main Points of "Working" Definition:

1. The manufacture of certain craft products is limited to a small percentage of the total number of individuals in any given community.
2. These individuals devote some of their productive time to the manufacture of these craft products.
3. Consequently, they must withdraw themselves from some or all of the basic subsistence activities.
4. Thus, they must obtain some or all of their subsistence goods through some kind of exchange system for their craft products (Evans 1973:55).

Hypotheses:

1. craft specialization varies directly with population size;
2. craft specialization varies directly with the technological complexity of the craft;
3. the degree of efficiency of any particular craft varies directly with the degree to which that craft is performed by craft specialists;
4. the more complex the technological knowledge necessary to perform a particular craft, the greater the probability that that craft will be performed by specialists;
5. as craft specialization increases there is an increasing spatial differentiation of work space;
6. as craft specialization increases there is an increasing morphological differentiation of the tools utilized to perform particular crafts (Evans 1973:xi).

Expectations "Deduced" From Hypotheses:

1. Workshops: specialized areas for craft activities;
2. Tool kits: specialized tools for craft activities;
3. Storage facilities and/or hoards: delimited locations for storing completed craft products;

Table 4 continued.

4. Product uniformity;
5. Resource exploitation: regular exploitation of particular resources;
6. Exchange and trade: distribution of resources or craft products;
8. Temporal variation (Evans 1973: 55-67; 1978:115).

Related Expectations:

1. Population growth;
2. Agricultural development;
3. Role and status differentiation;
4. Competition (Evans 1973:67-0).

examples . . . " (Gregg 1975:5-6). Because the site is located near a lake, a "working hypothesis" is that aquatic resources should be involved in specialized production, plus "agricultural and/or craft specialization were also considered possibilities" (Gregg 1975:86). Huge water fowl bone middens, fishing tools, agricultural fields and charred seeds, and specialized stone tools for working wood or bone were expected (Gregg 1975:88,170-171). Throughout the descriptive presentation, it is obvious that the material remains and context are continually under inference for evidence of specialization. The actual evidence appears to be relatively typical structural features, ceramics, and lithics for this archeological region. The lithic evidence showed "great refinement in the application of economizing techniques in procurement and transportation" of distant cherts (Gregg 1975:232), along with efficiency and "composite" tools (Gregg 1975:245,263). But the inferences are weak. For example conjectured multi-use "composite" flake tools are considered strong indicators of "economization" (Gregg 1975:263). Hoe chips (resharpening flakes) are the only lithic evidence infered to be the result of specialized production (Gregg 1975:279). In concluding the study, aquatic resource specialization is rejected because the faunal evidence was diverse, and small quantities of lithics and ceramics are suggested to show specialization beyond domestic production. Specialization in farming is offered as a possibility because of the hoe chips and widely occurring carbonized maize (Gregg 1975:337). This work has two faults: 1) the search to confirm craft specialization is overemphasized throughout the work, and 2) the specific archaeological evidence argued to support the presence of craft specialization is inadequate.

A fourth dissertation uses archaeological evidence to test "viable conceptual models of socioeconomic organization" at an Inca site (Shimada 1976:85-86). Use patterns related to architectural (i.e. spatial) divisions are sought, including specialized economic activities. Criteria for specialized functions are derived from elaborate construction, absence of domestic debris, high quality pottery, storage facilities, and so on (Shimada 1976:221-223,287-288). The best evidence found at this Moche V Period (ca. A.D. 700) site was that of metal working: polished hammer and anvil stones, possible adobe work tables, a copper strip, and a possible ceramic crucuble for ingot molding (Shimada 1976:291-294). It is suggested this "low-level, low-output" workshop produced simple, practical goods such as fish hooks (Shimada 1976:294,335). Other weak evidence of possible craft specialization involves weaving, based on the existence of spindle whorls (Shimada 1976:335-343). Again, archaeological evidence is slanted to support preconceptions of craft specialization. If a spindle whorl indicates weaving specialists, then by analogy potters' tools could indicate ceramic specialists, stone cutting chisels could depict masons, and so on. Where should this kind of inference stop? This is a real problem in craft specialization studies, and one which I cannot claim to resolve here.

Arnold has recently examined chert bladelet-drill material for patterns of craft specialization (Arnold 1983). Unfortunately, I have only examined an article related to this dissertation (Arnold 1984). The material comes from her fieldwork on the Santa Barbara Channel Islands off California. Her definition of craft specialization involves "reduced subsistence-directed activity, but the precise level is not strictly defined because it varies cross-culturally" (Arnold 1984:4). In other words, craft specialization "must be evaluated on a case be case basis (Arnold 1984:3)." "Incipient specialization" is contrasted to "institutional specialization." The former is variable, small-scale, and tends to occur in societies less complex than chiefdoms or states. Institutional specialization is essentially the opposite: stability, guild structures, and centralized or hereditary powers. Five indicators are used to identify specialization: 1) great production volume, 2) standardization in production methods, 3) activity areas of repeated and intensive use, 4) control of resources, and 5) specialist's paraphernalia in burial associations. These ideas are restated into "case hypotheses" (Arnold 1984:17-19). In field survey on Santa Cruz Island, a concentrated chert outcrop was identified which indicated that Chumash village sites from ca. A.D. 900 to 1785 had differential access to lithic resources - an important precondition for craft specialization (Arnold 1984:10). Within that time, the Chumash initially manufactured trapezoid-cross-section bladlets for decorative shell bead making. About A.D. 1200 this activity was stepped up when the shell beads became a form of money under greater economic and political centralization (Arnold 1984:12). The bladelets were more frequently triangular in cross-section. Arnold assumes that the pre-A.D. 1200 Chumash had a system of incipient craft specialization, while after this time institutional craft specialization developed. The hypothesis testing (based on the five indicators named above) largely addresses the fully developed craft specialization of the post A.D. 1200 Chumash. The testing methodology often consists of comparing evidence, primarily lithic debris and its excavation context, from this time period to that of the earlier. Great production volume is confirmed for the centralized late settlement of Santa Cruz Island. This is based on estimation of bladelet density at one site - about 2400 per cubic meter for the total site area (Arnold 1984:25). Standardization in manufacturing is believed to be shown by triangular-cross-section bladelets (which were sturdier for drilling) and prepared core corner ridges. Arnold uses some unexplained assumptions of flintknapping efficiency and skill in this paper (Arnold 1984:31-34). The best evidence offered for craft specialization activity areas is blade production evidence located in volcanic saddle terrain near the chert outcrops (Arnold 1984:28). Control of resources is argued to derive from the easily defended natural restriction of shell and chert resources in the local area. The institutional craft specialists centralized their work at a village site, while earlier workers produced bladelets directly at the quarry area. The technological and contextual evidence appears good for this claim. No burial evidence was directly examined due to the wishes of modern activists. Because I have not examined the dissertation, no criticisms are offered.

In recent times a number of journal articles have focused on craft specialization (usually tying it to a case study of evidence or theoretical emphasis). Below I discuss only three. Many more are making the circuit as papers presented at scholarly meetings.

Because it deals with lithics, Richard Yerkes's (1983) article on Mississippian craft specialization has particular relevence for my thesis. The framework of Evan's work (1978), discussed above, is combined with use-wear analysis of microliths (small blades and other perforator-like tools). A microscopic and replicative examination of 50 such tools is conducted. Of these, nine were from the Poverty Point site, with the remainder from Cahokia or Cahokia area sites. Most of the Cahokian tools were used (apparently exclusively) to drill shell. None of the small sample of Poverty Point tools showed evidence of drilling shell. This finding is important because drilled shell beads are commonly found at Mississippian sites. The beads are argued by some to represent either money or ritual tokens (Yerkes 1983:508,513-514). Yerke's article raises several points relevant to my thesis. The raw material for stone tools is recognized as a factor in determining product morphology, which later may be examined for attributes of craft specialization. That is, the natural variability or quality of raw material can affect product form <u>and</u> our perception of what constitutes a "craft specialist" product. Second, he explicitly calls to question the notion that if a tool is found to be functionally specialized (as for the Cahokia tools), does that imply the presence of craft specialization? Because microdrills are located at many other smaller, rural Mississippian sites, Yerkes believes that there is <u>no</u> real evidence the tools at Cahokia were used by "full time" craft specialists (Yerkes 1983:512).

Prentice (1983) proposes a "cottage industry" model that is a timely companion to Yerkes' effort. Small scale, part-time household production for trade is emphasized (Prentice 1983:17-18). A good background on economic studies is given, and ethnographic examples from Africa are used by analogy. Again, the presence of shell beads and stone drills is described for Cahokia area sites, but caution is shown for inferring an eloborate exchange system (Prentice 1983:41). The term "full-time" is used but not defined (Prentice 1983:40).

Eric Gibson (1982b) also deals with lithics and craft specialization. His work is derived from a thesis on Upper Paleolithic blade technology (Gibson 1980). I think this article signifies the "band wagon" effect craft specialization has recently engendered. The investigation of craft specialization is based on what in the thesis were "speculations . . . far removed from the study data" (Gibson 1980:102). The theoretical nature of the article is markedly influenced by Sackett (1982) and others who suggest "that studies of stylistic variability should concentrate on those formal attributes that vary within the social context of manufacture (Gibson 1982b:41)." Gibson seeks to test standardization for a collection of Evolved Perigordian blades and flakes from the site of Corbiac. He assembles nine attributes that can be measured for both classes. The attributes are basic ones such as states of cortex, body shape, and striking platform angle (most have nominal values). In comparing percentage breakdowns for each group (blades versus flakes), "the assemblage seems uniform and consistent (Gibson 1982b:45,Tables 1,2)." Adding this to a major assumption that Upper Paleolithic people were specialized reindeer hunters (Gibson 1982b:46), and reflecting on Torrance's criteria (Table 2,this thesis), it is suggested that rudiments of craft specialization were present (Gibson 1982b:47).

The bulk of references to craft specialization I have encountered have been in the form of minor, often passing, comments representing someone's undefined or under-defined conception of specialization. A typical example may be that of Sears (1961). In order to aid in the study of North American social-religious systems, Sears identifies cultural units and their respective evidence. Specialization in artifact manufacturing, "perhaps a minor category (Sears 1961:229)," is next to last in a list of settlement patterns, ceremonial structures, burials and grave goods, and artistic representation. However, Florida Gulf coast mortuary furnishings are provided as an example having "technical virtuosity" and "considerable quantities" which "demonstrate that there was a class of trained artisans, who were supported by their societies... (Sears 1961:229)." Artifacts of the Hopewell and Southern Cult cultures are also seen as likely evidence, and "full-time" specialists may have existed at restricted locations within a regional network (Sears 1961:229). Other minor references frequently come from grand syntheses, such as that of Hayden (1981) where a cultural ecology approach is made in explaining world wide post-Pleistocene traditions (Mesolithic/Archaic times). He sees a "tendency toward specialization in habitually exploited resources in resource rich areas" and, fewer but more technologically specialized and complex tool classes (Hayden 1981:519-520).

Studies of Craft Specialization in Mesoamerica

I am aware of only a few studies that focus on archaeologically known craft specialization in Mesoamerica. However, as would be expected in such a study area of ancient civilization, there are relatively many brief examinations of the subject and minor comments. The following studies are reviewed in groups pertaining to economics (production, trade, and consumption), the urbanized or major sites known for evidence of craft specialization, minor references, and ethnographic studies.

Production/Trade/Consumption. Because of his combination of technical analysis and explicit theory, Payson Sheet's (1972) studies of obsidian production debris in Guatemala and elsewhere in the Maya area have contributed much to understanding craft specialization. Sheets provides useful discussion of incipient theory in the technological analysis of lithics (e.g. Sheets 1975). Further, he explicitly defines his major assumptions for interpretive use. For example, mass replication and industry (Sheets 1978:66; 1975:372) have specific meanings. The former is associated with specialized workers in a highly developed economy with standardized, efficient production, while the later is essentially a productive enterprise of common means for processing a raw material. Craft production for Sheets refers to part-time craft specialists who make variable but high quality goods (Sheets 1978:66). His article "From Craftsman to Cog: Quantitative Views of Mesoamerican Lithic Technology (Sheets 1978)" is a landmark study of craft specialization and Mesoamerican lithic technology. Indices of classified obsidian debitage are shown to be useful in measuring production efficiency, and in testing hypotheses. These indices are based on blade width, ratio of cutting length to mass, and core preparation techniques. The error rate in manufacturing waste is described. For the Chalchuapa area in El Salvador, a transition through time from rural "skilled craftsmen" to more efficient, standardized "urban" specialists is shown by these measurements. Other discussion includes themes such as the role of ritual behavior in tool manufacturing and problems related to economic theory.

In the Rio Bec area of Campeche, Mexico, Thompson (1981) conducted a study of chert mounds at the site of Becan. The abstract states: "it is suggested that the mounds evidence [sic] intensive and specialized stone tool [celt] production during the Late Classic period (Thompson 1981:iii)." However, I believe the evidence provided is inconclusive. For example, the proportion of lithic tool debitage in the mounds is paltry compared to the great amount of unaltered nodules (Thompson 1981:Figure 5). Admittedly, Thompson (1981:1) argues the mounds were "lithic reserves and reduction loci." Yet based on the debitage description, I think the mounds cannot be considered workshops beyond locations for initial, rather than total manufacturing - a point not stressed. It is difficult to prove that every unaltered nodule was potential raw material for knapping and not serving a function as structural fill or a landscaping deposit. In fact, nearly half of the nodules examined for knapping quality were considered unsuitable for reduction (Thompson 1981:34). The term "specialization" and its associated meanings are not defined. This is a hindrance because assumptions are made for "standardized" morphology of flakes and celts (Thompson 1981:47,64,72). Also, interpretations are offered but not qualified for "intensity" and "mass production" (Thompson 1981:72-73). Finally, there is no solid evidence to speculate that "elite" social classes controled "retainers" or "slaves" who made artifacts (Thompson 1981:72-73).

The work of Rathje (1972,1975) is one of the better known examples of model building for trade networks in the Maya area. The "core" of the Maya Lowlands (the

Tikal area and northward) is portrayed as an area deprived of certain necessities because some natural resources are scarce: basalt for food processing tools, obsidian for cutting tools, and salt for dietary needs. "Buffer zones" of Maya settlement surrounded this area to facilitate import of these materials (in product form) in trade for other Lowland products. In short, the management leadership necessary for this trade integrated communities and the overall developement of civilization. The model has been criticized (Hammond 1982:131) because there were other possible ways for the core area Maya to meet the requirements of Rathje's model (i.e. chert tools of local material, etc.). The importance for craft specialization lies in the way that it would play an important part in such a model. Other studies in this genre are those of Sabloff and Friedel (1975), Hammond (1972,1976), and Fry (1979) to name a few.

In comparing two production and exchange systems over time between ancient Mesoamerica and the northeastern U.S., Spence (1982) details a developement of craft specialization. Discussing obsidian workshop sites in the Valley of Mexico, an important assumption is stated: a change in quantities of lithic debitage and tool classes will follow a shift from part-time (Formative) to full-time (Classic) production of obsidian (Spence 1982:174-181). Although a list of overly generalized data common to both regions is provided, no substantial comparative synthesis or analysis takes place. Why the northeastern U.S. data was selected rather than that of other areas is not clear.

Kintz (1983) offers a "cottage industry" concept for the study of economic production and craft specialization in the Coba archaeological zone in Quintana Roo, Mexico. Guild organizations are a second kind of "production unit" mentioned on but not developed in the study (Kintz 1983:150,158). Interpretations are derived from the belief "that platforms with no apparent room foundations represent loci of economic specialization in the form of cottage industries and/or guild formations." (Kintz 1983:152). In essence questionable or implied assumptions (e.g. "elite" behavior, Kintz 1983:155) are placed on minimal evidence. Conclusions such as "economic production must have been a major activity in Classic Maya centers. . . (Kintz 1983:159)" reflect this. The work of Prentice (1983), which I have mentioned earlier, is a much better examination of cottage industries.

Finally, the study by Rice (1981) of specialized pottery production is the best recent effort at linking a model of detailed craft specialization theory to a test of data. General research questions are explicit and theoretical terms are extensively defined (Rice 1981:219-222). For example:

> Craft specialization is here considered an adaptive process (rather than a static structural trait) in the dynamic interrelationship between a nonindustrialized society and its environment. Through this process, behavioral and material variety in extractive and productive activities is regualted or regularized. . . . This paper is based on the hypothesis that such variety regulation is focused on the patterns of access to or utilization of some resource, . . . In other words, craft specialization represents a situation in which access to a certain kind of resource is restricted to a particular social segment (Rice 1981:219-220).

She goes on to discuss non-ranked, ranked, and stratified societies (Rice 1981:220), then:

> In the products and/or in the productive

> activities, the objective results of such regulation of access may take the form of standardization (reduction in variety), elaboration (increase in variety), or both. Standardization may emphasize reduced variety in behavior and in the product. Standardization of manufacturing methods (mass production, routinization), standardization of shapes, sizes, colors, etc., all would fall into this realm. Elaboration may be exhibitied in an increase in the number of kinds of goods produced (Mortensen's [1973] "innonvation curve") and also in unusual forms, in decorative styles or motifs, and in utilization of new (and possibly rare) raw materials (Rice 1981:220).

A trial model is set up to depict four "steps" of development from nonspecialization to specialization, including explicit test implications (Rice 1981:222-223). Essentially, standardization versus variability is tested for ceramics from the Barton Ramie site in Belize. This is done by using ecological concepts and formulas for richness and diversity (Rice 1981:222). It is predicted that: 1) ceramic vessel pastes became standardized through time, 2) decoration (i.e. painting, etc.) became standardized for utilitarian vessels, and 3) decoration became elaborate (variable rather than standardized) for vessels of elite/ceremonial use (Rice 1981:Table 1). In analysis of data plots, the model is at least partly supported. Of interest, Rice (1981:227) explicitly avoids the part-time/full-time question of craft specialization. Two weaknesses of the work, which the author notes (Rice 1981:236), are that model is highly linear, and that the Barton Ramie ceramics were not the best choice of data.

Urbanization/Major Sites known for Craft Specialization. Extensive field work at Tikal, Guatemala, conducted by the University of Pennsylvania has provided a number of studies related to craft specialization. An article by Marshall Becker (1973) sums up work related to craft specialization at that site and infers the existence of six types of craft specialists there: flint and obsidian knappers, potters, woodworkers, dental workers, mason-stucco-construction workers, and stone worker-monument carvers. In reviewing the work of Adams (1970), Becker points to early speculation made on Maya craft specialization by Kidder (1950:4-8), who believed the first occupational specialization did not occur until Classic times. Relying heavily on architectural units at Tikal correlated with the number and types of artifacts recovered, building "group" collections are compared to support interpretations of craft specialization (Becker 1973:397). A high percentage of "ovate bifaces" (relative to that collected site-wide and at other groups) is identified at Group 4F-1 and Group 4F-2. Because of this and other waste material found at these groups, Becker concludes that craft specialists occupied those structures (Becker 1973:398-399). He does not explain the precise context of these collections (i.e. how much came from rubble fill?). Interpretation of other occupational categories comes from similar reasoning and the assumption, for example, that certain tool forms "generally called drills" are indicative of wood workers (Becker 1973:400). In the discussion on knappers, it is also pointed out that Fry (1967:6-7) tested an obsidian workshop at the site, and Puleston (1969) studied a collection of obsidian tools and manufacturing debris possibly related to specialist activity. Becker concludes by discussing inferences on craft specialization outside Tikal, emphasizing the kind of activities that are not well preserved archaeologically, and by giving examples suited to testing hypotheses (Becker 1973:402-403). A final comment points out that no capullec or guild areas have been recognized at Tikal (Becker 1973:404). A later article by Haviland (1974:494-497) adds information to Becker's "knapper" architectural groups. Evidence is cited to suggest that masons and monument carvers lived at Structure 4F-3, Group 4F-1.

Another major site where the presence of craft specialists has been studied is Teotihuacan, Mexico. Also, Sanders (1965) suggests the association of craft specialists and guild areas within the ancient cities of the Teotihuacan area. At Teotihuacan, Millon (1970:1079) identifies workshops for obsidian tool manufacturing, pottery making, and lapidary activities. Hundreds of obsidian workshops exist at the site. A recent study concerning craft specialization at the site is that of Spence (1981) "Obsidian Production and the State in Teotihuacan" (see also Spence 1982). He examines raw material types of obsidian (grey and green) and workshop locations to study the balance that knapper groups experienced between independence and state control. Spence finds both elements to be present in the patterns of evidence.

Also in the Valley of Mexico, Brumfiel (1980) uses archaeological and ethnohistorical information to study economic specialization at the site of Huexotla, a town site once dominated by Texcoco (a city-state ally of nearby Teotihuacan). It is argued the Huexotla evidence shows that as the Aztec civilization developed, local specialization and regional exchange did not. Instead, exchange of tribute for food between the urban and rural populations occurred. This interpetation is based on a surface survey where the local environment and artifact types, densities, and locations are analyzed (Brumfiel 1980:463-465). As critics point out (Brumfiel 1980:474), the paper lacks a theoretical core statement (or model) that her data can test. Instead, inferences are informally made, influenced largely by ethnohistoric information on the Aztec (Mexica). A weak inference is made that "felsite and prismatic blades, scrapers, [and] thick-walled vessels" were agricultural tools (Brumfiel 1980:463). Barbara Price, who with William Sanders conducted original work in the area which guided Brumfeil, points out that two kinds of archaeolgical craft specialist evidence were not searched for: 1) "settled wards of craftsmen" and 2) "a large, dense, permanently resident urban population (Brumfeil 1980:473)."

Some of the best evidence for ancient Mesoamerican craft specialziation, in the Maya area at least, is found at Colha. The references listed in Chapter II provide basic citations. Recent papers (Adams 1979; Hester 1982; Shafer 1982) suggest that Colha is an extraordinary example of craft specialization evidence in the Maya Lowlands. Also, Shafer (1982) uses Torrance's eight criteria for craft specialist stone workers (Torrance 1981:193; Table xx this thesis) and briefly compares them to the Colha material. Craft specialization is confirmed to have been present at Colha. The evidence cited is largely from analysis of three workshops at the site (Shafer 1979; Shafer and Oglesby 1980).

Before Colha was well known, R.E.W. Adams studied ancient Maya craft specialization evidence with regard to the way that "occupational" specializations could be ranked "by degree of complexity of skill and time demanded by their practice (Adams 1970:490)." Based mainly on inferences made from depictive sources, four stratified social classes are proposed. The highest class consists of leaders of ascribed status in administration, religion, warfare, trade, and public works. The three lower classes were ranked in status depending on the amount of direct communication their roles required with the elite. Here there were scribes and accountants, artisan specialists, and farmers last. Adams's placement of stone knappers was quite low (Adams 1970:497). This judgement might have been different had he then known of Colha's massive evidence.

Minor References. Numerous studies in Mesoamerican archaeology contain minor information (or opinions) on the presence of ancient craft specialization. Below I list a limited number of such sources.

In almost any study of trade in Mesoamerica, there is some implication for craft specialization. The material evidence is usually pottery or obsidian. For example, certain pottery types, such as Thin Orange wares (Smith 1958), are remarkably uniform and widespread. This may be an indication of highly developed trade and hence production (i.e. craft specialization). Rands (1967,1969,1973), Rice (1977,1980), and Fry (1979) have examined the role of ceramics in trade.

For early villages of Oaxaca, Flannery (1976) describes ancient household units and their probable relation to craft specialization. Part-time specialist flintknapping and mirror making, regional metate manufacturing specialization, and obsidian workshops are discussed (Flannery 1976:16,38,40). Continuing at the community level, a number of scholars have pointed to the importance of economically specialized communities and their regional interdependence (cf. MacNeish

1975:85-88; Beals 1975:41; Voorhies 1973). Voorhies (1973) offers an interesting comment for the potential social factors involved here, where a circulation of local resources and special products may occur for social requirements not crucial to the village self-sufficiency.

In the earlier described nucleation of Cerros, a site near Colha, Cliff (1982:46) believes "Occupational specialization may be a causative factor in the process of nucleation, especially in the case of urbanization". His support given for this idea includes the work at Teotihuacan, where the most densely settled and oldest occupational area corresponds to craft specialization evidence (Millon 1974:346-347).

Adams and Smith (1981) describe important analogies between the ancient Maya and feudal European civilization. The models of possible social systems are extra important here for craft specialization studies because of the nature of European craft guilds. Marcus (1983:469-473) has criticized aspects of this approach.

Finally, technological material described by Mesoamerican archaeologists sometimes offers implications for craft specialization. This could be simply in identification of "workshop" evidence that may or may not represent the traits I have promoted. Such technical examples are the Yucatecan shell celt industry described by Eaton (1974), mason's tool kits identified by Andrews and Rovner (1973), jade manufacturing workshops in Guatemala (Walters 1980), and obsidian quarries in Mexico (Clark 1979) and Guatemala (Coe and Flannery 1964). One warning here is that workshops do not always indicate the blanket presence of craft specialization. For example, at an outstanding obsidian quarry in the Valley of Mexico "localities we have designated as workshops are quite small and not representative of any intensive use." (Spence and Parsons 1972:19). It turns out that the workshop activities were unrelated to the major quarrying which probably sent raw material to distant urban craft specialists (Spence and Parsons 1972).

Ethnographic Studies. Many ethnographic studies have taken place in Mesoamerica and among them there is often a useful perspective for the study of ancient craft specializaiton. This why at least a few will be mentioned here. An assumption that archaeologists must make to use this information is that, although Mesoamerican culture and technology has changed quite a bit in recent times, at least some patterns of culture and technology (useful for analogy) are retained to some degree.

A major ehtnographic work in craft specialization in modern Mesoamerica is that of Ina Dinerman (1972). Here two types of specialized communities in Michoacan, Mexico, are described and contrasted: one a subsistence oriented Indian town, the other a Mestizo community. Through a series of comparisons of socio-economic data, it is determined that the Indian production is geared to maximizing security rather than pure monetary profit. For example, in Chapter 3 (Dinerman 1972), the peasant concept of confianza is explained. This is a type of informal credit establishment between circles of craftsmen. Although there are statements in Dinerman's work that post-European contact community specialization is not similar to ancient craft specialization, I think several ideas from this study should be kept in mind when considering ancient sites such as Colha. First, we cannot look at any craft community as isolated. Dinerman (1972:37) quotes Nash (1966:9) to say: ". . .

a regional marketing system based on economic specialization moves products along communities in a solar system . . .". A concept of Foster (1967:6) is noted: "It is not what peasants produce that is important, it is how and to whom they dispose of the produce that counts [Foster's emphasis] (Dinerman 1972:iv)". Finally, it is important to remember that "craft skills pass, not from adult to adult, but from adult to child (Dinerman 1972:39)". This is a factor that may account for some variation in the refuse and products of ancient craft specialists.

Considering more limited studies, Reina and Monaghan (1981) have documented community specialization in northwestern Guatemala. Certain Maya of the village of Sacapulas retain an ancient tradition of salt production. A major point is that symbols and tradition (costumbre) are a crucial element in the manufacturing activities, and in the desire for conservatism and continuity. For modern metate production in Oaxaca, Cook (1970) identifies marketing and non-marketing factors that probably influenced ancient craft specialists. A study of Sheils (1980) is a comparative analysis of 107 societies (including the Aztec and Maya). The unusual hypothesis is tested that human sacrifice occurs only in societies with a craft division of labor, corvee, and slavery. This is based on the reasoning that human life in such a context has great value both economically and spiritually - considered a condition ripe for religious sacrifice (Sheils 1980:247-248). Using Yale Human Area Relations File data, a statistical test suggests that increasing craft specialization does appear linked to slavery and sacrifice.

In terms of ethnohistory, Hicks (1982) investigates the Aztec urban wards or small dependent communities that were known as Calpolli. These production units had varied functions including structure as craft barrios (Hicks 1982:241-242). The discussion of production, tribute, social organization, and economic patterns in the broadest sense (i.e. city and "state" wide levels) has importance for the study of sites such as Colha.

A recent article (Hayden and Cannon 1983), in Maya Highland ethnoarchaeology, gives excellent insight on the distribution of waste matter by household and community units. Refuse is observed to have three potential states that predict disposal locations: 1) convenience (i.e. "casual", harmless refuse such as wood chips), 2) hindrance (i.e. "clutter" and possible dangerous items such as broken glass), and 3) potential for recycling (i.e. empty glass bottles that may be temporarily retained). Detailed discussion of behavior patterning and limits of evidence are provided (Hayden and Cannon 1983:157-160), and much of this has relevance to the archaeological study of craft specialization. Of pertinence to Colha, "discrete surface dumping areas" are assumed to relate to craft specialization in certain parts of Mesoamerica (Hayden and Cannon 1983:154).

Summary

The preceding dicussion should at least have given the reader an idea of how complex a subject craft specialization is. Perhaps even one researcher will hesitate to use the term without a bit of extra thoughtfullness.

To restate my definition of craft specialization, it consists of standardized, efficient production of goods by people who trade their products in some fashion for support from others. This activity takes place under a context of real or incipient civilization, where the craft specialists may be quite institutionalized. The concentration of this definition on efficiency and standardization is due to my own study interests - what I think the material under study is best suited to. Many other topics of craft specialization could be emphasized, and the potential for applying archaeological data from the Maya Lowlands is not necessarily limited for any of them.

Of the literature reviewed, I believe the better examples of study related to craft specialization are the work of Torrance (1981), Arnold (1984), Yerkes (1983), Prentice (1983), Sheets (1978), and Rice (1981). The cited dates of these efforts indicate the very recent interest in detailed studies of craft specialization.

CHAPTER V

LITHIC TECHNOLOGY

> The excecutioner approached promptly with a flint-stone, which was a knife that resembled a spearhead and was made of the hard stone with which they strike fire. The knife was not very sharp because, the stone being very coarse and brittle, it was not possible to make the knife very sharp. I mention this because many think that the knife was one of those which are made of the black stone . . .
>
> Motolinia's History of the Indians of New Spain (Steck 1951:114-115)

Introduction

This chapter is a combination of descriptive and technological explanation. It is both an entity in itself, by way of description, and a source of data for the interpretations of Chapter VI. In sequence below are the objectives of what I present in this chapter. This completes Objective 1 and addresses Objective 2 of my overall research plan (see Chapter I).

In "Explanation and Review of Lithic Analysis" I explain the nature of lithic analysis. A brief review of essential literature is necessary here. My aim is twofold: to explain this specialty of archaeology to the more general reader and to provide experienced researchers with a perspective on my approach. Certain terminology will be explained here.

Next the actual procedure of my analysis is detailed under "Analytical Procedure". This is mainly an explanation of how I measured the artifact forms and identified certain attributes. In part, this discussion continues to explain why I chose certain approaches and what my conception of lithic analysis is.

"Artifact Descriptions" present a rather lengthy description of the bulk of material collected at Op. 2007. Two major groups are portrayed: the biface and blade production systems. Other minor categories include battered and ground stone, and obsidian. All of these groups are broad technological classes previously identified at Colha. A textual discussion is aided by tabular data and illustrations. In this fashion quantification and simple statistics are coupled with a qualitative list of attributes.

In "Technology" I offer an explanation of the manufacturing process of the biface and blade industries - two prominent technological systems present. This is aided with simple linear models and helps to reconstruct the actual work behavior reflected in the evidence. Much of contemporary lithic analysis is a procedure of insight and inference-making based on the observation of descriptive information.

Finally with "Concluding Remarks", I offer information revealed by minor descriptive categories which represent parts of additional technological systems. This may include technological processes observed <u>besides</u> manufacturing. Next, the <u>oval biface</u> and <u>stemmed blade</u> manufacturing systems are discussed broadly as they relate to procurement, distribution, and so on. This includes speculative estimation of completed tool quantities.

Explanation and Review of Lithic Analysis

The study of lithic technology is a young discipline only now beginning to show indications of theoretical and technical cohesion. Stone technology has a continuous representation from at least the past two million years (Campbell 1982:222-227). Because this evidence is most durable and abundant, a variety of references exist. Only a few of many works will be cited below.

If early lithic studies were static, unfocused, totally descriptive, or under-descriptive, this is probably no more than a reflection of archaeology's growth as a discipline. As recently as the 1960s, lithic analysis was primarily descriptive, with a view that the evidence represented static outcomes: waste chips seldom worth collecting, and various tools always finished and utilized in simple, universal ways. Concepts and interpretations were often "buried in commonsense" assumptions (Spaulding 1982:1) to the effect that few if any explicit statements on the theory of lithic analysis existed. Intuitive, functional assessments followed morphological descriptions for stone artifacts frequently summarized by titles such as "knife, scraper" and so on. With an emergence of evolutionary themes, ecological views, and systems theory, archaeologists began to examine data - including lithics - in different ways (Willey and Sabloff 1974).

General Terms

Lithic technology is what archaeologists use to describe the procedure of making and using stone tools, by way of ancient evidence *and* modern replication. The word lithic is derived from Greek *lithos* or stone (Crabtree 1972:74). *Knapping* (Webster 1968:1004), a term often used by archaeologists, is synonomous with the act of breaking and shaping stone. For "flintknappers" (stoneworkers), Crabtree (1972:94) emphasizes technology to involve the importance of "interpreting the combined or distinct attributes of individual techniques" for stone artifact manufacturing. This is an adaptation distinct of the term as I earlier defined it. Under my definition, technology (including lithic technology) is better visualized as an interface between people and their environment.

Technological analysis follows Crabtree's definition of technology. It is a method and perspective for study where trajectories of artifact forms under a sequence of modifications are identified. Although particular attention is given to the reductive means of production for an artifact class, other stages are easily incorporated (i.e. use). A well worn truism for lithic technologists is that stone tool manufacturing is a reductive process in terms of mass. Once a stone is fractured the pieces cannot rejoin. Thus success and failure in working stone is a one-way process. Because the entire sequence of production is examined, technological analysis involves systems of evidence, where manufacturing waste and finished products alike are considered. As Crabtree (1969:4) states, waste flakes may sometimes furnish more information than finshed artifacts, which may be absent. Using information like this, the modeling of a system may take place. Sheets (1975:369-374) provides a detailed statement on the theory of technological analysis. In essence, the "objective is to translate, with as high a degree of accuracy as possible, the attributes observed into past actions, and then to place those actions in a heirarchy of procedures and products which represents the original organization of that industry (Sheets 1975:372)." The work of Shafer (cf. 1979) among others is an example of this kind of research. Flow chart models commonly depict technological analyses (see below). Even a single artifact may provide significant information affecting the construction of these models.

Materials

A variety of stone material is suitable for people to chip, batter, and grind into useful artifacts. These materials include flint, chert, basalt, chalcedony, jasper, quartzite, siliceous wood, and volcanic glass. Here, I will only define those types present in the Op. 2007 collection. Silica (SiO_2) is the basic constituent for all these materials. Many of these stones are _cryptocrystalline_ and relatively _isotropic_. The former term means that texture is such that individual crystals are too small to discern with the unaided eye. Isotropic quality exists in an object with the same property displayed in all directions. This means that if a stone is of relatively homogeneous material, its fracture potential is equal in all planes. Also, heat and moisture have an effect on stone material (Lawn and Marshall 1979:78; Crabtree and Butler 1964).

Flint and chert are basically of the same structure. Flint is "a dense fine-grained form of silica which is very tough and breaks with a conchoidal fracture . . . " (American Geological Institute 1976:165). Chert is "a compact siliceous rock of varying color composed of microorganisms or precipitated silica grains. Occurs as nodules, lenses, or layers in limestone and shales." (American Geological Institute 1976:72). Archaeologists tend to use the terms as interchangable, with some informal preference for chert. Flint is generally considered to be finer grained than chert. At Colha, chert constitutes the ubiquitous local resource. It is of "typically banded or mottled gray, yellowish brown or brown opaque or faintly translucent materials" (Shafer and Hester 1983:521). Patination, or chemical weathering, exists on many Colha artifacts including those of Op. 2007. Cortex has been recognized to have two forms. The first is present on nodules that have apparently been exposed on the surface for long periods of time. This cortex is pale to dark brown, thin (ca. 1-2 mm), dense, and resistant to abrasion (which has already occurred naturally). A minutely irregular surface often exists corresponding to interior banding, inclusions, and the like. The interior of surface cortex nodules is often brown or yellow-brown but various shades of grey also occur. The other cortex is considered "mined" because it has much thicker, chalky white cortex which may be easily removed, even unintentionally, by handling. Its surface is smooth. Occasionally a distinctive inner rind of black chert (ca. 1 mm) lies just under this cortex while the interior may be pale banded grey or brown.

Quartzite is a "granulose metamorphic rock consisting essentially of quartz . . ." (American Geological Institute 1976:351). I use the term here in a broad sense to refer to the material of the Maya Mountains (Rice 1974:9-11). Other metamorphic rocks, as well as igneous intrusives, were imported to northern Belize from this mountain range (Sidrys and Andresen 1976:181), which is a probable source for a small amount of groundstone described in this chapter.

Volcanic glass, or obsidian, was imported in small amounts at Colha. It is a natural glass produced by the rapid cooling of molten lava which prevents crystallization (American Geological Institute 1976:302,456). Colors may vary from black, grey, brown, red, and green with additional degrees of translucence. A small amount of obsidian is part of the present collection. Most if not all of the obsidian at Colha was imported from Guatemala (Hester and Michel 1980).

Broad Analytical Categories

Six analytical categories of lithic technology are discussed below. A technological analysis generally utilizes them all if possible, and I present them here as an extension of my explanative review. The headings are: terminology, morphology, typology, mechanics of fracture, replication, use-wear, and reduction models. Other specialties exist, such as the study of raw materials (chemical trace characterization, source mapping, etc.).

Terminology in lithic technology forms an essential but often inconsistent or vague glossary for archaeologists. From the time of de Perthes identification of "axes" in the 1800s (Campbell 1982:9), researchers have been mixing the use of intuitive, inferred, and original labels to describe and order the appearance and functions of stone artifacts. Since the 1950s New World archaeologists have adopted a more scientific approach (Willey and Sabloff 1974:182) and terminology in all facets of anthropology has improved. The "trickle-down" effects are only now reaching lithic analysis. Examination of Lithic Technology (origin 1972 as The Newsletter of Lithic Technology) reflects this trend. Both Hester (1976) and Sheets (1976) identify problems of lithic terminology specific to the Maya area. Focus has understandingly been on monumental evidence and the like in this region. For lithic analysts, the single best reference for terminology probably remains that of Crabtree (1972). If aided by other sources such as Hayden (1979:133-135) it is possible to interpret most contemporary information and to generate useful reports. A lingering problem is that lithic technologists remain an anthropological minority made up of basically independent researchers. In verbal and written expressions, individuals may interpret and offer multiple nuances from a single term. Formal and informal substitutes are often employed, and there is a tendency yet for personalized or uniquely defined terminology. The growth of a discipline often involves such confusion.

For archaeologists, morphology is the study of the material form (or structure) of an artifact or artifact group. The function of an artifact (see "use-wear" below) and other physical or interpretive analysis is inextricably dependent on a morphological base. Typology is one good example of this (again, see below). Morphological description is unfortunately sometimes conducted with little directive purpose. With stone artifacts this is probably because "one can occasionally get lost in insignificant details, or else not know how to seperate what is important from what is not." (Bordes 1969:3). Any kind of data analysis might evolve to this condition. The point I make is that morphological studies should have explicit objectives which, ideally, seek finer levels of new information beyond material description.

Typology, or classification, is "the ordering of phenomena into groups (classes), based upon the sharing of attributes" (Sharer and Ashmore 1979:560). It is an important category in particular because chronological schemes are often based upon it. While terminology and morphology have a part in all kinds of analysis, they are extra important for typology. Expedient and practical use of these combined approaches is common, but the logical foundations are actually complex and not well resolved. A recent collection of papers expressing this theme is that of Whallon and Brown (1982).

The mechanics of fracture is an aspect of lithic technology often explained from the perspective of physicists and engineers. Whenever a lithic mass is altered by manufacturing techniques of percussion, pressure, and abrasion, certain attributes of fracture are predictable. The distinctive attributes pertain to the examination of the fractured surface of the parent mass (e.g. core) or the residual item (e.g. flake). In practice, the minute features of the initial fracture area (the striking platform), the general field of fracture (the scar or flake face), and the area of termination (final detachment) are examined. The energy and effects of tensile, compressive, and shear forces are studied (Cotterell and Kamminga 1979). Brittleness is also investigated. This term pertains to qualities of elasticity in "material which fails [fractures] by well-defined crack growth" (Hayden 1979:xvii; see also Faulkner 1972:6-12). A good conceptual view for brittleness is to consider it a degree of rigidity. That is, an elastic undergoes a fracture from loaded force, but it is resistant to deformation up to the moment of fracture. All resultant fragments of material are essentially rigid - they spring back to their original sizes. One example would be for a person to press (and bend) a window pane until it breaks. Rigid material is not necessarily strong (i.e. a wine glass, sheet rock panels, etc.). Some important statements of fracture are the works of Tsirk (1979), Faulkner (1972), and Speth (1972). One concept well explained by Tsirk (1979) remains poorly understood by some archaeologists.

This is the principle that tensile (bending) forces are interacting with compressive stress when material like chert is reduced (cf. Cotterell and Kamminga 1979). Details in the production of stone tools generally cannot be concealed from one knowledgeable in both fracture mechanics and practical flintknapping.

Replication for lithic technology is the manufacturing and use of stone tools by modern researchers seeking insight on ancient behavior. This practice of analogy may be placed under the rubric experimental archaeology (Sharer and Ashmore 1979:472-473), where replication has been attempted even for whole communities. Because it permits the controled production of total collections of material for comparison, replication is among the most useful activities for students of lithic technology. Francois Bordes and Don Crabtree were among the premier replicators of stone technology. Two replicative studies of Mesoamerican obsidian blades happen to be among the best examples of published studies. Crabtree (1968) utilized a chest crutch pressure tool and vise to produce near perfect copies of the original artifacts. In the midst of some controversy over the early Spanish accounts of blade-making, which are somewhat vague, Clark (1982a) replicated obsidian blades using a second conjectured Aztec technique. Here, the worker sits and uses a pressure tool braced by stomach and hands against a core held by the feet. Ethnographic analogy, which could be considered a seperate category of analysis, is an important companion of replication (e.g. Cook 1976).

Use-wear in lithic technology pertains to the careful examination of the working surfaces of stone tools for an explanation of function. This involves both the use of microscopes and unaided observation.

Often dependent on replication for "control" artifacts, use-wear analysis links archaeological inferences to the physical material. This is an important advancement emphasized since Semenov (1964) pioneered modern use-wear analysis. Olausson (1980) provides a good review of the history of use-wear studies. Because the material from this workshop is primarily manufacturing refuse, I do not attempt use-wear analysis. Although a seperate category could be assigned, I will mention the study of style here because it is both the partner and antithesis of utilitarian function (Sackett 1977:370). Any definition of style is ambiguous, but it involves "a highly specific and characteristic manner of doing something . . . always peculiar to a specific time and place" (Sackett 1977:369-370). Material attributes may be the result of style, but the concept itself works at the level of meaning rather than form. Style has an important role in typology (Read 1982:76-79; Brown 1982:180-183).

Reduction models, or more properly, linear reduction models, have been used increasingly to show the sequence of modifications in a stone artifact's "life". Flow charts or tree-diagrams are the usual graphic construction. The continually subtractive process of mass reduction (discussed earlier) is portrayed by these schemes. In the actual procedure, a fair sample of the range of lithic evidence from a site or region is first examined and sorted with technolgical attributes in mind. Next, inferences are based on identified stages of the reduction continuum, and exemplary artifacts are related, often provisionally, to a model format. Examples of this kind of research include the work of Kobayashi (1979), Collins (1974), Muto (1971), Schiffer (1972), Bradley (1975), and Shafer

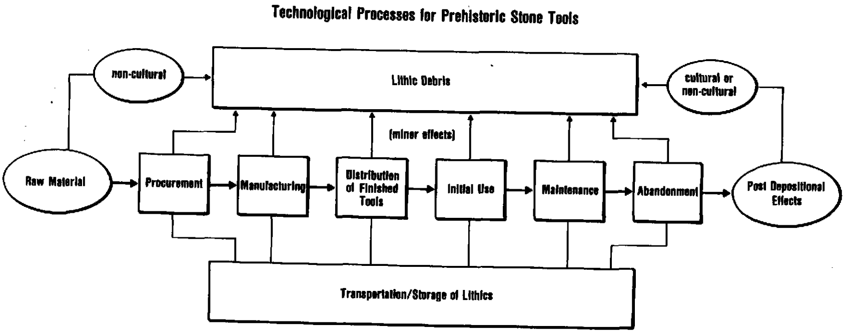
(1973, 1979).

Technological Stages

I use a very generalized technological flow chart (Figure 11) as a background model for studying the process of lithic technology. It is discussed here as a final explanation of lithic technology. Specific linear reduction models can be superimposed on the scheme. I have based this general model on Sheet's (1978b) use of a model of Luten (1971). The six technological stages (Figure 11) are briefly discussed below. I believe this approach can be modified to the analysis of stone tools in almost any context.

Procurement is the collection and possible initial reduction of lithics at their natural source. The investigation of procurement is intimately related to raw materials. Raw materials also can be visualized as the indirect material basis for any of the following stages. Obviously, improved knowledge at this point aids understanding the later stages. Note that this activity creates the first culturally produced lithic debris, and that the movement by humans of material from its source may begin.

Artifact manufacturing actually begins with procurement. A division is made here because: 1) procurement can involve only movement of raw materials without modification, 2) "manufacturing" as an activity best summarizes the bulk of reductive effort seperating raw material from the finished product, and 3) there is a trend in the archaeological literature to suggest that major reduction and "finishing" of stone artifacts occurs as a spatial and technical activity distinct from procurement (cf. Torrance 1981:226-227). Various situations may be complex. For example, cobbles may



Technological Processes for Prehistoric Stone Tools

Figure 11. Flow chart for broad scheme of lithic technology.

outcrop in sizes efficient for potential transport to domestic bases where both intial and final reduction takes place. Complete reduction might also occur at the procurement locality. Or, only a few "test" flakes may be removed to verify material quality at the time of procurement. A specific manufacturing process depends on the ultimate product form sought. With few exceptions the majority of lithic debris is created at this stage.

The term distribution is used here to refer to the economic distribution of finished stone artifacts. This process can range from primitive hunter-gatherers making and using their own tools to the sophisticated redistributive systems found in civilized groups. Transportation may be at its greatest here, while lithic debris is often minimal, assuming finished products are not broken or severely reduced in transit! Again, it is possible that manufacturing may grade into distribution. For example, products may be distributed with the final modifications to be done by the consumer.

The initial use of tools is the technological stage where an artifact functions as originally intended, and remodification and deletrious wear has not occurred. Rarely is substantial lithic debris produced at this point. Without experimental and use-wear studies, it is often difficult to seperate finished but unused stone tools from those that reflect intial use. I suspect that there has been some mixing of the two states in various studies, but intuition also suggests that tools made for a certain mundane task seldom enter the archaeological record unused.

Maintenance pertains to the sustained use of tools in their original function and the recycling of tools or tool fragments for new uses. In the former case, modification such as edge sharpening may occur, while recycled lithic artifacts are often termed "reworked". Shafer (1983) describes tools which probably came from Colha and underwent this process in a consumer area. I subsume recycling to maintenance because, while this activity probably most often happens at this point, abandoned tools and lithic debris from any stage can be recycled into what may be called "second order" tools (Shafer 1983).

The term abandonment refers to the discard of artifacts by their original users. Because all archaeological material is abandoned in the larger sense, the search for patterns here is a popular but complex realm of study (e.g. Binford 1978). Only rarely is disposal nicely isolated - the lithic midden of this thesis being an exception. Abandoned materials of many types and technical stages are often informally scattered in prehistoric and modern societies. Although this process also includes artifacts occasionally lost (i.e. not deliberately discarded), I consider this to be of minor effect. Post-depositional effects may severely alter the artifacts or their context (Schiffer 1972).

Summary for Introduction

If the preceding discussion is difficult for the person not oriented to lithics, I recommend two readings. Crabtree's (1972) lexicon remains a basic reference although its terminology is sometimes modified or ignored in various recent works. Most of Crabtree's definitions are self-explanatory to the general reader. Second, the edited volume of Hayden (1979) is essential reading. Despite its title, Lithic Use-Wear Analysis, the book has a good range of information from the mechanics of fracture to the nature of raw material.

Terminology is refined and explict (Hayden 1979:133-135). The manufacturing process, however, is not a primary topic here. Hester (Review of Hayden, American Antiquity 47[2]:453-455) provides an overview of the work.

Analytical Procedure

Lithic analysis is generally conducted through a process of morphological analysis with technological inferences based on various observations. Because perspectives can change for the analyst as morphological analysis is conducted, the procedures explained below do not exactly recite the sequence of my analysis. This lack of analytical formality is largely because few persons today have a highly developed practical knowledge of lithic technology. When this situation does exist, the person is often a replicator required to be interested either in generalized aspects of lithic technology without concentration on a particular time, place, and culture, or in one of a few very specialized aspects. In other words, one might spend years (indeed a lifetime) simply trying to achieve mastery of one particular class of tools known from Colha. I admittedly practice lithic analysis without the complex insight of analysts such as Bordes or Crabtree.

Despite growing sophistication, lithic analysis remains very much a "hands on" process of artifact inspection. The analyst potentially makes inductive judgements from the first exposure of artifacts in the field. These inferences are often supported through knowledge of work by others, previous laboratory experience, and other personal experience including replication. As a result, procedure and reasoning are often flexible and implicit. On the positive side this permits an adaptive approach where new information can be quickly accepted, and previous ideas modified or rejected. For example, a novel attribute may be found on a single artifact encountered after months of analysis. This information might greatly affect the on-going model of reduction for that artifact class. The drawback is that explicit research for lithic analysis of this sort can seldom be formalized in a precise or deductive fashion. Also, provisional ideas an analyst might have may never be expressed in writing. General procedures of analysis may become intuitive and variable to an unreasonable degree. In any event, this practice of flexible assessment works when the analyst is competent and percieved as such professionally.

Objectives Reviewed

At this point I reemphasize the objectives that directed my lithic analysis (see also Chapter I). A basic morphological description of the collection serves three purposes: 1) it completes the major descriptive presentation of the workshop, 2) it provides a base for the inference-making related to technological analysis, and 3) it provides some of the data useful for interpreting craft specialization. As the previous explanations make clear, morphological study is not a simple undertaking. Many of the other analytical categories I describe are involved.

Initial Sorting

After field recovery, cataloguing, and transportation of the material to Texas, early analysis pertained to the manipulation of the collection into broad classes. Bags from sub-operations and levels were first put into order and their contents emptied upon large tables. Only the debitage column samples did not have individual artifacts (i.e. flakes) labeled. The typology used was one earlier established at Colha (Hester et al. 1980a:10-11). Late Classic oval bifaces and a core-blade industry are the major artifact classes at Op. 2007. None of the above procedure was necessarily difficult, but this stage of general inspection is important for the inductive process of lithic analysis.

Equipment

Unless certain use-wear studies are conducted, lithic analysis does not require overly specialized or expensive tools. I used the following equipment: a transparent ruler (mm), a caliper (mm, plastic prefered), a plastic contact goniometer (0-180°, 10 mm long), a transparent grid counter for core platform area measurement (in cm^2), a 2610 gm capacity triple beam scale, and seven geologic sieves (squares labeled - 2.5 inch [63.5 mm]; 2 inch [50.8 mm]; 1.49 inch [37 mm]; .75 inch [19 mm]; .625 inch [16 mm]; .375 inch [9.52 mm]; .25 inch [6.35 mm]. The larger of these seives are not commonly used by geologists or soil scientists. I obtained them from transportation engineers who use them in sorting road bed aggregate. Computer coding sheets, plenty of table and shelf space, and good lighting was also required. A final elaborate tool I had access to was an Amdahl 470 computer (see below).

Measurements

The material required binomial, nominal, and ratio scales of measurement respectively for presence/absence categories, states of quality or quantity, and metric forms. Except for small classes of artifacts, such as the obsidian, all measurements were coded for computer manipulation. For each artifact examined, additional comments were often made on the coding sheet margin or in notes elsewhere. In almost every case, single artifacts were assigned unique numbers which were penciled or inked near the original label. This permitted unusual artifacts to be reexamined, and coding errors to be checked. The specific measurement codes for each class or type of artifact are listed in Appendices 1-3. Most of the measurements are very basic to the descriptive and technological needs of lithic analysis. Some assessments were admittedly subjective. For example, I judge chert grain to have three states. Fine grain is that which has a vitreous-like surface in appearance and feel. Coarse grain is definitely that. A textured minute surface is both visible and noticeable to the touch. Mixed grain pertains to an item that typically has fine grain with substantial veins or inclusions of coarse grain. Because an objective way for measuring grain texture of chert artifacts apparently does not exist, I think terms like "medium" as compared to "fine" grain are overly ambiguous. As I discuss in Chapter VII, the accurate relationship between any single measurement and specific behavioral implications is not necessarily well understood. The measurements strike a compromise for relevance both in terms of my objectives and the traditional comparitive needs of other reseachers.

Sampling-Attribute Coding

Despite the benefits of a computer, laboratory sampling was required for one type of artifact recovered in great quantity: unmodified blades. I attempted to measure the total collection (ca. 2500) but later restricted certain units and levels to random samples of at least 20% drawn in the following way. I unbagged and spread out all of the blades from an excavation provenience in a subjectively random series of rows on a table. Next, unique numbers were penciled adjacent to each blade on the paper table cover. I then took numbers from a statistical table of random digits until the sample size was achieved. Combined with the first attempt of total examination and additional nonrandom selections, about 68% (ca. 1700) of the blades were measured. Others have indicated that blades are an artifact well suited to restricted sampling (Redman 1975:149; Cherry 1978; Torrance 1978). Additionally, I ran sampling tests on one unit's level which had been totally measured (700+ blades). Indications were that simple statistics varied little with decreased random samples within that group (Table 5).

Actual attribute coding was not complicated for the material. Those morphological traits traditionally measured by lithic analysts were assessed. Only the column sample debitage and small classes of artifacts such as battered stone were not computer coded. Chert color and patination were so variable, even within single artifacts, that these qualities were not examined. Appendices 1-3 list specific attributes coded for bifaces, blades, and blade cores. The values of attributes are briefly explained in the listings.

Apart from the bifaces, blades, and blade cores, the constant volume samples were sorted into groups related to probable blade or biface reduction categories. The debitage was then quantified via the sieves. The small amount of obsidian and battered or ground stone was only briefly examined. Measurements and description here are more limited.

Table 5. Results of random sample of Sub-op. 1, Level 1 blade measurements compared to total collection.

	N	Mean	Standard deviation	Minimum value	Maximum value	Variance	Coefficient of variance
Maximum length (mm), total collection	727	25.97	11.27	3	90	12.70	43.39
Maximum width, 20 % sample	150	24.76	9.73	7	46	9.48	39.29
Maximum length (mm), total collection	728	61.51	24.47	10	149	59.90	39.78
Maximum length, 20% sample	150	61.05	22.89	19	118	52.43	37.49
Maximum thickness (mm) total collection	728	6.48	4.29	1	41	1.84	66.20
Maximum thickness, 20% sample	150	6.16	4.09	1	22	1.67	66.39
Platform width (mm) total collection	463	13.98	6.96	1	48	4.84	49.78
Platform width, 20% sample	99	13.12	6.13	2	35	3.76	46.72
Platform depth (mm), total collection	460	5.85	3.67	1	33	1.34	62.73
Platform depth, 20% sample	99	5.51	3.47	1	19	1.20	62.97
Platform angle (°), total collection	438	100.22	8.92	70	135	79.60	8.90
Platform angle, 20% sample	93	98.89	9.19	70	125	84.57	9.29

Computing

While encoding data may be time consuming, I believe it is no more so than working with hand written laboratory data. Computer encoding sheets can double as written records (there is usually room for written comment at the end of each entry) and, most important, data assembled like this must be logically organized. Once the information is on tape, it can be rapidly utilized in many ways. I have used the facilities of Texas A&M (Data Processing Center 1983) and the Statistical Analysis System program (SAS 1982). SAS is considered a generalized package for statistical analysis, graphics, and report writing. Although the SPSS program (Nie et al. 1975) has been popular with anthropologists, SAS is a competitive alternative. As will be seen, very basic descriptive statistics are the primary use I made of this program. Other benefits of computer use include the permanent, transferable data record created, its compatability for future additions of data, and its potential for use in more sophisticated statistical analyses.

Descriptive Presentation

For each class or sub-class of lithic artifact I provide a descriptive summary including illustrations and tables of simple descriptive statistics. The sections here are: bifaces, tranchet flakes, blades, blade cores, core tablets, battered-abraded stone, and obsidian. Technological interpretations are later made for the same groups. Unique items and finer divisions for some artifact classes may be found under "Technological Insight" and "Concluding Remarks". The provenience of bifaces, blades, and blade cores (the major collection) may be found within the series of descriptive tables cited for each group. Terms of lithic technology are either defined in the text, or assumed to be known by the reader.

Bifaces (N=309)

General Morphology. A biface is a chipped stone artifact with two major faces (Crabtree 1972:38). The biface collection almost exclusively represents manufacturing failures. The vast majority of these artifacts are classified as oval bifaces (N=285, Figures 12-13; Shafer 1979:54-60). If completed and found in other contexts, they are assumed to have been used as axes or hoes (Shafer 1983). A small number of Op. 2007 bifaces are tranchet-bit tools (N=15, Figure 14; Shafer 1979), tapered bifaces (Shafer and Hester 1983:531), and unclassified forms (Figure 15). The bifaces are sorted into proximal (tapered), distal (oval), and medial fragments plus whole specimens (Table 6). Of the oval biface fragments, 28 were refitted as 14 complete specimens (Figures 12-13). The sizes of these reconstructed bifaces range from 275x94x31 mm to 130x55x24 mm (length-width-thickness, respectively). Specific measurements on biface morphology are provided by Tables 7-13.

Material. The bifaces are all made from local Colha chert. Of 287 oval bifaces, about 40% have no cortex, 52% have cortex which is probably of surface origin, and 7% have "mined" cortex (Table 12; see "Technological Insight" below). Most of the material is considered fine grained (Table 12), although material flaws and coarse grained material are present.

Additional Variables. A few other variables were

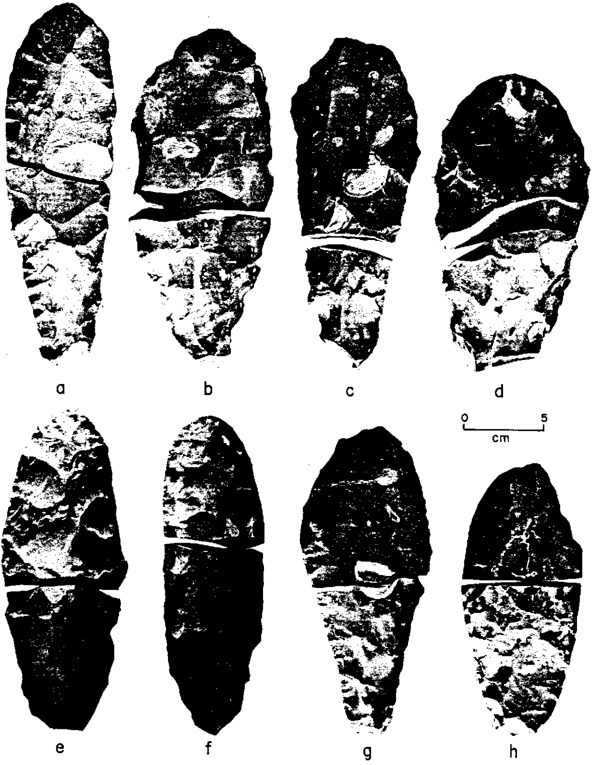


Figure 12. Refitted <u>oval</u> <u>bifaces</u> broken in manufacture (a-h).

Figure 13. *Oval bifaces*: (a-d,g,h) refitted manufacturing failures; (e) resharpened *oval biface* with example of resharpening flake; and (f) complete but rejected *oval biface*.

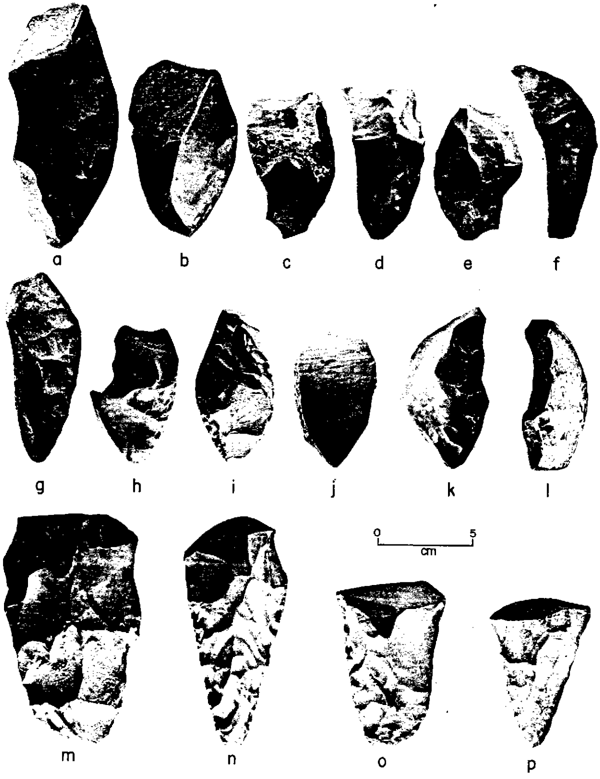


Figure 14. Tranchet technique artifacts: (a-l) tranchet flakes, and (m-p) tranchet-bit bifaces.

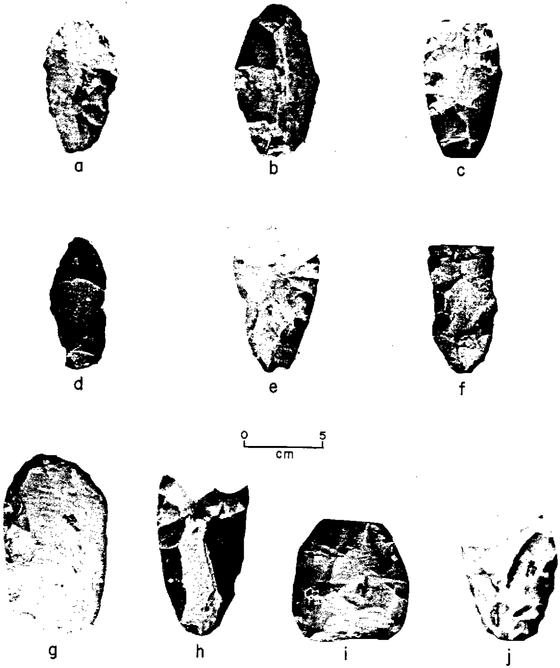


Figure 15. Miscellaneous bifaces from Op. 2007 (a-j).

Table 6. Provenience of Bifaces at Op. 2007, Sorted by Two Classes and Five Forms.

		BIFACE CLASS											
		Oval					Tranchet-Bit						
		BIFACE FORM					BIFACE FORM						
		Whole, Unused	Whole, Used	Prox. Frag.	Medial Frag.	Distal Frag.	Whole, Unused	Whole, Used	Prox. Frag.	Medial Frag.	Distal Frag.		Level Totals
SUBOPERATION	EXCAVATION LEVEL	N	N	N	N	N	N	N	N	N	N	Freq.	N
Subop. 1	Level 1	2	3	20	1	4	2	0	0	0	0	32	32
	Level 2	2	0	2	1	8	0	0	0	0	0	13	13
	Level 3	1	0	8	1	10	1	0	0	0	0	21	21
	Level 4	0	0	14	1	10	2	0	0	0	0	27	27
	Level 5	1	0	10	0	9	0	0	0	0	0	20	20
	Level 6	2	1	14	0	8	1	0	0	0	0	26	26
	Level 7	0	0	9	0	6	0	0	0	0	0	15	15
	Level 8	1	0	15	0	14	1	0	0	0	0	31	31
	Level 9	0	0	4	0	1	0	0	0	0	0	5	5
Subop. 2	Surf./No Prov.	0	0	0	0	0	1	0	0	0	0	1	1
	Level 1	1	0	0	0	0	0	0	0	0	0	1	1
	Level 2	2	1	0	0	0	2	0	0	0	0	5	5
	Level 4	1	2	0	0	0	0	0	0	0	0	3	3
	Level 5	2	2	0	0	1	0	0	0	0	0	5	5

(CONTINUED)

Table 6 continued.

		BIFACE CLASS											
		Oval					Tranchet-Bit						
		BIFACE FORM					BIFACE FORM						
		Whole, Unused	Whole, Used	Prox. Frag.	Medial Frag.	Distal Frag.	Whole, Unused	Whole, Used	Prox. Frag.	Medial Frag.	Distal Frag.		Level Totals
		N	N	N	N	N	N	N	N	N	N	Freq.	N
SUBOPERATION	EXCAVATION LEVEL												
Subop. 3	Surf./No Prov.	0	0	1	0	3	0	0	0	0	0	4	4
	Level 1	9	6	20	0	25	0	1	0	0	0	61	61
Subop. 4	Level 1	2	1	3	0	0	0	0	0	0	0	6	6
Subop. 5	Level 1	1	0	1	0	2	1	0	0	0	1	6	6
Subop. 6	Level 1	0	0	0	0	0	3	0	0	0	0	3	3
Subop. 7	Level 1	2	2	0	0	0	0	0	0	0	0	4	4
Subop. 8	Level 1	1	0	0	0	0	0	0	0	0	0	1	1
Subop. 9	Level 1	1	0	0	0	0	0	0	0	0	0	1	1
Subop. 11	Level 1	0	0	1	0	0	0	0	0	0	0	1	1
	Level 2	0	0	5	0	4	0	0	0	0	0	9	9
Biface Totals		31	18	127	4	105	14	1	0	0	1	301	301

Table 7. Maximum Length of Op. 2007 Bifaces, by Class and Form.

		MAXIMUM LENGTH (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BIFACE CLASS	BIFACE FORM						
Oval	Complete, Unused	31	108.2	80	202	26.7	24.7
	Complete, Used	18	99.1	74	128	14.6	14.7
	Proximal Frag.	127	89.3	15	150	23.2	25.9
	Medial Frag.	3	98.3	70	130	30.1	30.6
	Distal Frag.	106	91.0	32	158	22.0	24.2
Tranchet-bit	Complete, Unused	14	96.3	77	125	14.2	14.7
	Complete, Used	1	113.0	113	113	.	.
	Distal Frag.	1	38.0	38	38	.	.
Total		301	92.8	15	202	23.2	25.0

Table 8. Maximum Width of Op. 2007 Bifaces, by Class and Form.

		MAXIMUM WIDTH (mm)					
BIFACE CLASS	BIFACE FORM	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
Oval	Complete, Unused	31	57.4	45	79	7.3	12.8
	Complete, Used	18	58.3	43	75	7.6	13.0
	Proximal Frag.	127	64.0	36	125	14.1	22.1
	Medial Frag.	4	54.0	46	63	8.8	16.2
	Distal Frag.	106	71.4	46	115	13.3	18.7
Tranchet-bit	Complete, Unused	14	53.4	42	70	7.5	14.1
	Complete, Used	1	49.0	49	49	.	.
	Distal Frag.	1	64.0	64	64	.	.
Total		302	64.9	36	125	13.8	21.2

Table 9. Maximum Thickness of Op. 2007 Bifaces, by Class and Form.

		MAXIMUM THICKNESS (mm)					
BIFACE CLASS	BIFACE FORM	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
Oval	Complete, Unused	31	25.9	18	52	7.1	27.4
	Complete, Used	18	24.4	15	35	5.9	24.1
	Proximal Frag.	127	25.0	10	40	5.3	21.3
	Medial Frag.	4	21.3	11	27	7.0	33.1
	Distal Frag.	106	26.0	13	45	5.3	20.3
Tranchet-bit	Complete, Unused	14	24.2	18	37	5.2	21.5
	Complete, Used	1	25.0	25	25	.	.
	Distal Frag.	1	20.0	20	20	.	.
Total		302	25.3	10	52	5.6	22.0

Table 10. Width at Break for Op. 2007 Biface Fragments, by Class and Form.

		WIDTH AT BREAK (mm)					
BIFACE CLASS	BIFACE FORM	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
Oval	Complete, Unused	0	.	.	.	.	.
	Complete, Used	2	44.0	36	52	11.3	25.7
	Proximal Frag.	123	65.6	36	116	13.9	21.1
	Medial Frag.	2	53.0	46	60	9.9	18.7
	Distal Frag.	104	66.4	37	115	15.6	23.5
Tranchet-bit	*Complete,* Unused	0	.	.	.	.	.
	Complete, Used	0	.	.	.	.	.
	Distal Frag.	1	46.0	46	46	.	.
Total		232	65.6	36	116	14.8	22.6

Table 11. Thickness at Break for Op. 2007 Biface Fragments, by Class and Form.

		THICKNESS AT BREAK (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BIFACE CLASS	BIFACE FORM						
Oval	Complete, Unused	0	.	.	.	.	.
	Complete, Used	2	16.0	15	17	1.4	8.8
	Proximal Frag.	121	23.6	12	40	5.3	22.2
	Medial Frag.	3	24.7	23	27	2.1	8.4
	Distal Frag.	106	23.8	10	45	5.5	23.1
Tranchet-bit	Complete, Unused	0	.	.	.	.	.
	Complete, Used	0	.	.	.	.	.
	Distal Frag.	1	20.0	20	20	.	.
Total		233	23.6	10	45	5.3	22.6

Table 12. Texture and Cortex of Op. 2007 Bifaces, by Class and Form.

		TEXTURE										
		Fine			Coarse			Mixed				
		CORTEX TYPE			CORTEX TYPE			CORTEX TYPE				
		None	Surface	"Mined"	None	Surface	"Mined"	None	Surface	"Mined"		
		N	N	N	N	N	N	N	N	N	N	Percentage
BIFACE CLASS	BIFACE FORM											
Oval	Complete, Unused	10	6	0	2	1	0	8	4	0	31	10
	Complete, Used	8	2	1	1	0	0	3	1	0	16	5
	Proximal Frag.	10	53	10	19	11	0	9	13	2	127	42
	Medial Frag.	0	1	0	1	0	0	1	0	0	3	1
	Distal Frag.	24	40	8	6	6	1	10	11	0	106	35
Tranchet-bit	Complete, Unused	6	4	0	0	0	0	3	1	0	14	5
	Complete, Used	0	1	0	0	0	0	0	0	0	1	0
	Distal Frag.	1	0	0	0	0	0	0	0	0	1	0
Total		59	107	19	29	18	1	34	30	2	299	100

Table 13. Descriptive statistics for tranchet flakes (N=64).

Primary with cortex (N=24):

	Mean	S.D.	Minimum	Maximum	
Length (mm)	78.4	13.3	31	96	
Width (mm)	35.0	8.0	17	58	
Bit Angle (^{o})	69.8	8.0	55	86	

Primary without cortex (N=28):

	Mean	S.D.	Minimum	Maximum	
Length (mm)	85.6	12.4	64	102	(missing=9)
Width (mm)	32.8	6.1	16	43	
Bit Angle (^{o})	67.7	10.5	49	89	(missing=2)

Secondary Removal with cortex (N=2):

	Mean	S.D.	Minimum	Maximum
Length (mm)	93.5	n/a	92	95
Width (mm)	47.5	n/a	45	50
Bit Angle (^{o})	66	n/a	61	71

Secondary Removal without cortex (N=10):

	Mean	S.D.	Minimum	Maximum
Length (mm)	72.5	10.9	47	87
Width (mm)	35.4	4.2	26	41
Bit Angle (^{o})	69.2	8.6	57	84

encoded for bifaces. These are break types, manufacturing stages, and cortex location on proximal ends. This and other information is discussed under "Technological Insight".

Tranchet Flakes (N=64)

General Morphology. These are flakes (Figure 14) which reflect the creation of the working ends of tranchet-bit bifaces (Figure 14). Shafer (1979:56-63) has described the process. These numerous and consistently shaped flakes were originally thought to be tools (Wilk 1976). Actually they are only rarely recycled for use as evidenced by edge modification. A few of the specimens are thermally altered (considered fortuitous). Table 13 presents metric data for the specimens. They are sorted into two major groups: primary and secondary. The former group represents the first removal of a tranchet flake while the later consists of a tranchet flake which has a dorsal scar showing it was removed after first or intermediate removal of a tranchet flake. Cortex may appear on either kind of tranchet flake. The material of the tranchet flakes reflects that of the general biface collection.

Blades (N=ca. 2500; ca. 1700 analyzed)

General Morphology. A blade is an elongate flake artifact deliberately (and usually sequentially) detached from a prepared core (Crabtree 1972:42-43). Ridges on the core's surface determine the field of fracture, although the free surface of a core defines fracture planes in the greater sense (Faulkner 1972). In other words, a contrived ridge does not always have to be present for blade (or flake) removals if general core shape is appropriate. A natural ridge initial blade (described later) is a good example of this. Each blade removed has at least one ridge and creates new ones along the scar retained on the core (Figure 16-20). An entire sequence of blade-making debitage (i.e. discarded blades) constitutes most of this collection. Only about 9% (N=243) of the blades (including fragments) are modified (Figure 21-28). Most of these specimens are a stemmed form (Table 14) distinctly smaller than the macroblades of the Late Preclassic at Colha (Shafer 1979:63-64). Modified and unmodified blades have been sorted into proximal (striking platform) fragments, distal (termination) fragments, medial fragments, and complete blades. Provenience and descriptive measurements (nominal, metric, and technological assessments) for unmodified and modified blades is provided in Tables 14-47. Most modified blade stems were parallel sided (Table 37). Where stems contracted, measurement was made at midpoint on the stem or distalward of that location. If a stem expanded, measurement was at midpoint or proximal of it. In retrospect, minimum and maximum transverse measurements would be more appropriate for these stem forms. The morphology of striking platforms was also recorded in terms of width and depth (Tables 40,41) and angle (Table 18,19). Platform angle was measured with a contact goniometer placed against the ventral face and platform surface. Minor bias resulted from robust bulbs of force, which are relatively consistent in the collection. Most platforms were single faceted with angles easily read (Table 20). Multi-faceted and crushed platforms were more difficult to assess and often not measured. Blade outlines and blade platform

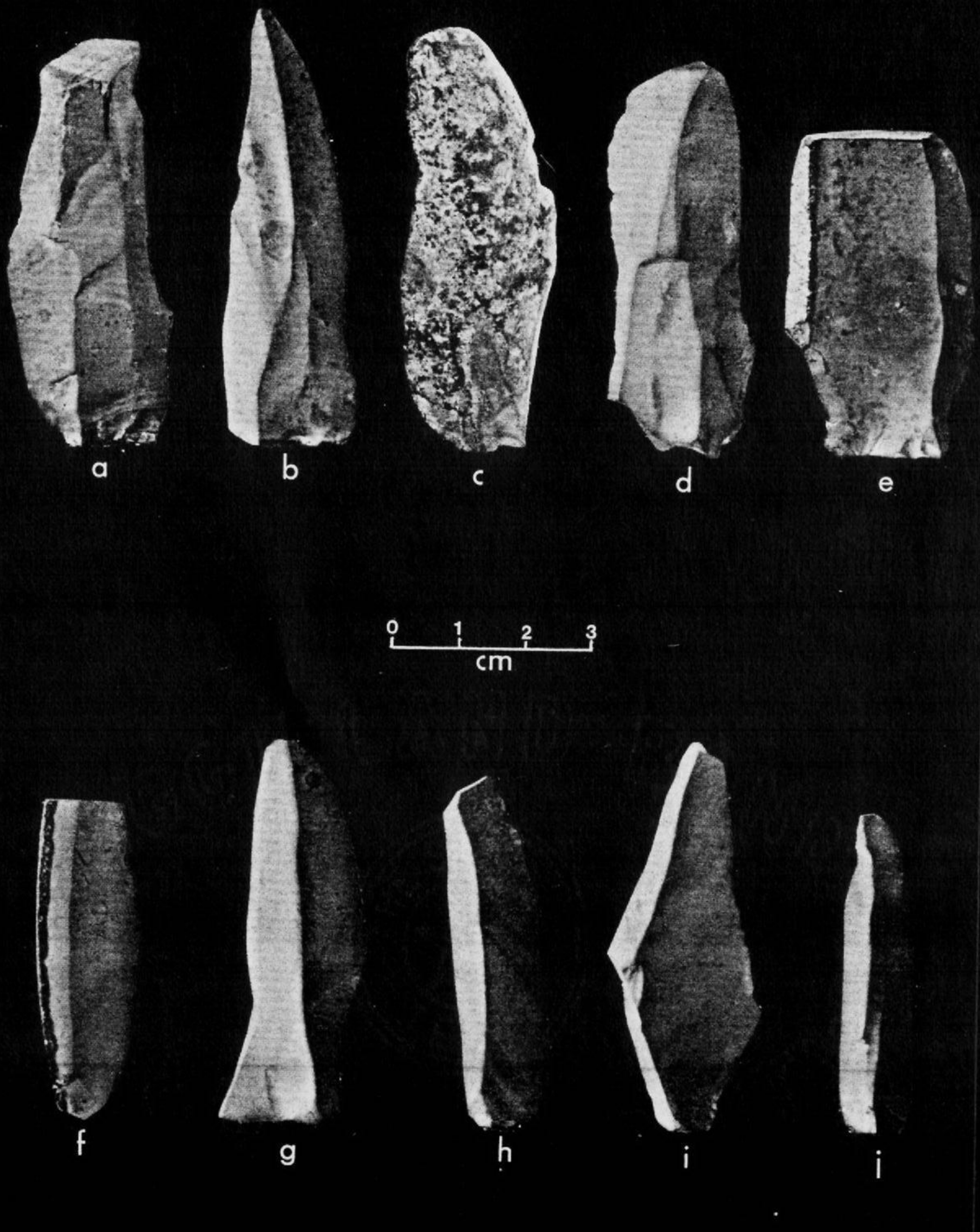


Figure 16. Unmodified blades (a-j).

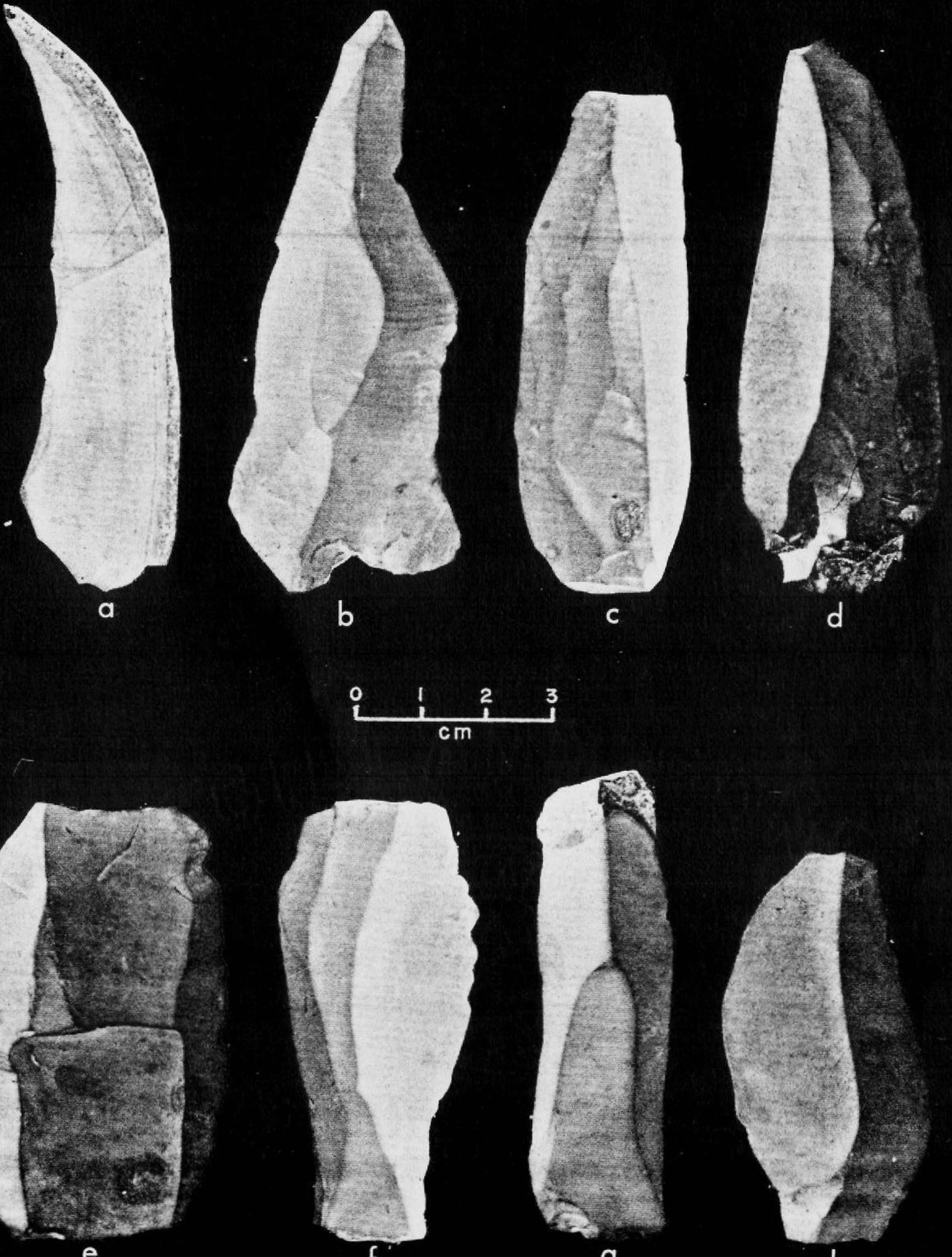


Figure 17. Unmodified blades (a-h).

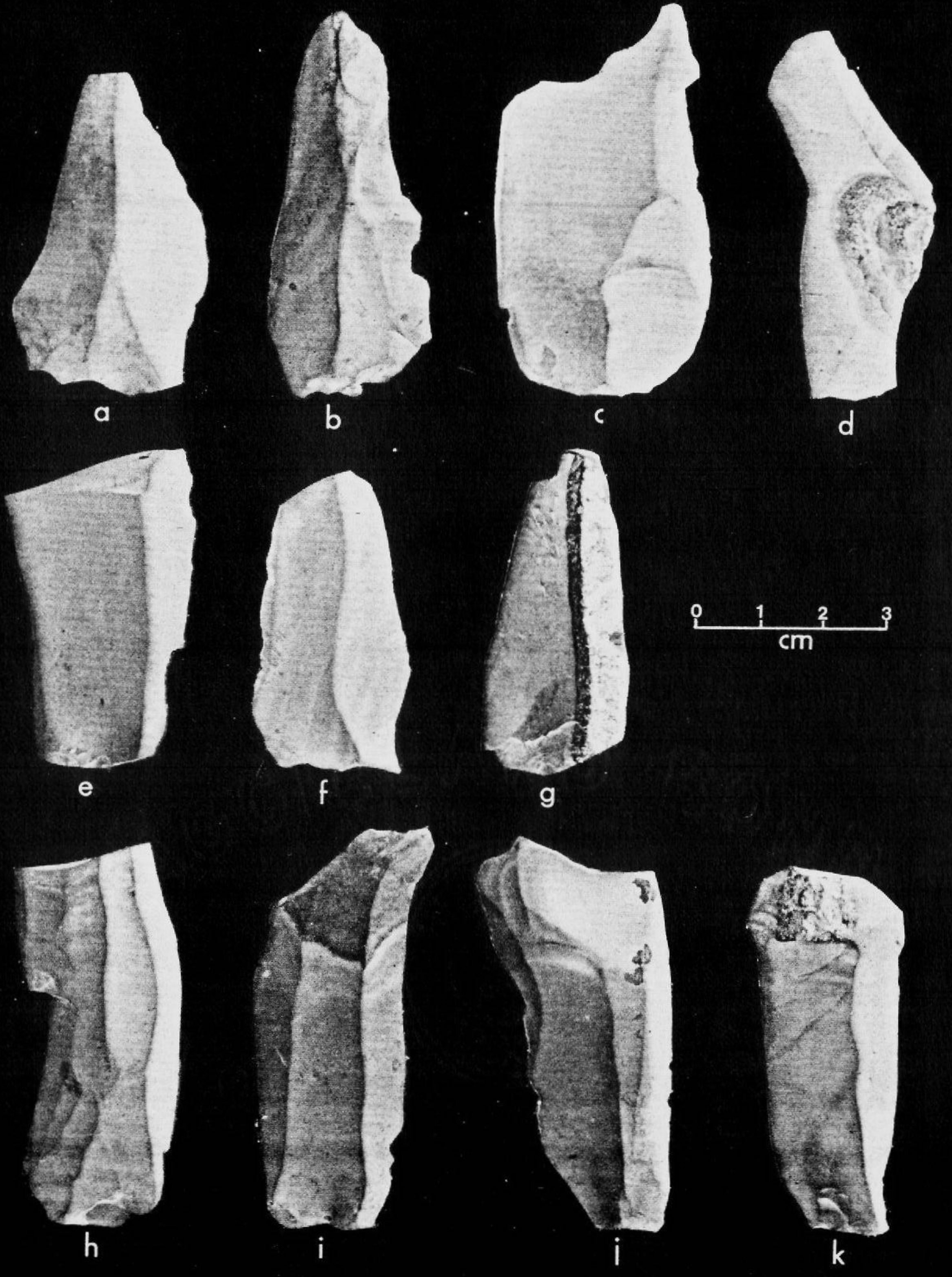


Figure 18. Unmodified blades (a-k).

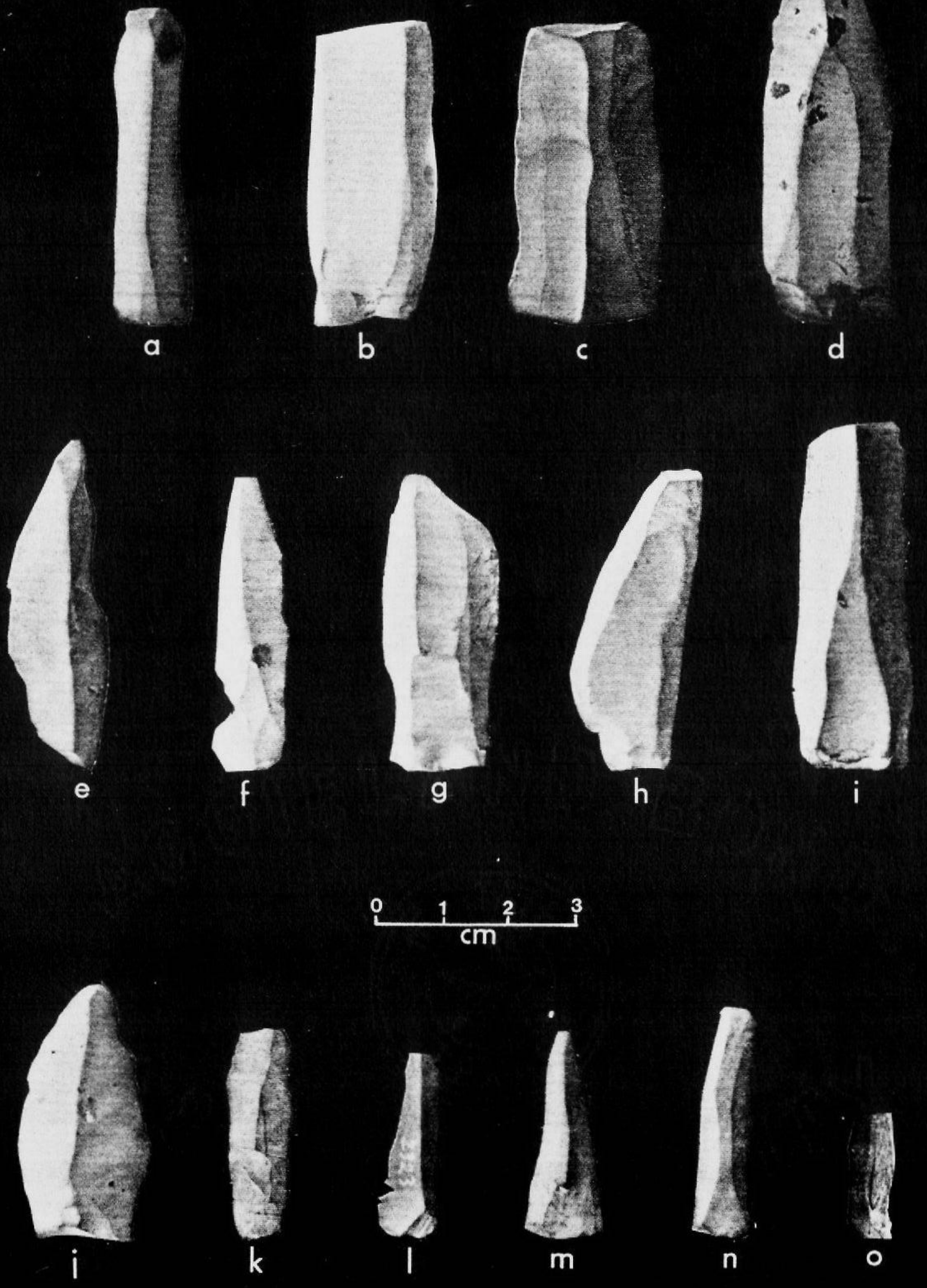


Figure 19. Unmodified blades (a-o).

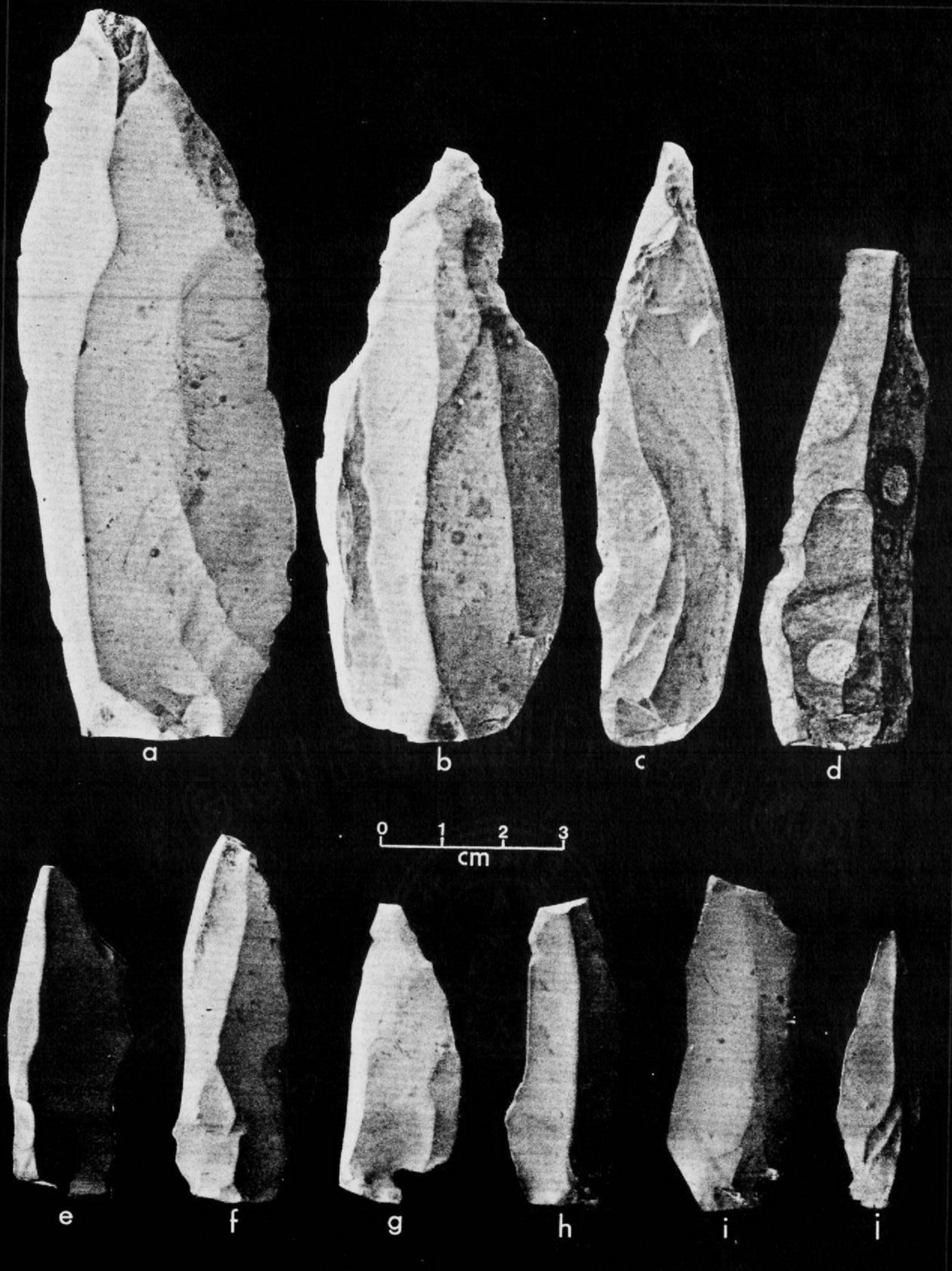


Figure 20. Modified blades not stemmed but related (a-j).

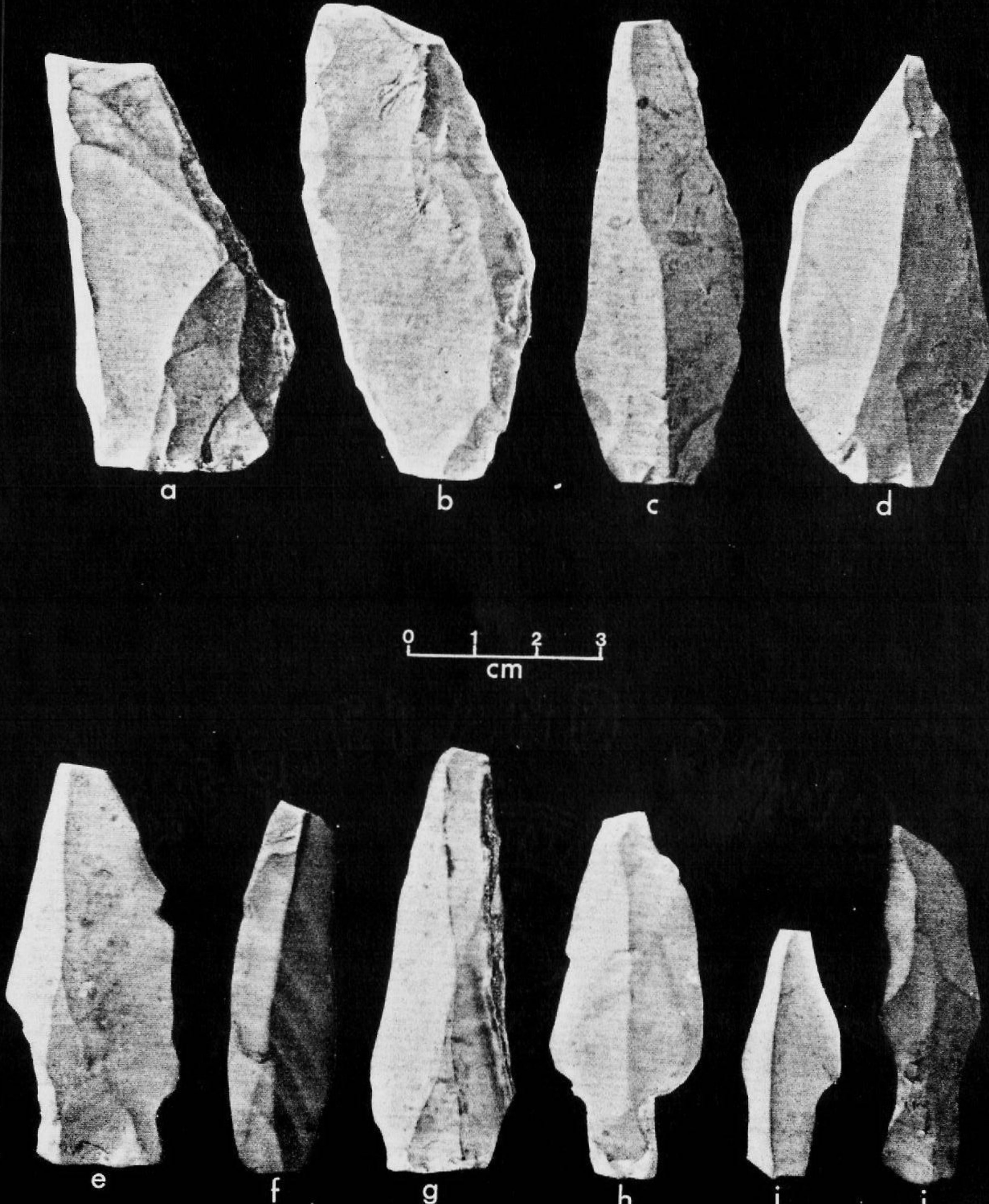


Figure 21. Modified blades: (a-d,f,g) not stemmed but related; (e) incipient stem modification; (h,i) stemmed with no distal modification; and (j) stemmed bifacial thinning flake.

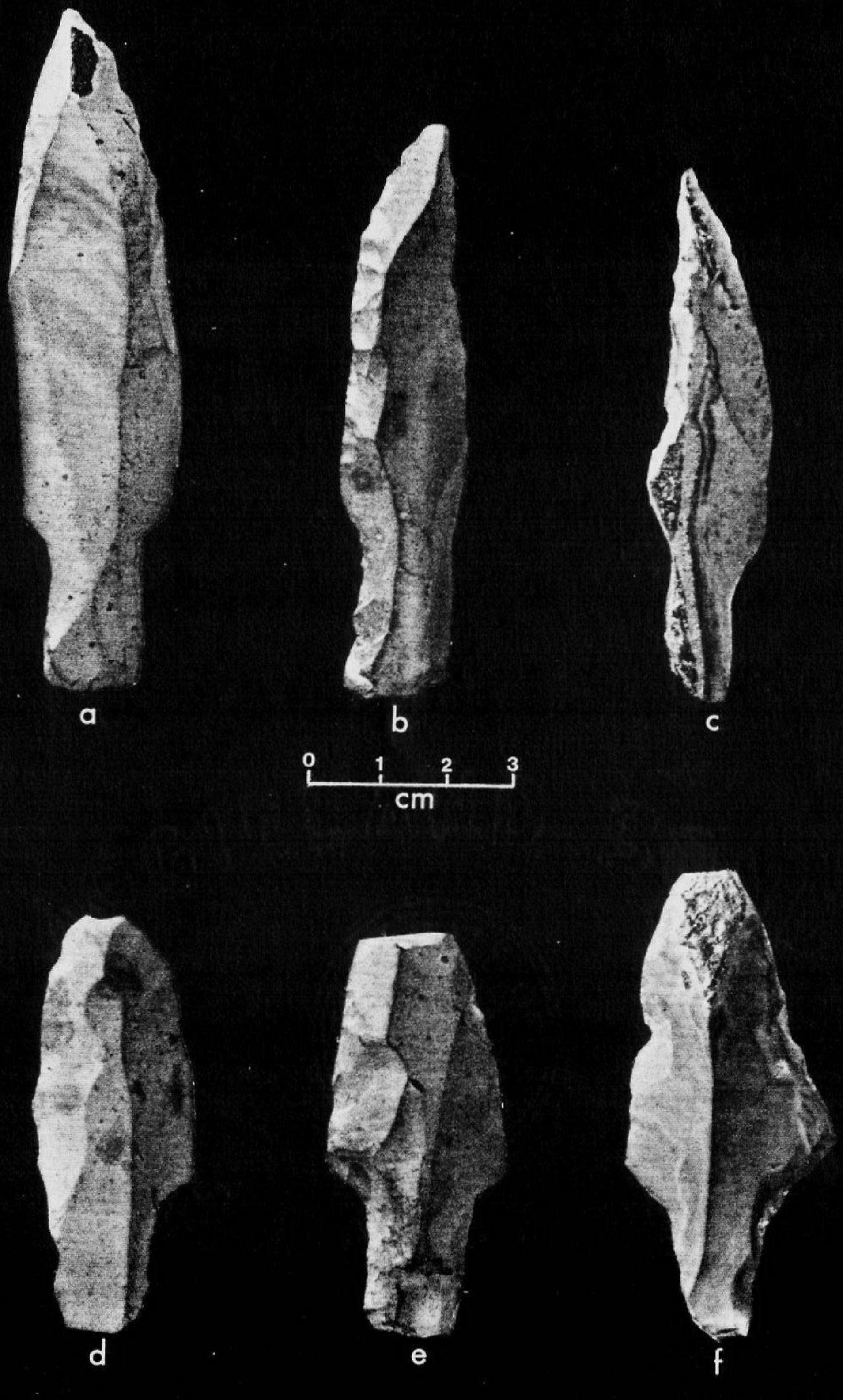


Figure 22. Modified, stemmed blades (a-f).

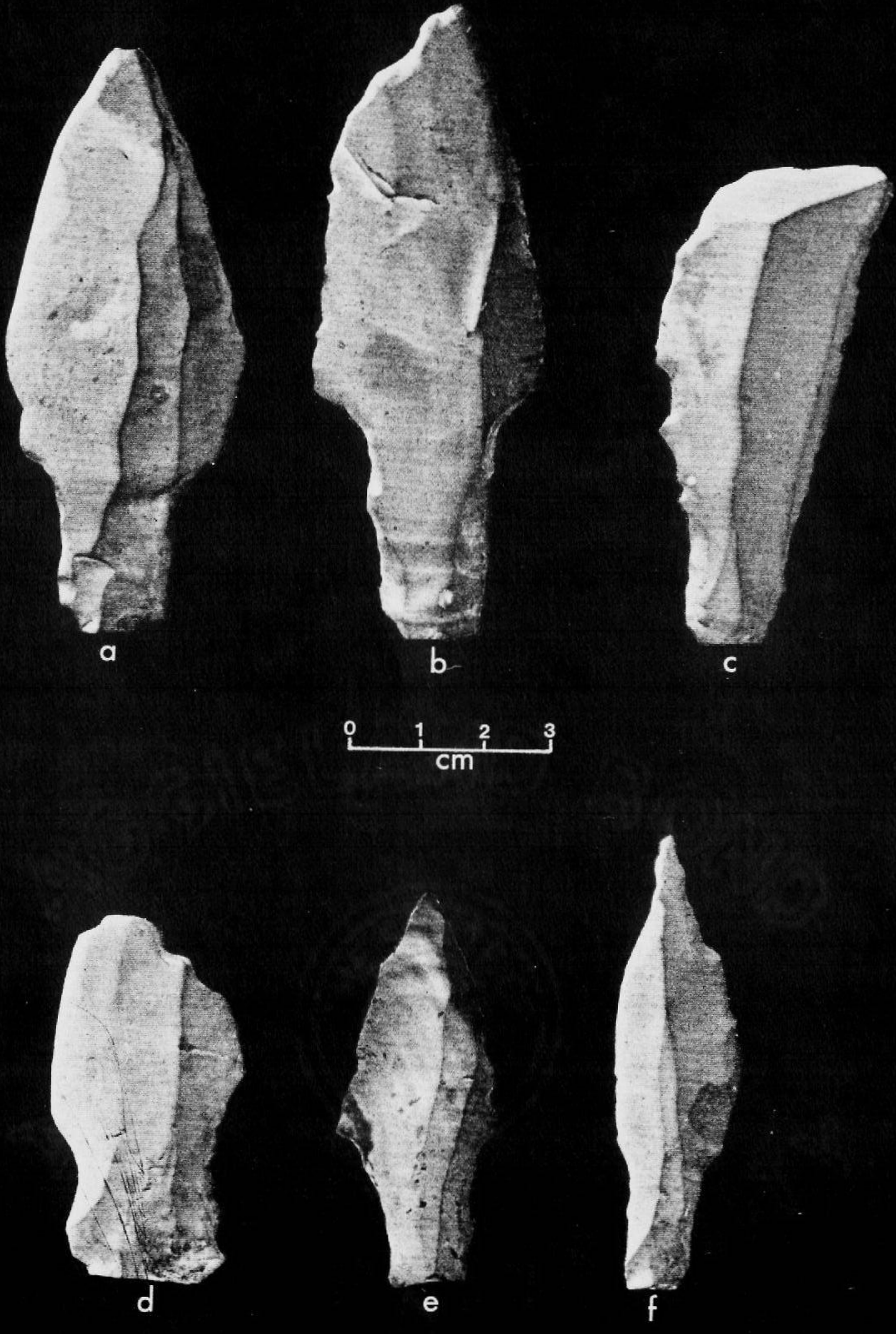


Figure 23. Op. 2007 modified, stemmed blades (a-f).

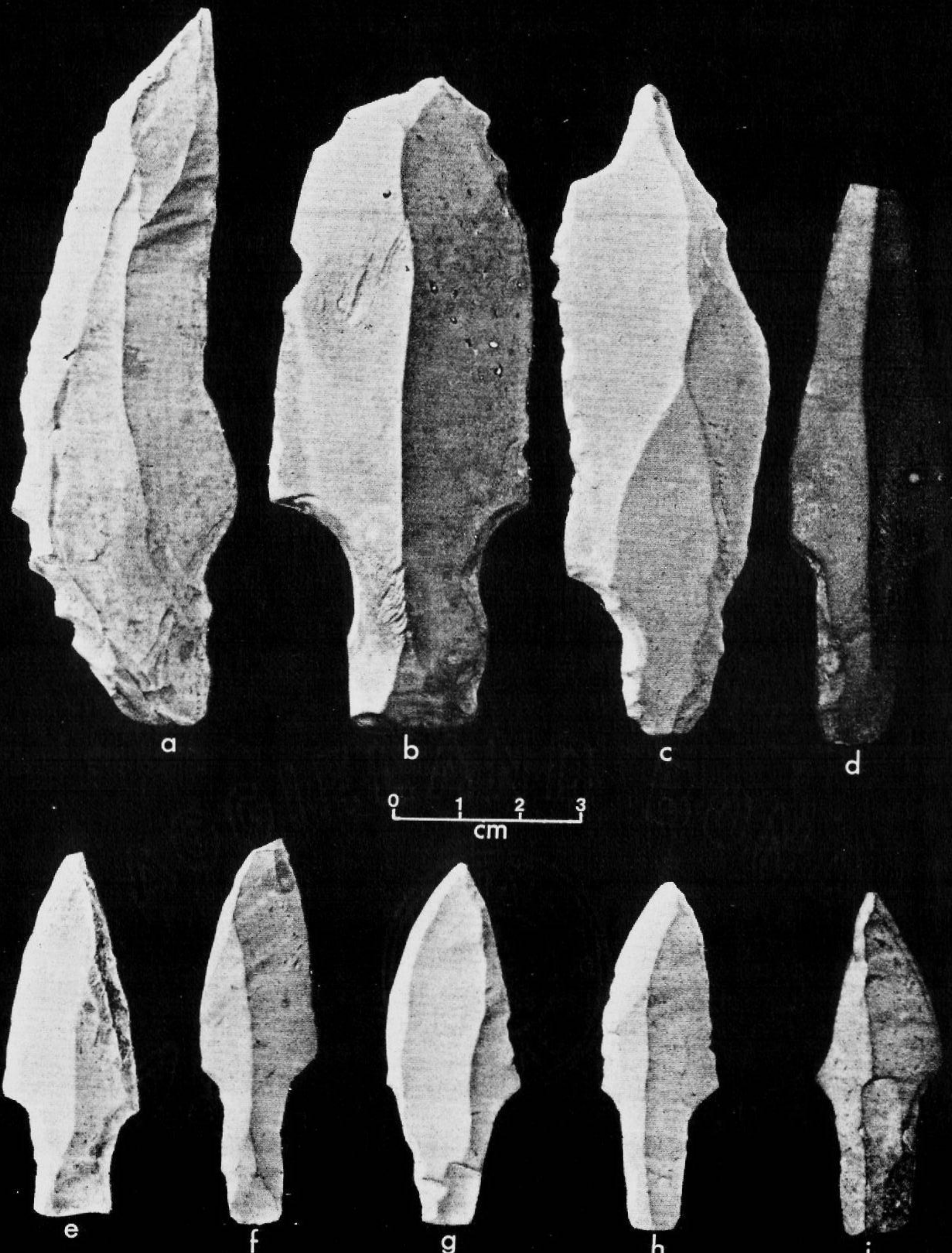


Figure 24. Modified, stemmed blades (a-i).

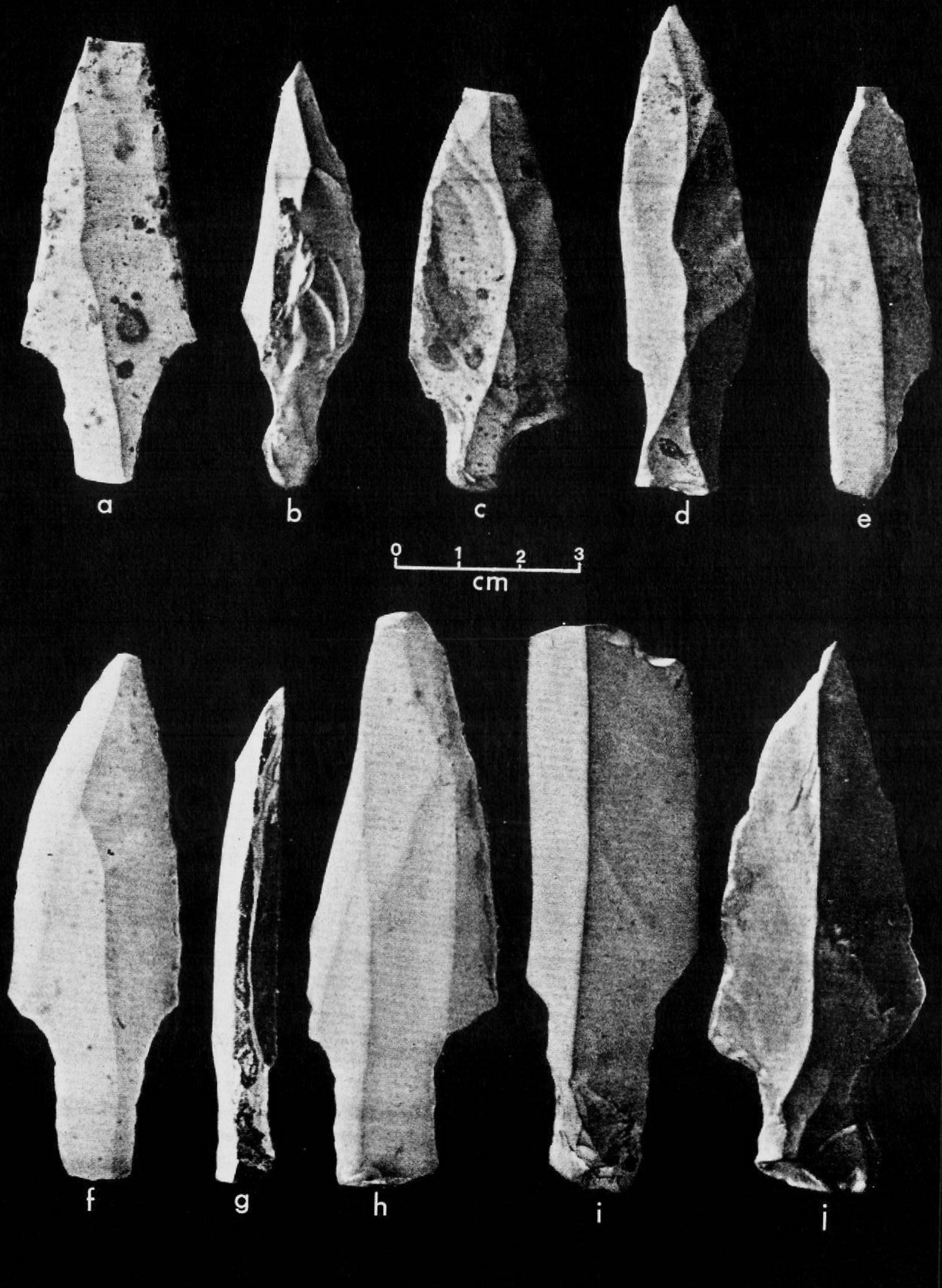


Figure 25. Modified, stemmed blades (a-j).

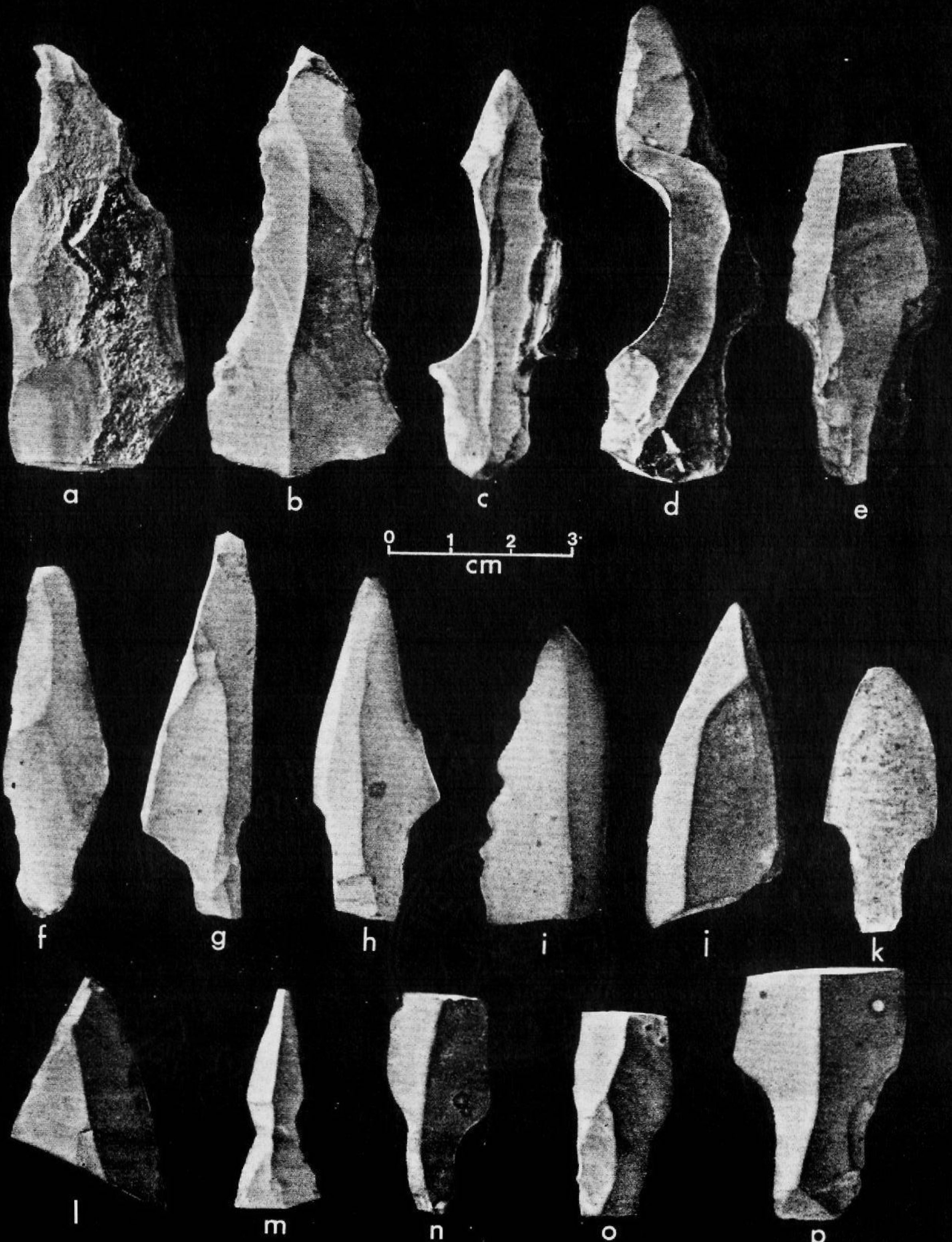


Figure 26. Modified blades: (a,b) not stemmed but related; (c,d) stemmed with unusual lateral breaks; and (e-p) various whole and fragmentary stemmed specimens.

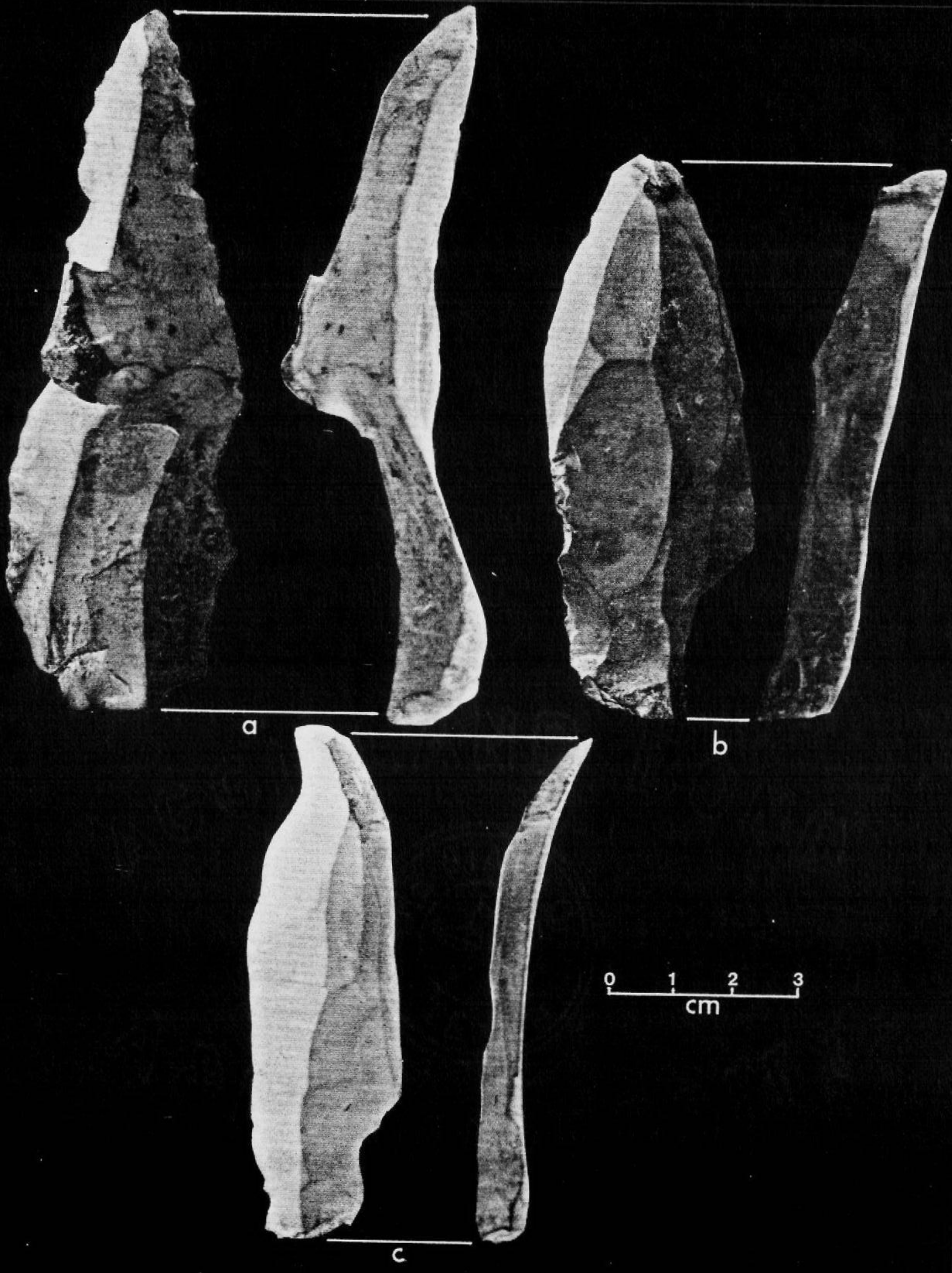


Figure 27. Modified blades with excessive curvature: (a) specimen with cortex "knot", (b) unusually thick stemmed blade, and (c) stemmed blade.

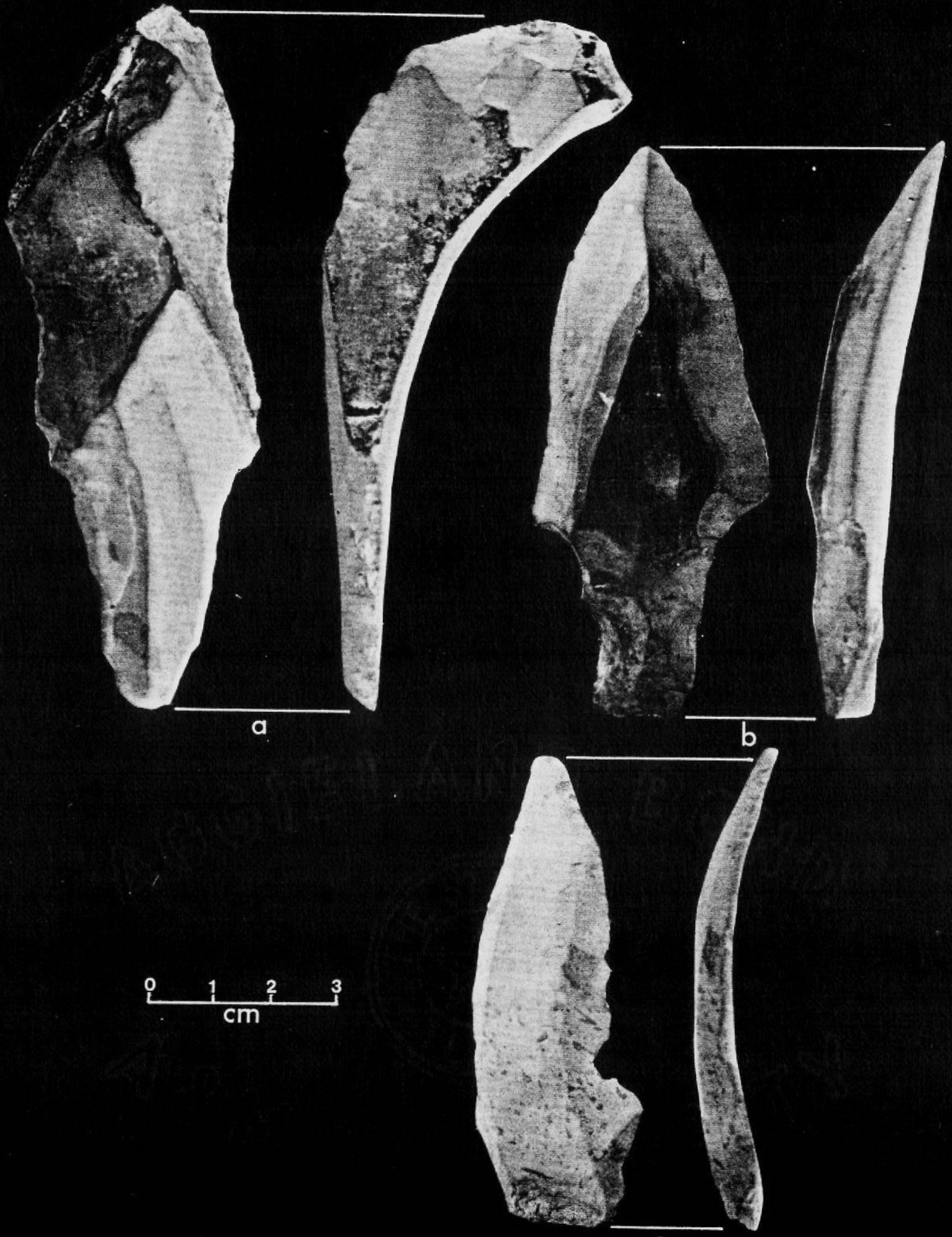


Figure 28. Modified blades: (a) overshot, prepared ridge specimen; (b) curved, thick stemmed blade; and (c) curved blade.

Table 14. Provenience of Blades at Op. 2007, Sorted by Modified and Unmodified Forms.

		BLADE TYPE								
		Whole, Unmod.	Prox., Unmod.	Dist., Unmod.	Med., Unmod.	Whole, Mod.	Prox., Mod.	Dist., Mod.	Med., Mod.	Level Totals
		N	N	N	N	N	N	N	N	N
SUBOPERATION	EXCAVATION LEVEL									
Subop. 1	Level 1	595	66	60	16	19	6	10	3	775
	Level 2	43	3	10	2	10	1	3	0	72
	Level 3	112	10	22	6	16	4	6	1	177
	Level 4	38	3	8	1	7	2	2	0	61
	Level 5	20	3	3	0	3	3	2	0	34
	Level 6	26	5	2	0	9	1	1	2	46
	Level 7	7	0	1	0	2	1	1	0	12
	Level 8	14	0	5	0	1	0	1	0	21
	Level 9	90	9	16	2	5	1	0	0	123
Subop. 2	Level 2	0	0	0	0	1	0	0	0	1
Subop. 3	Surface	55	3	19	1	9	2	5	0	94
	Level 1	64	5	5	1	23	3	5	1	107

(CONTINUED)

Table 14 continued.

		BLADE TYPE								Level Totals
		Whole, Unmod.	Prox., Unmod.	Dist., Unmod.	Med., Unmod.	Whole, Mod.	Prox., Mod.	Dist., Mod.	Med., Mod.	
		N	N	N	N	N	N	N	N	N
SUBOPERATION (cont.)	EXCAVATION LEVEL									
Subop. 4	Level 1	10	1	4	0	1	0	0	0	16
	Level 2	12	1	3	1	6	0	0	0	23
Subop. 5	Level 1	14	0	0	0	20	5	5	0	44
Subop. 6	Level 1	0	0	0	0	9	0	1	0	10
Subop. 7	Level 1	2	0	0	0	1	0	0	0	3
Subop. 8	Level 1	0	0	0	0	2	1	0	0	3
Subop. 9	Level 1	0	0	0	0	1	0	0	0	1
Subop. 11	Level 1	18	2	7	1	0	3	1	0	32
	Level 2	6	3	5	1	0	0	0	0	15
Type Totals		1126	114	170	32	145	33	43	7	1670

Table 15. Maximum Length of Op. 2007 Blades, by Unmodified and Modified Forms.

	MAXIMUM LENGTH (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM						
Whole	1144	68.7	10	176	25.3	36.8
Proximal Frag.	114	41.2	18	82	14.4	34.8
Distal Frag.	172	52.1	16	126	19.2	36.9
Medial Frag.	31	34.9	9	51	11.0	31.5
Whole, Modified	158	71.0	36	130	19.8	27.9
Proximal Frag., Modified	32	50.9	24	95	15.9	31.2
Distal Frag., Modified	47	50.6	27	120	18.5	36.5
Medial Frag., Modified	7	108.0	26	491	169.5	156.9
Total	1705	64.1	9	491	27.0	42.2

Table 16. Maximum Width of Op. 2007 Blades, by Unmodified and Modified Forms.

	MAXIMUM WIDTH (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM						
Whole	1142	26.8	6	99	12.0	44.7
Proximal Frag.	114	25.4	3	85	13.1	51.6
Distal Frag.	170	23.2	8	65	10.5	45.4
Medial Frag.	30	21.6	10	45	8.3	38.2
Whole, Modified	156	25.4	11	60	8.7	34.1
Proximal Frag., Modified	32	25.7	15	45	7.8	30.5
Distal Frag., Modified	45	23.6	10	71	10.8	45.5
Medial Frag., Modified	7	35.3	19	79	22.4	63.6
Total	1696	26.0	3	99	11.6	44.6

Table 17. Maximum Thicknesses of Op. 2007 Blades, by Unmodified and Modified Forms.

	MAXIMUM THICKNESS (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM						
Whole	1142	7.6	1	41	4.8	63.8
Proximal Frag.	114	5.5	2	18	2.9	53.2
Distal Frag.	171	6.1	1	28	4.2	69.0
Medial Frag.	31	4.4	2	7	1.6	36.3
Whole, Modified	158	8.3	3	25	3.9	46.7
Proximal Frag., Modified	32	8.0	4	15	2.9	36.0
Distal Frag., Modified	46	7.0	2	28	4.9	70.2
Medial Frag., Modified	7	9.0	5	20	6.0	67.0
TOTAL	1701	7.3	1	41	4.6	62.9

Table 18. Platform Angle for Unmodified Blades.

	PLATFORM ANGLE					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM						
Whole, Unmodified	790	100.4	70	135	8.4	8.4
Proximal Frag., Unmodified	83	99.0	76	135	8.6	8.7
TOTAL	873	100.3	70	135	8.4	8.4

Table 19. Platform Angle for Modified Blades.

		PLATFORM ANGLE					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM	KIND OF MODIFICATION						
Whole, Modified	Stemmed	46	101.2	90	125	6.9	6.9
	Not Stemmed but Related	33	101.3	91	112	5.1	5.0
	Other (Macro, etc.)	6	105.2	94	116	7.8	7.4
Proximal, Frag., Modified	Stemmed	9	100.1	89	108	7.0	6.9
	Not Stemmed but Related	9	96.7	87	112	8.5	8.8
	Other (Macro, etc.)	0	.	.	.	.	.
TOTAL		103	101.0	87	125	6.7	6.6

Table 20. Platform Type by Unmodified and Modified Blade Forms.

	PLATFORM TYPE					
	Multiple Facet		Single Facet		Crushed or Missing	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
BLADE FORM						
Whole	119	21.2	280	50.0	111	19.8
Proximal Frag.	8	1.4	4	0.7	5	0.9
Whole, Modified	6	1.1	21	3.7	3	0.5
Proximal Frag., Modified	1	0.2	0	0	2	0.4
TOTAL	134	23.9	305	54.5	121	21.6

Table 21. Platform Outline by Unmodified Blade Forms.

	PLATFORM OUTLINE			
	"Single Ridge" Type		"Two Ridge" Type	
	Frequency	Percentage	Frequency	Percentage
UNMODIFIED BLADE FORM				
Whole	564	67	192	23
Proximal Frag.	57	7	26	3
TOTAL	621	74	218	26

Table 22. Blade Lengths Divided by Widths for Unmodified and Modified Forms.

	RATIO: BLADE LENGTHS DIVIDED BY WIDTHS					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM						
Whole	1142	2.8	0	9	0.8	30.4
Proximal Frag.	114	1.9	1	13	1.3	66.6
Distal Frag.	170	2.4	1	11	0.9	38.1
Medial Frag.	30	1.9	0	3	0.9	46.3
Whole, Modified	156	2.9	1	8	0.8	26.3
Proximal Frag., Modified	32	2.1	1	4	0.6	30.0
Distal Frag., Modified	45	2.3	1	5	0.7	31.9
Medial Frag., Modified	7	1.7	1	2	0.4	22.5
Total	1696	2.6	0	13	0.9	34.7

Table 23. Unmodified Blades' Cortex Locations.

	UNMODIFIED BLADE FORM						
	Whole	Prox. Frag.	Dist. Frag.	Medial Frag.			TOTAL
	Freq.	Freq.	Freq.	Freq.	Freq.	Percent.	Freq.
CORTEX LOCATIONS ON BLADES							
No Cortex	533	83	78	24	718	51.1	718
Total Cortex	5	0	0	0	5	0.4	5
Proximal Edge	80	6	2	0	88	6.3	88
Distal Edge	180	1	24	1	206	14.7	206
Right Edge	77	6	9	1	93	6.6	93
Left Edge	72	8	6	3	89	6.3	89
Right, Left	5	0	0	0	5	0.4	5
Distal, Right, Left	11	0	0	0	11	0.8	11
Distal, Right	31	0	8	0	39	2.8	39
Proximal, Distal, Right	19	0	0	0	19	1.4	19
Proximal, Left	26	3	0	0	29	2.1	29
Distal, Left	36	0	5	0	41	2.9	41
Proximal, Right	26	0	1	0	27	1.9	27
Proximal, Distal	13	0	0	0	13	0.9	13
Proximal, Distal, Left	18	0	0	0	18	1.3	18
Proximal, Right, Left	1	0	0	0	1	0.1	1
Distal, Proximal, Right, Left	4	0	0	0	4	0.3	4

Table 24. Unmodified Blades' Major Dorsal Ridge Count.

	MAJOR DORSAL RIDGE COUNT							
	None		One		Two		Three	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
UNMODIFIED BLADE FORM								
Whole	1	0.1	691	47.9	417	28.9	25	1.7
Proximal Frag.	0	0	62	4.3	51	3.5	1	0.1
Distal Frag.	0	0	104	7.2	58	4.0	4	0.3
Medial Frag.	0	0	18	1.2	10	0.7	0	0
TOTAL	1	0.1	875	60.7	536	37.2	30	2.1

Table 25. Unmodified Blades' Texture.

	TEXTURE					
	Fine		Coarse		Mixed	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
UNMODIFIED BLADE FORM						
Whole	909	62.4	27	1.9	205	14.1
Proximal Frag.	94	6.5	5	0.3	15	1.0
Distal Frag.	134	9.2	9	0.6	28	1.9
Medial Frag.	23	1.6	.	.	8	0.5
TOTAL	1160	79.6	41	2.8	256	17.6

Table 26. Unmodified Blades' Assessed Curvature.

	ASSESSED CURVATURE			
	Slight		Pronounced	
	Frequency	Percentage	Frequency	Percentage
UNMODIFIED BLADE FORM				
Whole	718	49.4	421	29.0
Proximal Frag.	96	6.6	16	1.1
Distal Frag.	122	8.4	49	3.4
Medial Frag.	29	2.0	1	0.1
TOTAL	965	66.5	487	33.5

Table 27. Platform Outlines of Modified Blades.

		PLATFORM OUTLINE			
		"Single Ridge" Type		"Two Ridge" Type	
		Frequency	Percentage	Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE				
Whole	Stemmed	23	29	10	13
	Not Stemmed but Related	18	22	10	13
	Other (Macro, etc.)	4	5	1	1
Proximal Frag.	Stemmed	5	6	1	1
	Not Stemmed but Related	5	6	3	4
TOTAL		55	69	25	31

Table 28. Maximum Length for Various Kinds of Modified Blades.

		MAXIMUM LENGTH (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM	KIND OF MODIFICATION						
Whole, Modified	Stemmed	91	70.5	40	123	17.6	24.9
	Not Stemmed But Related	51	67.7	43	125	16.9	25.0
	Other (Macro, etc.)	15	82.3	36	130	32.2	39.2
Proximal Frag., Modified	Stemmed	16	54.4	34	95	15.9	29.2
	Not Stemmed But Related	14	47.4	24	83	16.6	35.0
	Other (Macro, etc.)	2	47.5	42	53	7.8	16.4
Distal Frag., Modified	Stemmed	4	50.0	38	63	10.6	21.2
	Not Stemmed But Related	36	46.2	27	83	12.7	27.5
	Other (Macro, etc.)	7	73.7	41	120	29.6	40.2
Medial Frag., Modified	Stemmed	3	44.7	33	54	10.7	23.9
	Not Stemmed But Related	1	26.0	26	26	.	.
	Other (Macro, etc.)	3	86.0	37	153	60.1	69.8
Total		243	63.9	24	153	21.8	34.1

Table 29. Maximum Width for Various Kinds of Modified Blades.

		MAXIMUM WIDTH (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM	KIND OF MODIFICATION						
Whole, Modified	Stemmed	89	23.7	11	44	6.9	29.3
	Not Stemmed But Related	51	25.0	14	41	7.1	28.3
	Other (Macro, etc.)	15	36.1	12	60	14.0	38.8
Proximal Frag., Modified	Stemmed	16	23.4	15	40	7.4	31.5
	Not Stemmed But Related	14	26.7	16	41	6.8	25.6
	Other (Macro, etc.)	2	37.0	29	45	11.3	30.6
Distal Frag., Modified	Stemmed	3	20.7	13	25	6.7	32.2
	Not Stemmed But Related	36	20.7	10	35	5.8	27.8
	Other (Macro, etc.)	6	42.8	22	71	16.1	37.5
Medial Frag., Modified	Stemmed	3	23.3	20	30	5.8	24.7
	Not Stemmed But Related	1	19.0	19	19	.	.
	Other (Macro, etc.)	3	52.7	27	79	26.0	49.4
TOTAL		239	25.4	10	79	9.7	38.2

Table 30. Maximum Thickness for Various Kinds of Modified Blades.

		MAXIMUM THICKNESS (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM	KIND OF MODIFICATION						
Whole, Modified	Stemmed	91	7.6	4	14	2.2	28.3
	Not Stemmed But Related	51	7.3	3	12	2.1	29.2
	Other (Macro, etc.)	15	14.4	5	25	7.4	51.3
Proximal Frag., Modified	Stemmed	16	8.0	4	12	2.3	28.1
	Not Stemmed But Related	14	7.3	4	15	3.0	41.5
	Other (Macro, etc.)	2	12.5	10	15	3.5	28.3
Distal Frag., Modified	Stemmed	3	5.3	2	9	3.5	65.8
	Not Stemmed But Related	36	5.6	2	10	2.0	36.9
	Other (Macro, etc.)	7	15.1	4	28	7.8	51.8
Medial Frag., Modified	Stemmed	3	5.3	5	6	0.6	10.8
	Not Stemmed But Related	1	5.0	5	5	.	.
	Other (Macro, etc.)	3	14.0	7	20	6.6	46.8
TOTAL		242	7.9	2	28	3.9	49.2

Table 31. Length Divided by Width for Various Kinds of Modified Blades.

		MODIFIED BLADE LENGTHS DIVIDED BY WIDTHS					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM	KIND OF MODIFICATION						
Whole, Modified	Stemmed	89	3.1	2	8	0.8	25.7
	Not Stemmed But Related	51	2.8	2	4	0.6	21.0
	Other (Macro, etc.)	15	2.5	1	5	1.0	39.9
Proximal Frag., Modified	Stemmed	16	2.4	2	4	0.6	25.6
	Not Stemmed But Related	14	1.8	1	2	0.4	21.3
	Other (Macro, etc.)	2	1.3	1	1	0.2	14.6
Distal Frag., Modified	Stemmed	3	2.5	2	3	0.5	20.6
	Not Stemmed But Related	36	2.3	1	3	0.5	21.6
	Other (Macro, etc.)	6	2.3	1	5	1.7	75.5
Medial Frag., Modified	Stemmed	3	1.9	2	2	0.4	19.1
	Not Stemmed But Related	1	1.4	1	1	.	.
	Other (Macro, etc.)	3	1.5	1	2	0.3	22.5
Total		239	2.7	1	8	0.8	31.2

Table 32. Stem Lengths, Widths, and Thicknesses for Modified Blades.

		STEM LENGTHS (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE						
Whole	Stemmed	89	18.5	5	32	5.7	30.9
Proximal Frag.	Stemmed	16	21.9	15	32	5.6	25.7
TOTAL		105	19.0	5	32	5.8	30.6

		STEM WIDTHS (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE						
Whole	Stemmed	90	14.0	8	27	3.9	27.9
Proximal Frag.	Stemmed	16	14.7	8	22	4.5	30.7
TOTAL		106	14.1	8	27	4.0	28.2

		STEM THICKNESSES (mm)					
		Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE						
Whole	Stemmed	89	6.6	2	14	2.5	37.0
Proximal Frag.	Stemmed	16	7.7	3	12	2.6	33.5
TOTAL		105	6.8	2	14	2.5	36.6

Table 33. Major Dorsal Ridge Count for Various Kinds of Modified Blades.

		MAJOR DORSAL RIDGE COUNT							
		None		One		Two		Three	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE								
Whole	Stemmed	2	0.9	46	20.1	38	16.6	3	1.3
	Not Stemmed but Related	0	0	26	11.4	21	9.2	2	0.9
	Other (Macro, etc.)	0	0	12	5.2	1	0.4	0	0
Proximal Frag.	Stemmed	0	0	10	4.4	6	2.6	0	0
	Not Stemmed but Related	0	0	4	1.7	9	3.9	0	0
	Other (Macro, etc.)	0	0	2	0.9	0	0	0	0
Distal Frag.	Stemmed	0	0	2	0.9	1	0.4	0	0
	Not Stemmed but Related	0	0	15	6.6	18	7.9	0	0
	Other (Macro, etc.)	0	0	2	0.9	4	1.7	0	0
Medial Frag.	Stemmed	0	0	2	0.9	1	0.4	0	0
	Other (Macro, etc.)	0	0	0	0	1	0.4	1	0.4
TOTAL		2	0.9	121	52.8	100	43.7	6	2.6

Table 34. Stem Modification for Various Kinds of Modified Blades.

		STEM MODIFICATION							
		Beveled "Clockwise"		Beveled "Anti-clockwise"		Unifacial, Ventral		Unifacial, Dorsal	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE								
Whole	Stemmed	18	15.9	14	12.4	8	7.1	50	44.2
	Not Stemmed but Related	0	0	2	1.8	0	0	0	0
Proximal Frag.	Stemmed	6	5.3	1	0.9	1	0.9	8	7.1
	Not Stemmed but Related	1	0.9	0	0	0	0	2	1.8
	Other (Macro, etc.)	1	0.9	0	0	0	0	1	0.9
TOTAL		26	23.0	17	15.0	9	8.0	61	54.0

Table 35. Area of Modification for Modified Whole Blades.

		AREA OF MODIFICATION					
		Proximal		Distal		Proximal and Distal	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
BLADE FORM	KIND OF MODIFIED BLADE						
Whole, Modified	Stemmed	16	10.3	0	0	74	47.4
	Not Stemmed but Related	2	1.3	37	23.7	12	7.7
	Other (Macro, etc.)	2	1.3	7	4.5	6	3.8
TOTAL		20	12.8	44	28.2	92	59.0

Table 36. Modification Techniques for Blades.

		MODIFICATION TECHNIQUE			
		Unifacial		Unifacial with Bifacial	
		Frequency	Percentage	Frequency	Percentage
BLADE FORM	KIND OF MODIFIED BLADE				
Whole	Stemmed	87	36.2	3	1.2
	Not Stemmed but Related	48	20.0	3	1.2
	Other (Macro, etc.)	11	4.6	3	1.2
Proximal Frag.	Stemmed	13	5.4	3	1.2
	Not Stemmed but Related	14	5.8	1	0.4
	Other (Macro, etc.)	2	0.8	0	0
Distal Frag.	Stemmed	4	1.7	0	0
	Not Stemmed but Related	34	14.2	1	0.4
	Other (Macro, etc.)	5	2.1	2	0.8
Medial Frag.	Stemmed	3	1.2	0	0
	Not Stemmed but Related	1	0.4	0	0
	Other (Macro, etc.)	2	0.8	0	0
TOTAL		224	93.3	16	6.7

Table 37. Modified Blade Stem Forms.

	STEM FORMS					
	Parallel		Expanding		Contracting	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
STEMMED BLADE FORM						
Whole	63	60.6	10	9.6	15	14.4
Proximal Frag.	13	12.5	1	1.0	2	1.9
TOTAL	76	73.1	11	10.6	17	16.3

Table 38. Unmodified Blade Terminations.

	BLADE TERMINATIONS							
	Feather		Hinge		Step		Overshot	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
UNMODIFIED BLADE FORM								
Whole	778	55.5	162	11.5	109	7.8	73	5.2
Proximal Frag.	5	0.4	14	1.0	77	5.5	0	0
Distal Frag.	126	9.0	14	1.0	8	0.6	17	1.2
Medial Frag.	0	0	3	0.2	17	1.2	0	0
TOTAL	909	64.8	193	13.8	211	15.0	90	6.4

Table 39. Unmodified Blade Body Outlines.

	BLADE BODY OUTLINES					
	"Parallel"		Strongly Converged		Strongly Expanded	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
BLADE FORM						
Whole, Unmodified	805	71	139	12	189	17

Table 40. Platform Depth on All Modified Blades and Stemmed Blades.

	PLATFORM DEPTH (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM						
Whole, Modified	97	6.0	1	20	2.8	47.4
Proximal Frag., Modified	19	5.9	4	10	1.9	31.9
TOTAL	116	6.0	1	20	2.7	45.2
KIND OF MODIFICATION						
Stemmed	66	5.6	1	12	2.4	42.5
Not Stemmed but Related	43	6.1	1	11	2.4	38.5
Other (Macro, etc.)	7	8.6	4	20	5.5	64.2

Table 41. Platform Width on All Modified Blades and Stemmed Blades.

	PLATFORM WIDTH (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
BLADE FORM						
Whole, Modified	68	14.3	2	38	5.9	41.6
Proximal Frag., Modified	11	15.5	11	21	2.8	18.2
TOTAL	79	14.4	2	38	5.6	38.8
KIND OF MODIFICATION						
Stemmed	32	12.5	2	19	4.2	33.3
Not Stemmed But Related	40	15.1	4	25	4.9	32.5
Other (Macro, etc.)	7	19.6	10	38	10.4	53.2

Table 42. Cortex Types for Unmodified and Modified Blade Forms.

	CORTEX TYPE					
	None		Surface		"Mined"	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
BLADE FORM						
Whole	537	31.6	533	31.4	69	4.1
Proximal Frag.	88	5.2	22	1.3	4	0.2
Distal Frag.	91	5.4	68	4.0	11	0.6
Medial Frag.	25	1.5	5	0.3	0	0
Whole, Modified	115	6.8	37	2.2	5	0.3
Proximal Frag., Modified	28	1.6	5	0.3	0	0
Distal Frag., Modified	36	2.1	10	0.6	1	0.1
Medial Frag., Modified	4	0.2	3	0.2	0	0
TOTAL	924	54.4	683	40.2	90	5.3

Table 43. Modified Blades' Cortex Locations.

	MODIFIED BLADE FORM						
	Whole	Prox. Frag.	Dist. Frag.	Medial Frag.			TOTAL
	Freq.	Freq.	Freq.	Freq.	Freq.	Percent.	Freq.
CORTEX LOCATIONS ON BLADES							
No Cortex	113	23	5	4	145	74.0	145
Proximal Edge	5	1	1	0	7	3.6	7
Distal Edge	15	0	0	0	15	7.7	15
Right Edge	6	0	0	0	6	3.1	6
Left Edge	5	3	0	1	9	4.6	9
Distal, Right, Left	2	0	1	0	3	1.5	3
Distal, Right	0	0	0	1	1	0.5	1
Proximal, Distal, Right	1	0	0	0	1	0.5	1
Proximal, Left	2	0	0	0	2	1.0	2
Proximal, Right	1	1	0	0	2	1.0	2
Proximal, Distal	3	0	0	0	3	1.5	3
Proximal, Distal, Left	2	0	0	0	2	1.0	2

Table 44. Modified Blades' Texture.

		TEXTURE					
		Fine		Coarse		Mixed	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE						
Whole	Stemmed	73	30.0	3	1.2	14	5.8
	Not Stemmed but Related	43	17.7	0	0	8	3.3
	Other (Macro, etc.)	13	5.3	0	0	2	0.8
Proximal Frag.	Stemmed	15	6.2	0	0	1	0.4
	Not Stemmed but Related	15	6.2	0	0	0	0
	Other (Macro, etc.)	1	0.4	0	0	1	0.4
Distal Frag.	Stemmed	4	1.6	0	0	0	0
	Not Stemmed but Related	35	14.4	0	0	1	0.4
	Other (Macro, etc.)	5	2.1	1	0.4	1	0.4
Medial Frag.	Stemmed	3	1.2	0	0	0	0
	Not Stemmed but Related	1	0.4	0	0	0	0
	Other (Macro, etc.)	3	1.2	0	0	0	0
TOTAL		211	86.8	4	1.6	28	11.5

Table 45. Modified Blade Terminations.

		BLADE TERMINATIONS							
		Feather		Hinge		Step		Overshot	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE								
Whole	Stemmed	80	41.0	0	0	4	2.1	1	0.5
	Not Stemmed but Related	42	21.5	2	1.0	1	0.5	0	0
	Other (Macro, etc.)	10	5.1	2	1.0	0	0	1	0.5
Proximal Frag.	Stemmed	1	0.5	0	0	1	0.5	0	0
	Not Stemmed but Related	0	0	1	0.5	0	0	0	0
Distal Frag.	Stemmed	4	2.1	0	0	0	0	0	0
	Not Stemmed but Related	34	17.4	0	0	0	0	1	0.5
	Other (Macro, etc.)	4	2.1	0	0	1	0.5	1	0.5
Medial Frag.	Stemmed	1	0.5	0	0	1	0.5	0	0
	Other (Macro, etc.)	0	0	1	0.5	0	0	1	0.5
TOTAL		176	90.3	6	3.1	8	4.1	5	2.6

Table 46. Modified Blades' Assessed Curvature.

		ASSESSED CURVATURE			
		Slight		Pronounced	
		Frequency	Percentage	Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE				
Whole	Stemmed	65	27.4	25	10.5
	Not Stemmed but Related	35	14.8	16	6.8
	Other (Macro, etc.)	6	2.5	8	3.4
Proximal Frag.	Stemmed	14	5.9	2	0.8
	Not Stemmed but Related	11	4.6	3	1.3
	Other (Macro, etc.)	2	0.8	0	0
Distal Frag.	Stemmed	4	1.7	0	0
	Not Stemmed but Related	29	12.2	5	2.1
	Other (Macro, etc.)	6	2.5	1	0.4
Medial Frag.	Stemmed	3	1.3	0	0
	Other (Macro, etc.)	1	0.4	1	0.4
TOTAL		176	74.3	61	25.7

Table 47. Interpreted Rejection Causes for Various Kinds of Modified Blades.

		INTERPRETED REJECTION CAUSES							
		Unapparent		Curvature		Thickness		Size	
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Whole	Stemmed	17	8.1	31	14.7	12	5.7	6	2.8
	Not Stemmed but Related	7	3.3	13	6.2	10	4.7	4	1.9
	Other (Macro, etc.)	0	0	0	0	1	0.5	0	0
Proximal Frag.	Stemmed	0	0	0	0	1	0.5	0	0
	Not Stemmed but Related	0	0	0	0	0	0	0	0
Distal Frag.	Stemmed	0	0	0	0	0	0	1	0.5
	Not Stemmed but Related	0	0	1	0.5	0	0	0	0
	Other (Macro, etc.)	0	0	0	0	0	0	0	0
Medial Frag.	Stemmed	0	0	0	0	0	0	0	0
TOTAL		24	11.4	45	21.3	24	11.4	11	5.2

continued

Table 47 continued.

		INTERPRETED REJECTION CAUSES							
		Material		Asymmetry		Body Broken		Thinness	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE								
Whole	Stemmed	1	0.5	9	4.3	4	1.9	4	1.9
	Not Stemmed but Related	0	0	7	3.3	4	1.9	1	0.5
	Other (Macro, etc.)	0	0	2	0.9	0	0	0	0
Proximal Frag.	Stemmed	0	0	0	0	13	6.2	0	0
	Not Stemmed but Related	1	0.5	2	0.9	10	4.7	0	0
Distal Frag.	Stemmed	0	0	0	0	3	1.4	0	0
	Not Stemmed but Related	0	0	0	0	34	16.1	0	0
	Other (Macro, etc.)	0	0	0	0	1	0.5	0	0
Medial Frag.	Stemmed	0	0	0	0	3	1.4	0	0
TOTAL		2	0.9	20	9.5	72	34.1	5	2.4

continued

Table 47 continued.

		INTERPRETED REJECTION CAUSES	
		Other	
		Frequency	Percentage
MODIFIED BLADE FORM	KIND OF MODIFIED BLADE		
Whole	Stemmed	4	1.9
	Not Stemmed but Related	4	1.9
	Other (Macro, etc.)	0	0
Proximal Frag.	Stemmed	0	0
	Not Stemmed but Related	0	0
Distal Frag.	Stemmed	0	0
	Not Stemmed but Related	0	0
	Other (Macro, etc.)	0	0
Medial Frag.	Stemmed	0	0
TOTAL		8	3.8

outlines were also inspected (Tables 21,27). The outline classification is related to the number of major dorsal ridges on a blade (generally scar boundaries from previous blade removals). Ratios were calculated to compare length and width on blades (Tables 22,31). Whole and fragmentary specimens are described here, although only whole-blades are appropriate for consideration of complete specimen proportions. As can be seen, the popular definition for blade morphology is met: "length being equal to, or more than, twice the width" (Crabtree 1972:42). Finally, curvature was subjectively coded (Tables 26,46).

Material. Again, the blades are all of local Colha chert. Of the unmodified blades, the numbers are very closely split between those with and without cortex (49% have cortex), while most modified blades have no cortex (75%). This information can be calculated from the breakdown of Table 42, which includes identification of "surface" versus "mined" cortex. Like bifaces, blades are most likely to be of fine grained chert (Tables 25,44). A further breakdown in cortex locations on blades is given in Tables 23 and 43. For both modified and unmodified blades, grain texture is most often fine.

Additional Variables. Only a few other variables were encoded. They pertain to fracture terminations, aspects of modification, and interpreted causes of rejection. This information is discussed under "Technological Insight".

Blade Cores (N=131)

General Morphology. These artifacts are the remnant lithic masses which blades were removed from. Many of the collected blades were probably derived from the specimens associated in excavation. Although ancient disposal practices likely spread and mixed much material into areas not sampled, a number of blades could be refitted to cores (Figures 29-36). All cores were sorted into three forms. Tabular cores are essentially that - distinctly flat shapes with a series of blades removed from one of the faces (Figures 37c,38c, and 39). These are the "tongue-shaped" cores mentioned by Shafer and Hester (1983:529-530). Polyhedral cores are cylindrical in shape due to a circumference of parallel blade scars. These are rare artifacts at Op. 2007 which were probably of fortuitous consequence (see "Technological Insight"). The third category, which about equals tabular quantities, I have refered to as "Other" in the tables. "Amorphous" might be a better term. These are blade cores of various angular, elongated, or spherical shapes which do not appear tabular. This is probably due to the initial form of the raw nodule. General measurements are provided by Tables 48-61. Core size ranges from 160x105x100 mm to 48x24x18 mm, with weights from 65 to 1640 gm. Depth on tabular specimens was generally a measurement from the main scar face inward. Weight was taken for cores and not blades or bifaces because I believe it better describes these artifacts and this variable might be of use for future comparative research. Relative location of the blade striking platforms on cores is listed in Table 57. Opposed platforms exist when blades were removed from one direction and later from exactly the other (N=23 cores, Figure 39). The unopposed multiple platform category pertains to more than one (rarely more than two) direction(s) of blade removal oriented in any fashion to

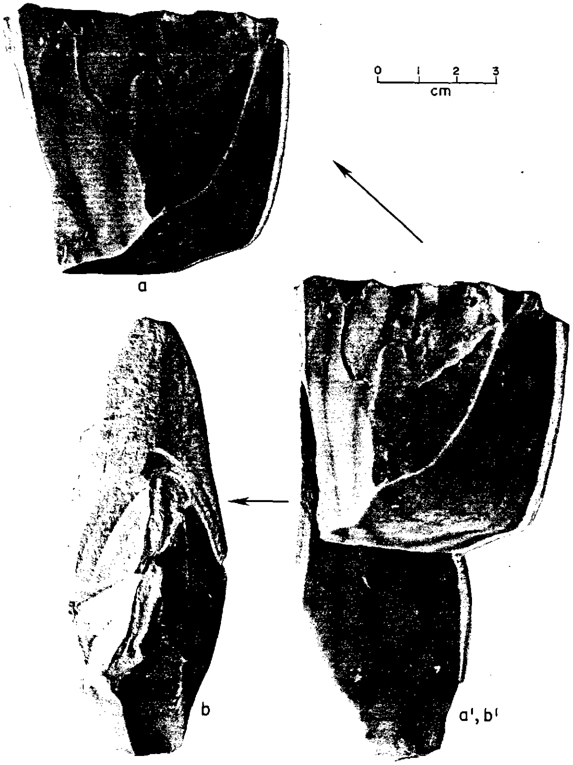


Figure 29. Articulated Blade Core (two fragments).

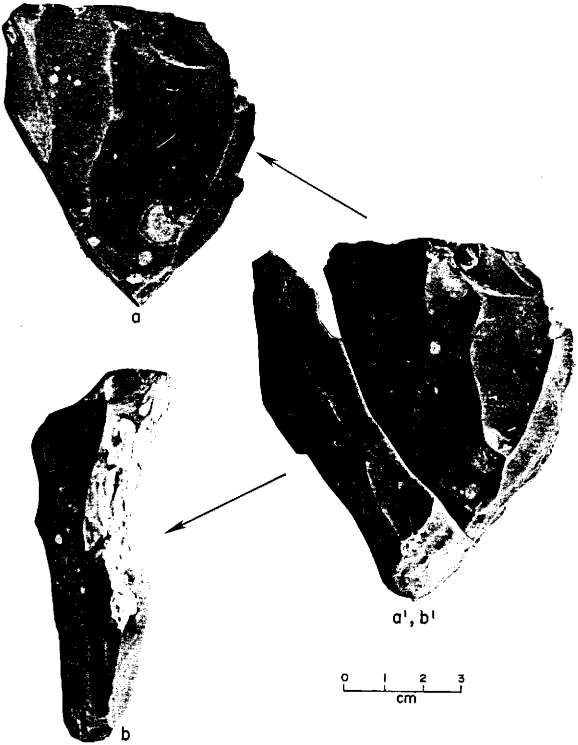


Figure 30. Second articulated blade core (two fragments).

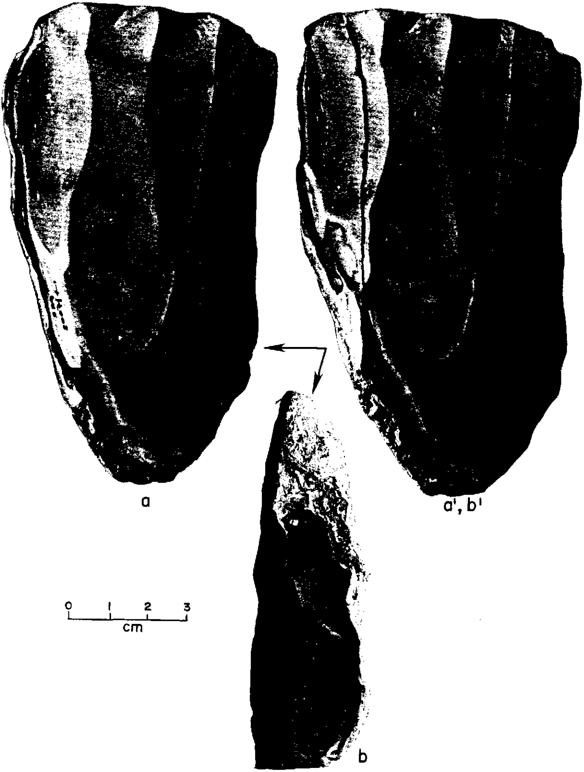


Figure 31. Third articulated blade core (two fragments).

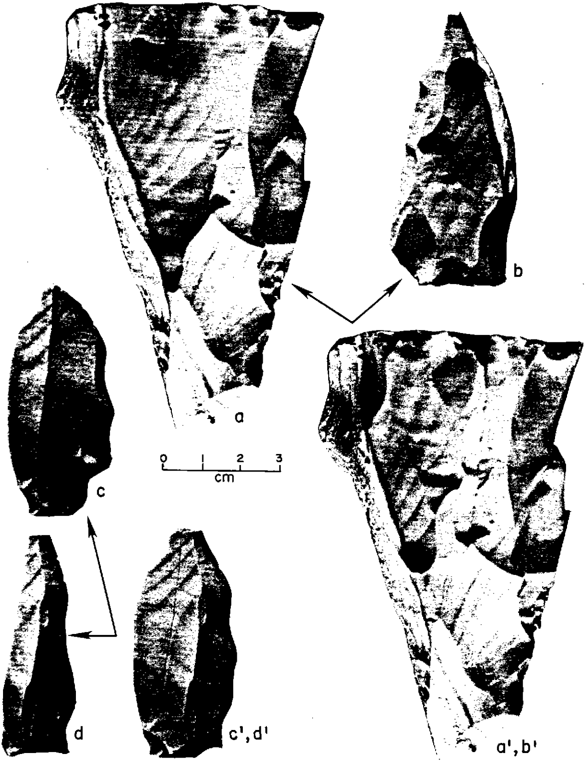


Figure 32. Core with one articulated blade (b), and two blades that fit each other (c,d) and match the core in material.

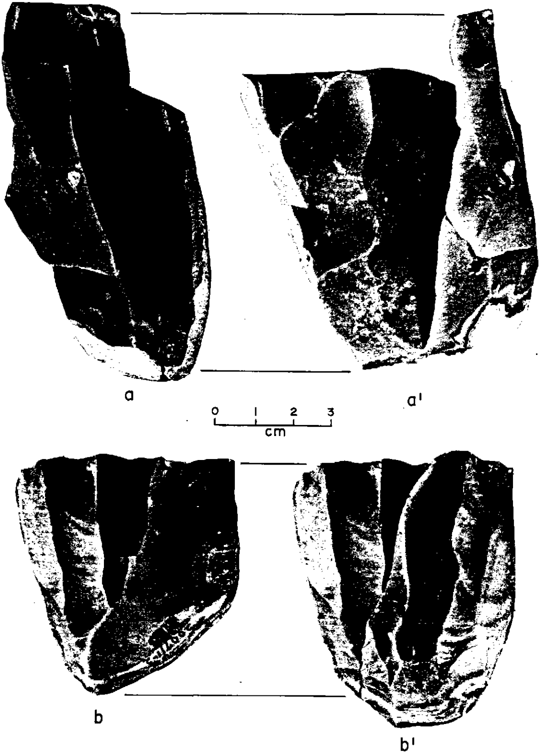


Figure 33. Two articulated blade cores: (a) with two blades, and (b) with one overshot blade/core fragment.

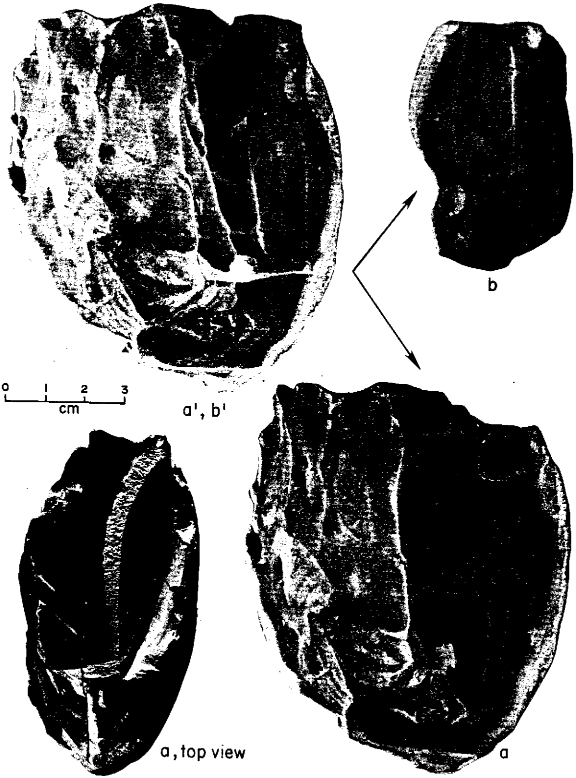


Figure 34. Blade core with one articulated blade: (a) core only; (b) blade only; and (a, top view) viewing same articulated specimen (a',b') - note ring crack on blade platform.

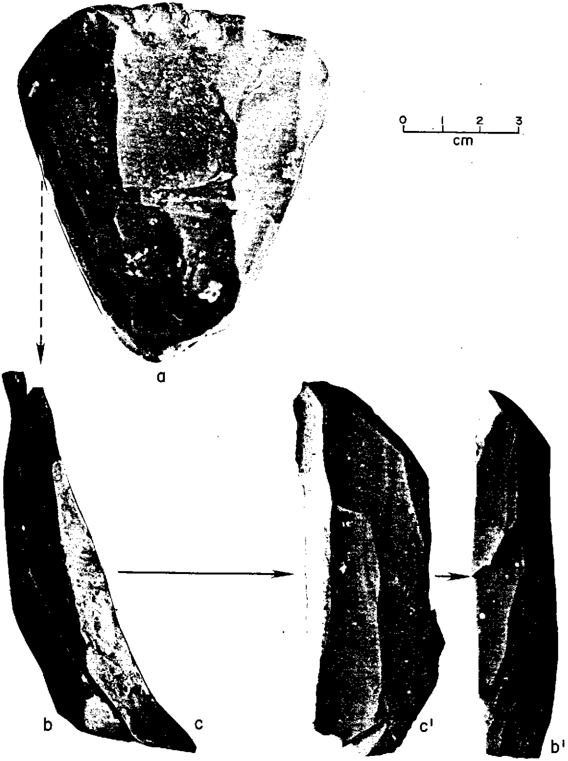


Figure 35. Two articulated blades (b,c) which match core (a) in material, and would articulate but for a missing blade along labeled facet of core's edge.

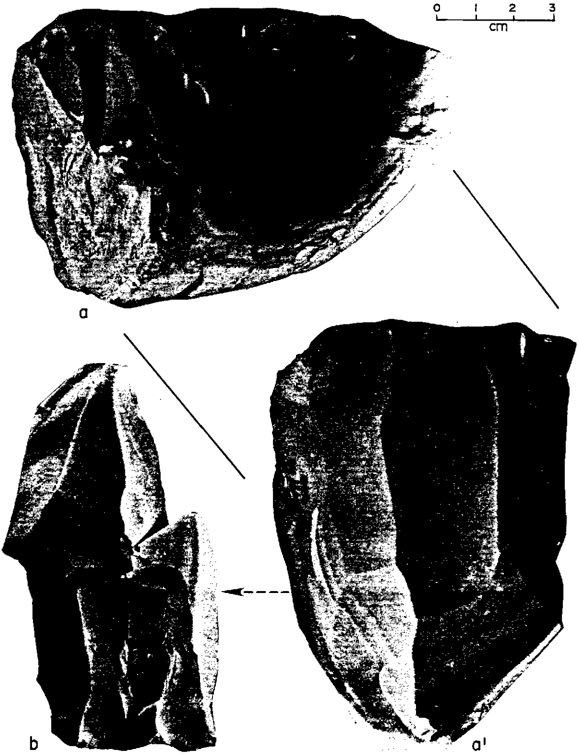


Figure 36. Two views of different blade/flake removal directions on the same core (a,a'), with two articulated blades that are a material match for the core.

Figure 37. Blade cores (a-c).

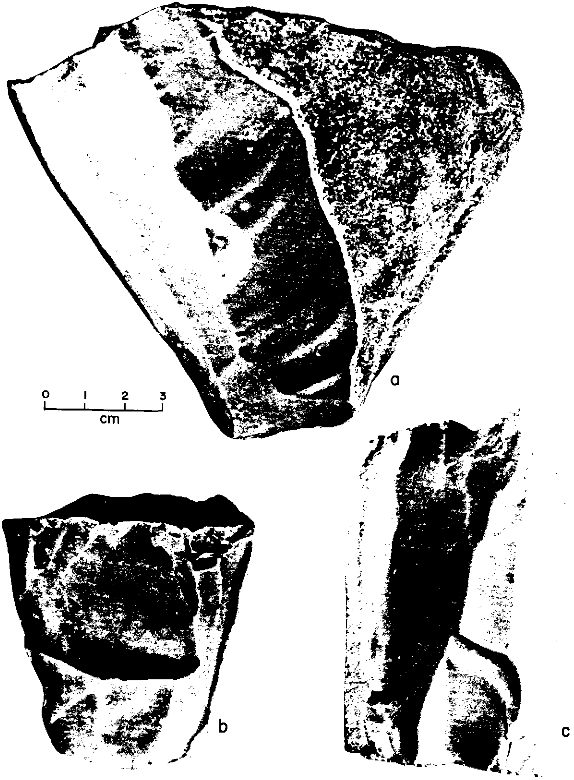


Figure 38. Op. 2007 blade cores (a-c).

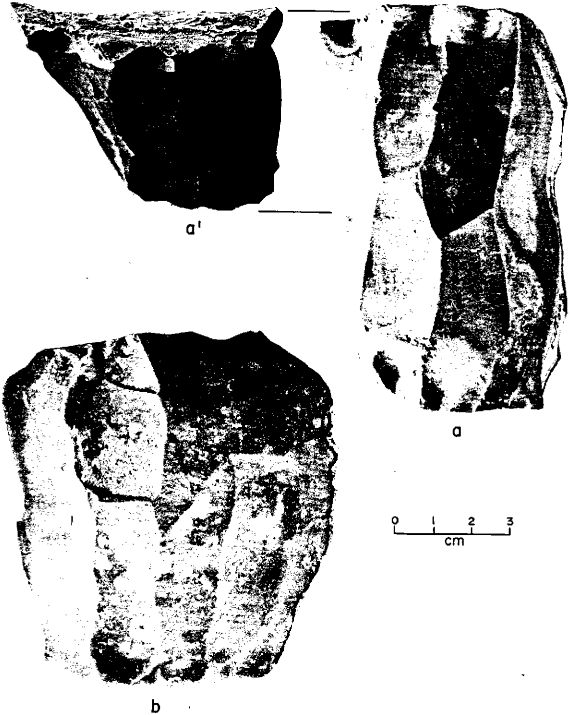


Figure 39. Two Blade Cores: (a,a') two views of a core with undetached blade, and (b) opposed platform blade core.

Table 48. Provenience of Blade Cores at Op. 2007.

		CORE FORM			
		Tabular	Polyhedral	Other	Level Totals
		N	N	N	N
SUBOPERATION	EXCAVATION LEVEL				
No Prov.	Surface	3	0	2	5
Subop. 1	Level 1	18	0	19	37
	Level 2	10	0	10	20
	Level 3	9	0	9	18
	Level 4	8	0	3	11
	Level 5	1	0	2	3
	Level 6	0	2	4	6
	Level 7	0	0	1	1
	Level 8	2	0	3	5
	Level 9	6	0	3	9
Subop. 2	Level 2	0	1	0	1
Subop. 3	Surface	0	1	0	1
	Level 1	6	0	6	12
Subop. 9	Level 1	1	0	1	2
Core Totals		64	4	63	131

Table 49. Maximum Length, Width, and Depth for Blade Cores.

	MAXIMUM LENGTH (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	64	87.3	63	130	13.7	15.7
Polyhedral	4	78.8	67	86	8.3	10.6
Other	63	91.4	48	160	19.2	20.9
ALL CORES	131	89.0	48	160	16.6	18.6

	MAXIMUM WIDTH (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	64	68.6	35.0	98	13.6	19.8
Polyhedral	4	54.5	40.0	68	12.4	22.8
Other	63	73.5	24.0	135	21.1	28.7
ALL CORES	131	70.5	24.0	135	17.8	25.3

	MAXIMUM DEPTH (mm, transverse to width)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	64	34.1	18	65	9.3	27.3
Polyhedral	4	38.8	26	53	14.8	38.1
Other	63	51.4	21	100	17.9	34.7
ALL CORES	131	42.6	18	100	16.5	38.8

Table 50. Cortex Types for Blade Cores.

		CORE FORM					
		Tabular		Polyhedral		Other	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
TEXTURE	CORTEX TYPE						
Fine	None	1	0.8	2	1.5	2	1.5
	Surface	48	36.9	1	0.8	34	26.2
	"Mined"	7	5.4	0	0	9	6.9
Mixed	None	0	0	0	0	1	0.8
	Surface	6	4.6	0	0	15	11.5
	"Mined"	2	1.5	0	0	2	1.5
ALL CORES		64	49.2	3	2.3	63	48.5

Table 51. Weight of Blade Cores.

	WEIGHT (gm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	64	235.7	65	616	119.3	50.6
Polyhedral	4	220.5	112	322	109.9	49.8
Other	62	361.8	87	1640	235.7	65.2
ALL CORES	130	295.4	65	1640	193.8	65.6

Table 52. Count of Major Scars on Blade Cores.

	MAJOR SCARS					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	64	6.0	2	10	1.9	31.9
Polyhedral	4	10.8	8	15	3.0	27.8
Other	63	6.8	2	15	2.6	37.7
ALL CORES	131	6.5	2	15	2.4	37.0

Table 53. Count of "Useful" Scars on Blade Cores.

	"USEFUL" SCARS					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	63	1.7	0	5	1.2	72.3
Polyhedral	4	3.5	1	6	2.4	68.0
Other	63	1.5	0	7	1.5	94.6
ALL CORES	130	1.7	0	7	1.4	84.2

Table 54. Length and Width of Longest Scar on Blade Cores.

	WIDTH OF LONGEST SCAR (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	54	21.2	9	35	5.6	26.4
Polyhedral	4	23.3	18	34	7.3	31.3
Other	47	20.4	12	35	5.4	26.5
ALL CORES	105	20.9	9	35	5.6	26.5

	LENGTH OF LONGEST SCAR (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	55	70.9	45	95	11.0	15.6
Polyhedral	4	68.3	55	84	13.2	19.4
Other	48	70.1	50	107	12.4	17.7
ALL CORES	107	70.4	45	107	11.7	16.5

Table 55. Length Divided by Width for Longest Scar on Blade Cores.

	LONGEST SCAR'S LENGTH/WIDTH (mm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	54	3.6	2	9	1.1	32.2
Polyhedral	4	3.0	2	4	0.6	19.3
Other	46	3.7	2	7	1.1	29.8
ALL CORES	104	3.6	2	9	1.1	30.8

Table 56. Platform Angle (corresponding to the missing blade platform) Above Longest Scar on Blade Cores.

	PLATFORM ANGLE ABOVE LONGEST SCAR					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	60	108.0	94	122	7.2	6.7
Polyhedral	3	95.7	80	104	13.6	14.2
Other	54	105.3	90	132	9.6	9.1
ALL CORES	117	106.4	80	132	8.8	8.2

Table 57. Blade Cores Sorted by Platform Categories.

	CORE FORM				
	Tabular	Polyhedral	Other		
	Frequency	Frequency	Frequency	Frequency	Percentage
SINGLE PLATFORM					
Absent	13	0	14	27	21
Present	51	4	49	104	79
MULTIPLE PLATFORM, OPPOSED					
Absent	51	4	53	108	82
Present	13	0	10	23	18
MULTIPLE PLATFORM, UNOPPOSED					
Absent	64	4	58	126	96
Present	0	0	5	5	4

Table 58. Total Platform Area on Blade Cores.

	EFFECTIVE PLATFORM AREA (square cm)					
	Frequency	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
CORE FORM						
Tabular	64	35.2	1	90	25.4	72.2
Polyhedral	4	30.3	13	50	17.6	58.3
Other	63	36.0	0	90	25.4	70.6
ALL CORES	131	35.4	0	90	25.1	70.8

Table 59. Terminations Noted on Blade Cores.

	CORE FORM				
	Tabular	Polyhedral	Other		
	Frequency	Frequency	Frequency	Frequency	Percentage
FEATHER TERMINATIONS					
Absent	1	0	3	4	3
Present	63	4	60	127	97
STEP TERMINATIONS					
Absent	51	3	44	98	75
Present	13	1	19	33	25
HINGE TERMINATIONS					
Absent	24	1	15	40	31
Present	40	3	48	91	69
OVERSHOT TERMINATIONS					
Absent	56	4	54	114	87
Present	8	0	9	17	13

Table 60. Interpreted Rejection Causes for Blade Cores.

	CORE FORM				
	Tabular	Polyhedral	Other		
	Frequency	Frequency	Frequency	Frequency	Percentage
DECREASED MASS					
Absent	10	0	31	41	31
Present	54	4	32	90	69
PLATFORM PROBLEMS					
Absent	57	4	46	107	82
Present	7	0	17	24	18
POOR RIDGE ALIGNMENT					
Absent	60	4	57	121	92
Present	4	0	6	10	8
TERMINATION PROBLEMS					
Absent	45	3	30	78	60
Present	19	1	33	53	40
NO APPARENT CAUSE					
Absent	61	4	58	123	94
Present	3	0	5	8	6
"EARLY STAGE" REJECTION					
Absent	62	4	51	117	89
Present	2	0	12	14	11

Table 61. Additional Attributes Noted on Blade Cores.

	CORE FORM				
	Tabular	Polyhedral	Other		
	Frequency	Frequency	Frequency	Frequency	Percentage
RING CRACKS					
Absent	55	2	54	111	85
Present	9	2	9	20	15
EXTREME BATTERING					
Absent	60	3	54	117	89
Present	4	1	9	14	11
UNDETACHED BLADE					
Absent	57	4	59	120	92
Present	7	0	4	11	8
PLATFORM OVERHANG					
Absent	26	2	32	60	46
Present	38	2	31	71	54
PLATFORM TRIMMING					
Absent	55	3	48	106	81
Present	9	1	15	25	19
PLATFORM CRUSHING					
Absent	51	3	51	105	80
Present	13	1	12	26	20

another other than opposite (N=126 cores, Figure 36). The effective platform area (Table 58) is a measurement of the remaining striking area remaining on the cores regardless of number of platforms. The average area was about 35 cm^2. Also note that some cores had no useful area left (i.e. zero). Table 52 summarizes a count of the "major" blade scars on the cores. Scars smaller than ca. 30 mm length were not considered here. The single longest blade scar on each core had basic measurements taken comparable to those of blades (Tables 54,55, and 56). The platform angles above these scars were read in a reverse manner with the goniometer (Table 56). The negative depression of the bulb of force slightly effected the instrument's precision.

Material. As shown, the chert blades matched some of the cores, and all material is Colha chert. A number of blades which could not be refitted to cores appeared nonetheless to match in color, cortex, and grain. Table 50 sorts both cortex and grain texture for cores. Only about 5% of the cores have no cortex. Like the other artifacts, the majority (ca. 79%) display fine grain.

Additional Variables. A number of other variables were coded for use in technological inferences. These variables include: certain platform traits, blade scars thought to reflect "useful" blades, terminations of blade scars on cores, and interpreted causes of rejection. This information is discussed in "Technological Insight".

Core Tablets (N=28)

General Morphology. A core tablet is a special rejuvenation flake where the platform portion of a core is removed to create a new platform surface (Figure 33a). Because this decreases vertical mass for blade-making, core tablets were removed only when problems could not be overcome utilizing the original platform (i.e. a poorly faceted or angled surface was present). Because core tablets do not always truncate the complete end of a core, only a few definitely can be related to tabular shaped cores. Most (N=16) depict amorphous, somewhat cylindrical shapes (Figures 40a,41a, and 42a). One specimen is from a true polyhedral blade core (Figure 40c). The remainder (N=10) are items I consider <u>platform ridged flakes</u> often related to core tablets in form or intent. Actually I see at least three technological patterns in these specimens (explained in "Technological Insight"). They are grouped here because I think they usually reflect core maintenance related to the form and function of core tablets. These artifacts often appear as thin ridged blades which had a blade core platform edge guide their removal. They fractured at planes about 45° relative to the ideal transverse core tablet fracture plane. A core tablet was found to match one of these <u>ridged flakes</u> (Figure 42b). In terms of measurement, the largest single core tablet is 135 mm wide, 90 mm deep (as in core dimensions), 40 mm maximum vertical thickness, and 479 gm (Figure 41a). The smallest core tablet (not considering the skewed ones) is 55 mm wide, 49 mm deep, 24 mm thick, and 67 gm (Figure 40b). The polyhedral core tablet is 73 mm wide, 80 mm deep, 26 mm thick, and 94 gm (Figure 40c).

<u>Material.</u> Core tablet material appears compatible with the blade core collection. Twenty-one specimens are fine grained, six are mixed (including the two that

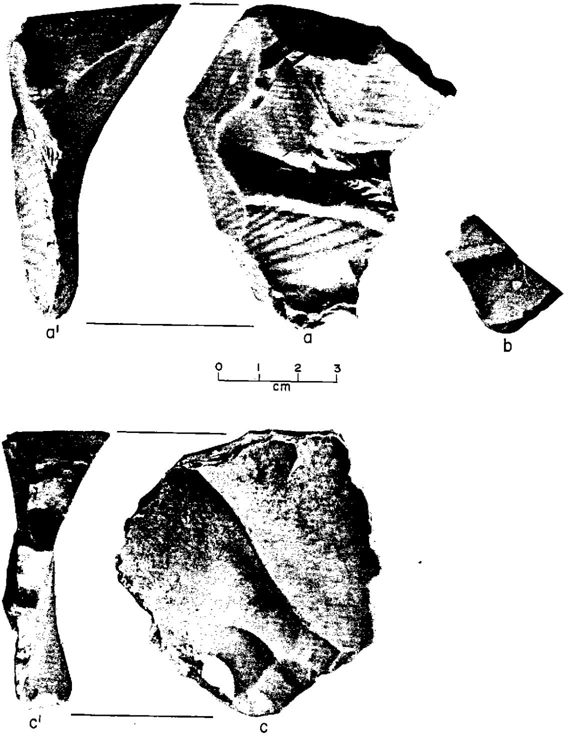


Figure 40. Blade core tablets: (a,a') two views of an incomplete removal; (b) smallest example; and (c,c') two views of a polyhedral specimen.

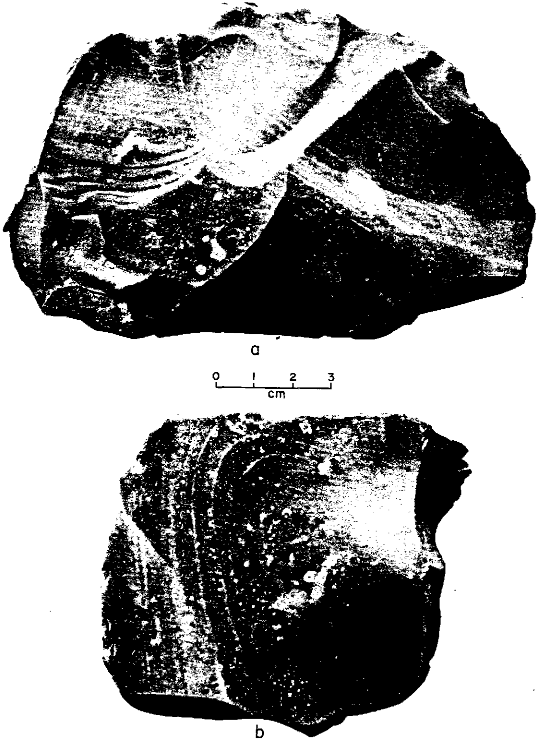


Figure 41. Blade core tablets: (a) largest example, dorsal view; and (b) ventral view of specimen - proximal/platform orientation for both (a) and (b) is to the right in this figure.

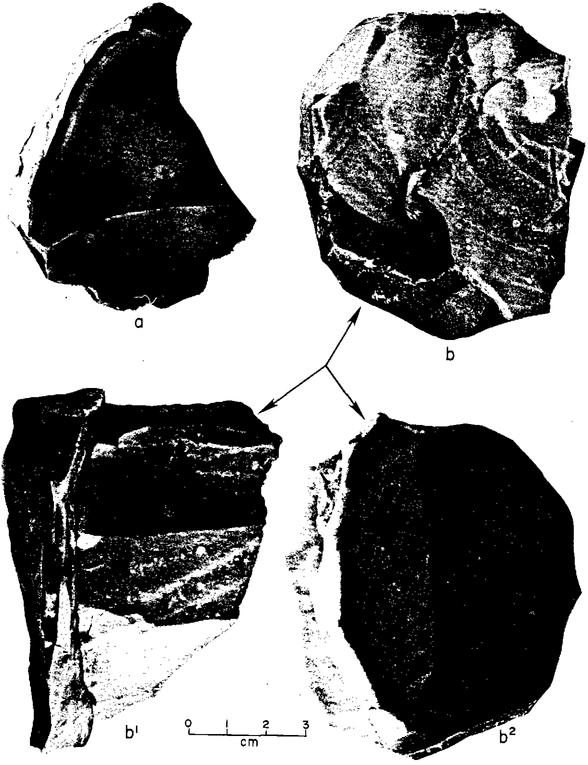


Figure 42. Blade core tablets: (a) incomplete removal example; and three views of a specimen that articulates to a platform ridge specimen related to further reduction of a core (b, b', b^2).

match), and one is coarse. Nine do not have cortex (most of these are platform ridge flakes). Of those with cortex, a few are of "mined" origin with the remainder having surface cortex. One core tablet is a badly burned fragment.

Battered-Abraded Stone (N=61)

General Morphology. Battered or abraded artifacts are sorted into four groups described without the benefit of a table. Most of these artifacts are battered chert specimens generally called "hammerstones", while only eight are highly abraded.

The first group consists of battered, generally spherical artifacts I classify formally as hammerstones. The function of these objects is later discussed. Within this category, 12 specimens are modified chert nodules, 12 are of limestone, and four are recycled blade cores. Of the chert nodules, four (of 12) are hemisphere-shaped fragments (Figure 43a-d). They range from 105 mm maximum width (689 gm) to 75 mm width (161 gm). The complete specimens range from a crudely shaped but highly battered nodule which is possibly an early stage blade core 135 mm x 84 mm x 72 mm (992 gm, Figure 43k) to a totally battered, small sphere with one flat side, 60 mm x 52 mm (317 gm, Figure 43g). An additional 12 specimens are made of limestone. Battering is more subtley shown on this material. Some of these artifacts tend to be elongate, with four having biconical shapes (Figure 43e,f,h, and 1) similar to Late Preclassic hammerstones known elsewhere at Colha (Shafer and Hester 1983:Figure 5f). The most complete biconical hammerstone is 83 mm x 50 mm x 40 mm (192 gm; Figure 43h). The other limestone hammerstones vary from a dense cherty-limestone split cobble 115 mm x 82 mm x 46 mm (708 gm, Figure 43j) to a i delicate item 83 mm x 33

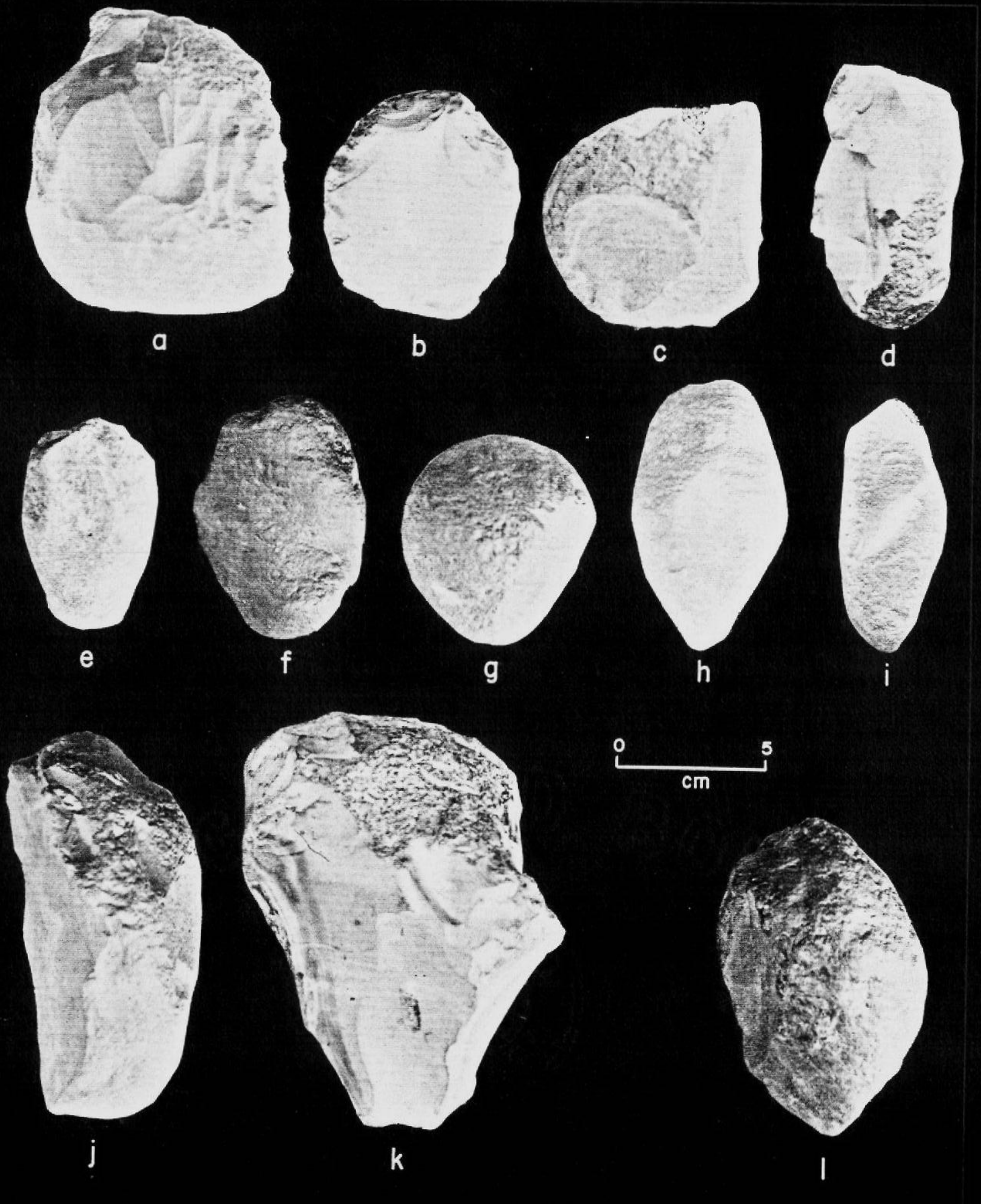


Figure 43. Battered/Abraded stone: (a-d) split chert hammerstones; (e,f,h,l) biconical limestone hammerstones; (g) totally battered chert hammerstone; (i) smallest limestone hammerstone; (j) dense limestone split cobble; and (k) large chert hammerstone/nodule.

mm x 23 mm (77 gm, Figure 43i). The final subgroup of chert hammerstones are five blade cores which were recycled as hammerstones (Figure 44a-e). One polyhedral core is an exceptional example with extreme battering shown on either end (size 76 mm x d 55 mm x 51 mm; Figure 44d). Core weights are 408, 462, 511, 306, and 100 gm respectively in Figure 44a,b,c,d, and e.

The second group relates to nine miscellaneous battered chert artifacts, most of which are some form of crude unclassified biface. Many archaeologists would also term these "hammerstones". The forms range from three small disc-shaped bifaces ca. 55 mm x 55 mm x 25 mm (Figure 45d-f, weight 109 gm for Figure 45f), to a large, thick biface with extreme battering on three sides, 120 mm x 68 mm x 46 mm (539 gm, Figure 45a). This later specimen could be classified as a "general utility tool" after Kidder (1947). Also, a crudely tapered biface has severe battering on its lateral area (358 gm, Figure 45b).

The third group consists of 14 artifacts of chert with areas of uniform, severe battering (or pecking). These artifacts, and some in the fourth group below, are classified as chert matate fragments. As seen in fragments, internal fractures from this battering often exceed 15 mm in depth. The largest specimen is a complete, trimmed macroflake (struck off a larger matate?) with its flat side of dorsal cortex deeply battered (Figure 46a,a'). It weighs 823 gm and is 142 mm x 85 mm x 54 mm. Most of the other artifacts are various flakes exhibiting similar battering. These flakes appear to be fragments of larger specimens. They range from 52 mm x 83 mm x 38 mm (Figure 46b, 571 gm) to small items ca. 10 mm x 20 mm x 8 mm (retrieved from the

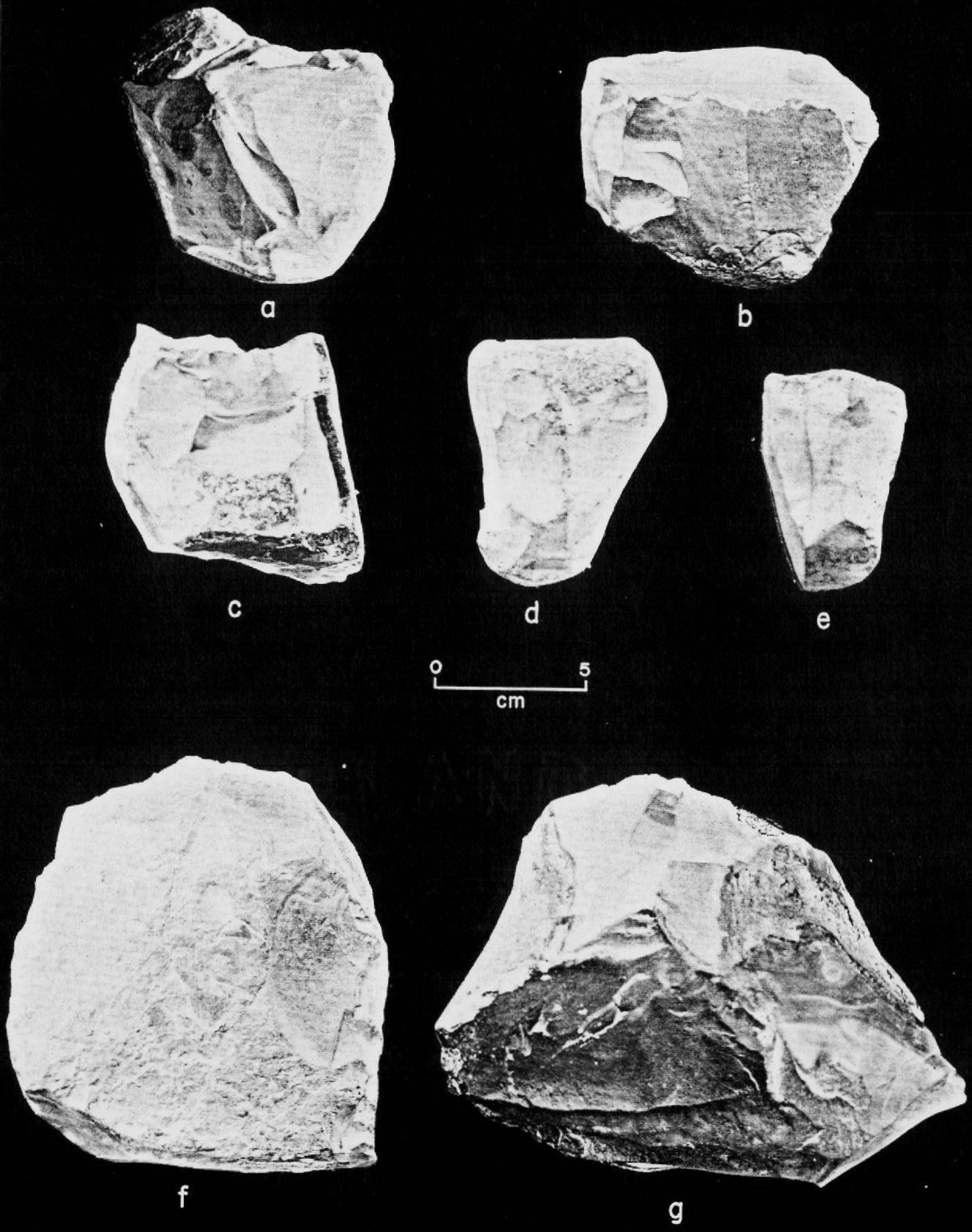


Figure 44. Battered stone and rejected cores: (a-e) blade cores recycled into hammers; and (f,g) two rejected core nodules possibly intended for use as blade cores.

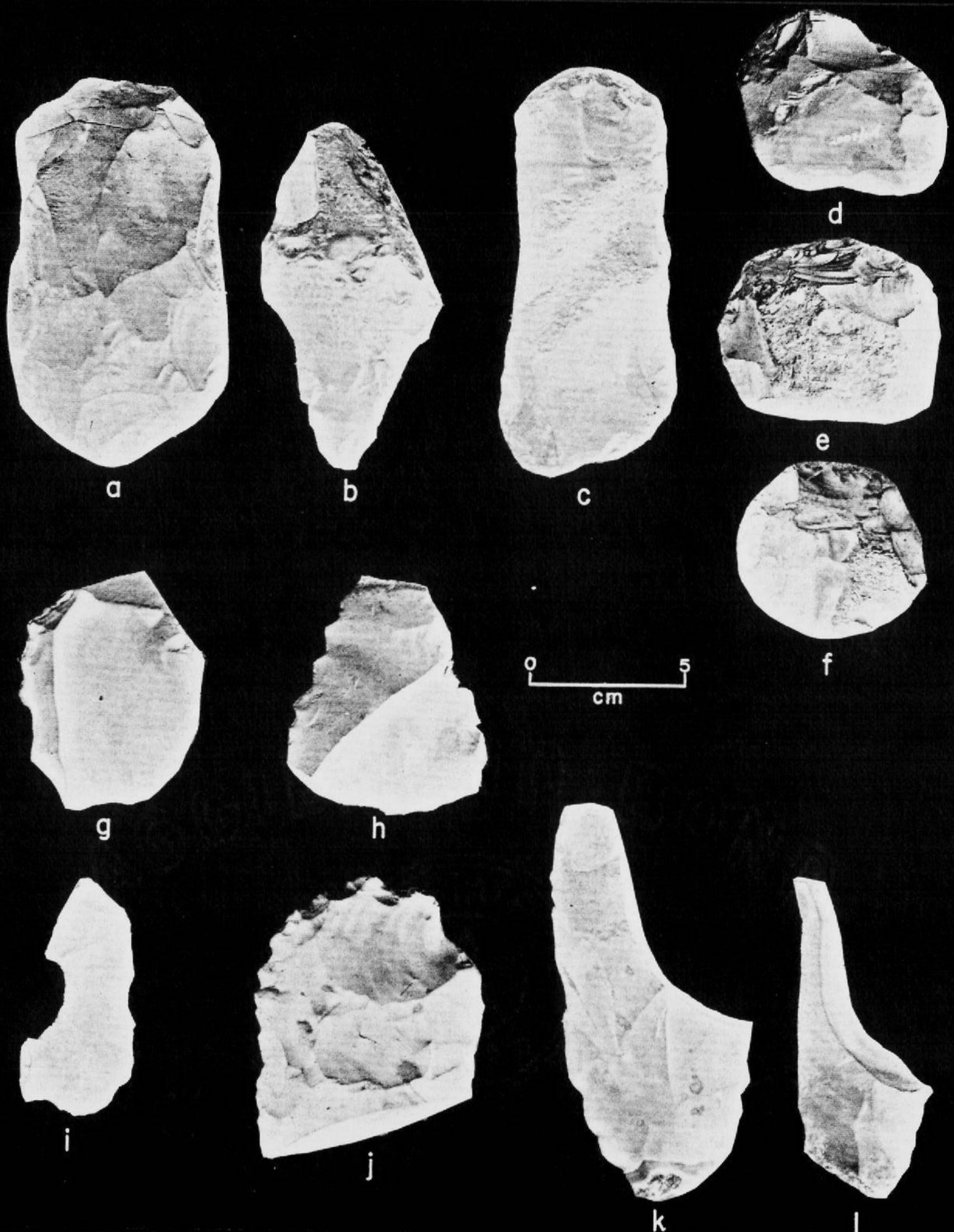


Figure 45. Various artifacts: (a) battered "general utility tool"; (b) battered, tapered biface; (c) battered/abraded biface; (d-e) battered biface disc-forms; (g-i) overshot biface thinning flakes; (j) biface fragment with evidence of rapid percussion; and (k-l) overshot ridged blades produced from biface fragments.

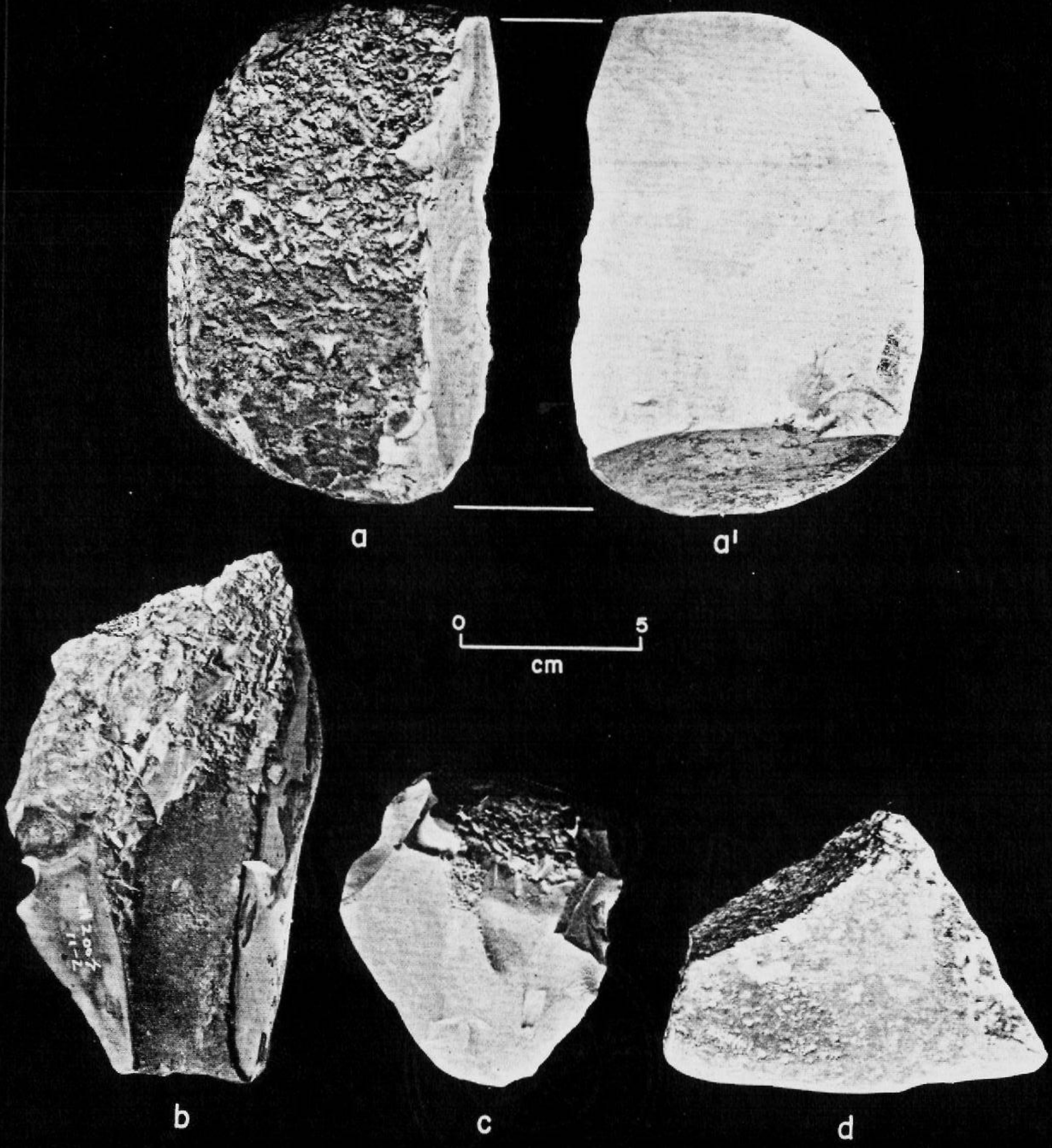


Figure 46. Matate fragments: (a,a') chert macroflake (?) struck from larger specimen; (b) large chert matate flake; (c) chert matate flake recycled into a plano-convex form; and (d) matate fragment of imported material.

debitage column sample). One of the larger fragments apparently was recycled into a plano-convex form with finer hammerstone type batter marks in addition to an area of severe pecking (Figure 46c, 315 gm).

The fourth group includes eight specimens that represent material both pecked and substantially abraded. Four of these specimens are chert flakes virtually identical to those above except that the roughened surface has been well smoothed. Another artifact is an elongated remnant biface which has been severely battered on all sides and one end (Figure 45c). Three distinct concave areas of battering on its sides were then abraded. It is 129 mm x 45 mm x 33 mm (333 gm). The three remaining specimens are fragments of non-chert groundstone _matates_. Only one of these is a collected artifact (Figure 46d). The other two are represented by field laboratory samples chipped away from two matates which have no descriptive record. These artifacts are stored in Belize. A ninth artifact of abraded stone appears to have been lost in processing. This is a pestle mapped in Sub-operation 5, Level 1 (Figure 7). It was a cylindrical object ca. 100-150 mm long and 50 mm in diameter, broken at one end and rounded at the other.

Material. The hammerstones are evenly divided between chert material which is inseperable from that described for the bulk of blades and bifaces. The limestone has no noticeable variation from any other limestone at Colha. The biconical hammerstones are of relatively lighter and softer consistency compared to the larger limestone hammerstones which definitely are of heavier and tougher material - what might be called cherty limestone. Although one battered blade core is thermally altered (which I consider fortuitous), no difference in material quality can be seen in comparison to the main collection of blade cores. The miscellaneous battered chert artifacts also have no unusual characteristics, although one of banded chert has cortex showing it was freshly mined. The chert of the third group, mostly pecked fragments, also indicates a typical range of local Colha material. The large complete specimen (Figure 46a) has brown, surface weathered cortex. Finally, the pecked _and_ abraded collection has some unusual material in the non-chert _matates_ described. The collected item (Figure 46d) appears to be of vasicular, crystalline limestone which may have been procured from the Richmond Hill vicinity of western northern Belize (H. Shafer, personal communication). The sampled _matate_ chips are forms of schist and granite. This material probably came from the Maya Mountains of southern Belize.

Obsidian (N=14; plus 11 missing)

General Morphology. Obsidian at Op. 2007 was a rare commodity. Of a total of 25 specimens noted and field collected, only 14 (Figure 47) were ultimately obtained. I suspect a number were lost on laboratory drying screens or in other processing. Most obsidian encountered was in the form of prismatic blade fragments: two proximal (Figure 47h,i), one medial (Figure 47g), six distal (Figure 47a-f), and three missing. Two complete blades were identified (Figure 47j; one missing). One proximal blade fragment (Figure 47h) is the smallest specimen of the entire obsidian collection (thickness 2 mm). It has a ground or cortex platform. The distal fragments ranged 18 to 48 mm in length, 9 to 18 mm in width, and 2 to 3 mm in thickness. Two display plunging curved terminations (Figure 47a,b). The whole blade (Figure 47j) has a small, crushed

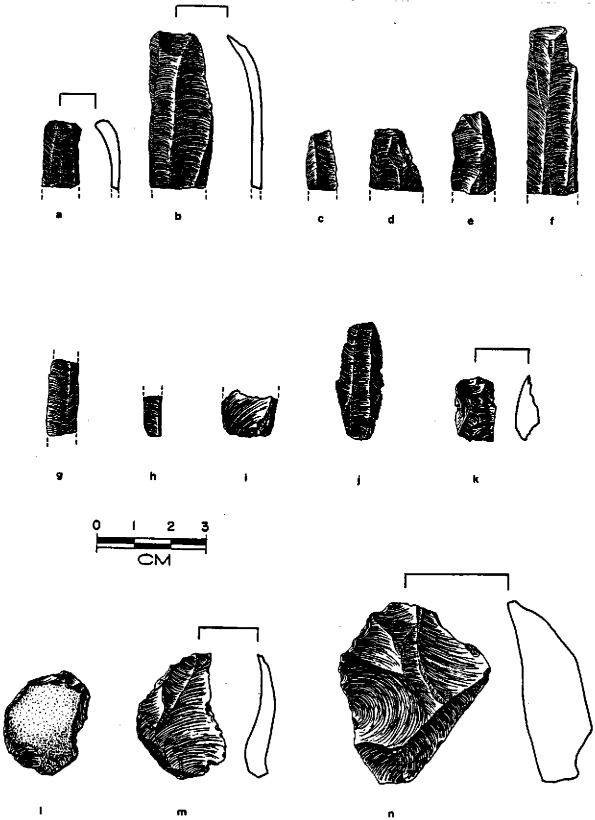


Figure 47. Obsidian: (a-i) blade fragments; (j) whole; (k-n) flakes.

platform, no prominent bulb of force, but strong undulation (ripples) on the ventral side. The other four specimens in the collection are various flakes. One (Figure 47k) is a complete item with step terminations and crushing on opposite ends (possible bipolar technique). It has a prominent bulb of force (thickness 7 mm). Another complete flake (Figure 47l) has fine, stream rolled cortex over most of one side. It has a large crushed platform area and is also 7 mm thick. The third flake appears to be the truncated distal end of a blade core (Figure 47m). Seven terminating scars are present on one side of the specimen. It has a single facet platform 4 mm x 2 mm, and a robust bulb of force. The fourth and largest flake also appears to be a core fragment (Figure 47n). It has a large single facet platform ca. 8 mm x 10 mm. The flake's length is 52 mm, width 42 mm, and maximum thickness 18 mm. It and the previous flake described have substantial edge modification.

Material. The obsidian collected can be described as translucent (Figure 47d,i), translucent black banded (Figure 47j), black/grey banded with distinct air bubbles (Figure 47n), and grainy translucent/soft grey banded (Figure 47a). Two samples submitted for trace element analysis indicate the sources of El Chayel and Ixtepeque, Guatemala (Figure 47a.b respectively). Late Classic obsidian collections of Colha typically display a majority of El Chayel material with some Ixtepeque T.R. Hester, personal communication). This situation is basically reversed in Postclassic times, and yet another major source (Rio Pixcaya) supplied Preclassic Colha (T. R. Hester, personal communication).

Constant Volume (Debitage Column) Samples

I present a descriptive overview here rather than a true description of the thousands of pieces of debitage collected from the profile face of Sub-operation 1. A detailed morphological study for this collection, based on problems I have not addressed, could take as much research time (or more) as I have currently expended. Here I am trying to simply give the reader an idea of the bulk appearance of the debitage. The column samples were 20 x 20 x 20 cm cubes retrieved every 20 cm depth (excavation Levels 1-7), stopping at the base of the debitage midden, ca. 140 cm below surface. I believe the actual volume of each level's sample was consistently biased to be slightly <u>over</u> 20x20x20 cm. Because quantification was a prime goal of my analysis (as I discuss later), the samples were first sorted into lithic debitage, ceramics, rubble, and shell/bone. A small amount of charcoal present is thought to be recent. It probably was introduced from upper wall slump as the samples were collected (because of the unstable debitage, samples were removed from top to bottom). Next I sorted the debitage into infered biface or blade trajectory assemblages. Then the debitage was sorted by the sieves previously descibed. Tables 62-71 provide the breakdown of these categories by weight. As can be calculated from this information, the total weight of the samples is 55.869 kilograms. Of this, 53.898 kg (96.5%) is lithic debitage, .28 kg (.5%) is ceramic sherds, and 1.689 kg (3%) is rubble or small pebbles. Shell or bone was of negligable weight. Of the lithic debitage, not considering the weight of sieve 7's small material and its fallout, 15.679 kg of material was judged to be related to blade production debris. The biface debitage was 24.3 kilograms. This

Table 62. Op. 2007, Subop. 1, Level 1 (0-20 cm), Material Sorted from 20x20x20 cm Sample.

Sieve	Gross Debitage Weights (gm)	Blade Debitage Weights (gm)	Biface Debitage Weights (gm)	Ceramic Weights (gm) for Total Level	Rubble, Pebble Weights(gm) for Total Level
1	485.5	485.5			
2	287.5	83.5	168		
3	844	625	222		
4	2227.5	874.5	1336	32 gm	753 gm
5	568	266.5	301.5		
6	1012	236	774		
7	670.5	------Not Examined------			
Fallout	1051.5	------------------------			

Debitage Total: 7146.5
Grand Total (all material): 7931.5

Table 63. Op. 2007, Subop. 1, Level 2 (20-40 cm), Material Sorted from 20x20x20 cm Sample.

Sieve	Gross Debitage Weights (gm)	Blade Debitage Weights (gm)	Biface Debitage Weights (gm)	Ceramic Weights (gm) for Total Level	Rubble,Pebble Weights(gm) for Total Level
1	0				
2	684.5	684.5			
3	802.5	448.5	354		
4	2529	1119.5	1409.5	25 gm	22gm
5	620.5	269	351.5		
6	962	188.5	773.5		
7	564	------Not Examined------			
Fallout	1253	------------------------			

Debitage Total: 7415.5
Grand Total (all material): 7464.5

Table 64. Op. 2007, Subop. 1, Level 3 (40-60 cm), Material Sorted from 20x20x20 cm Sample.

Sieve	Gross Debitage Weights (gm)	Blade Debitage Weights (gm)	Biface Debitage Weights (gm)	Ceramic Weights (gm) for Total Level	Rubble,Pebble Weights(gm) for Total Level
1	85.5		85.5		
2	182		182		
3	1350.5	691	566.5	109.5	272.5
4	2763	1111	1652		
5	592	214.5	377.5		
6	1001	254	747		
7	572	------Not Examined------			
Fallout	810	------------------------			

Debitage Total: 7356
Grand Total (all material): 7738

Table 65. Op. 2007, Subop. 1, Level 4 (60-80 cm), Material Sorted from 20x20x20 cm Sample.

Sieve	Gross Debitage Weigts (gm)	Blade Debitage Weights (gm)	Biface Debitage Weights (gm)	Ceramic Weights(gm) for Total Level	Rubble,Pebble Weights (gm) for Total Level
1	0				
2	0				
3	1190.5	621	569.5	12.5	105.5
4	2691	997.5	1693.5		
5	673.5	193.5	480		
6	1227.5	211	1016.5		
7	677.5	------Not Examined-----			
Fallout	995	------------------------			

Debitage Total: 7455
Grand Total (all material): 7573

Table 66. Op. 2007, Subop. 1, Level 5 (80-100 cm), Material Sorted from 20x20x20 cm Sample.

Sieve	Gross Debitage Weights (gm)	Blade Debitage Weights (gm)	Biface Debitage Weights (gm)	Ceramic Weights(gm) For <u>Total</u> Level	Rubble,Pebble Weights (gm) For <u>Total</u> Level
1	0				
2	783.5	332	274		
3	1095	529.5			
4	3049	1047	1891	13.5	9.5
5	743	169.5	573.5		
6	1344.5	156.5	1180		
7	930	------Not Examined------			
Fallout	1363	-----------------------			

Debitage Total: 9308
Grand Total (all material): 9331

Table 67. Op. 2007, Subop. 1, Level 6 (100-120 cm), Material Sorted from 20x20x20 cm Sample.

Sieve	Gross Debitage Weights (gm)	Blade Debitage Weights (gm)	Biface Debitage Weights (gm)	Ceramic Weights(gm) for <u>Total</u> Level	Rubble,Pebble Weights (gm) for <u>Total</u> Level
1	0				
2	395.5	207	188.5		
3	515.5	329.5	186		
4	2789	940	1849	68.5	58
5	690	204	475.5		
6	1485	213	1269.5		
7	1055.5	-------Not Examined------			
Fallout	1752	------------------------			

Debitage Total: 8682.5
Grand Total (all material): 8810

Table 68. Op. 2007, Subop. 1, Level 7 (120-140), Material Sorted from 20x20x20 cm Sample.

Sieve	Gross Debitage Weights (gm)	Blade Debitage Weights (gm)	Biface Debitage Weights (gm)	Ceramic Weights (gm) for <u>Total</u> Level	Rubble, Pebbles Weights (gm) for <u>Total</u> Level
1	859	215	644		
2	578	256	322		
3	1381	684.5	696.5		
4	1649	693	893	19	468.5
5	329	52	277		
6	605	76.5	520.5		
7	412	------Not Examined----			
Fallout	718.5	----------------------			

Debitage Total: 6531.5
Grand Total (all material): 7019

Table 69. Op. 2007, Subop.1, <u>Total</u> Debitage Weights of Seven 20x20x20 cm Samples, Sorted by Geological Sieves.

Sieve	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Sieve Totals
1	485.5	0	85.5	0	0	0	859	1430
2	287.5	684.5	182	0	783.5	395.5	578	2911
3	844	802.5	1350.5	1190.5	1095	515.5	1381	7179
4	2227.5	2529	2763	2691	3049	2789	1649	17697.5
5	568	620.5	592	673.5	743	690	329	4216
6	1012	962	1001	1227.5	1344.5	1485	605	7637
7	670.5	564	572	677.5	930	1055.5	412	4881.5
fall-out	1051.5	1253	810	995	1363	1752	718.5	7943
Totals	7146.5	7415.5	7356	7455	9308	8683.5	6531.5	53,895 gm grand total

Sieve sizes: (maximum diagonal width)

#1 - ca. 85 mm
#2 - ca. 68 mm
#3 - ca. 53 mm
#4 - ca. 25 mm
#5 - ca. 21 mm
#6 - ca. 13 mm
#7 - ca. 7 mm

Table 70. Op. 2007, Subop. 1, Blade Debitage Weights of Seven 20x20x20 cm Samples, Sorted by Sieves # 1-6 Only (Sieve 7 and Fallout excluded).

Sieve	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Sieve Totals
1	485.5	0	0	0	0	0	215	700.5
2	83.5	684.5	0	0	332	207	256	1563
3	625	448.5	691	621	529.5	329.5	684.5	3929
4	874.5	1119.5	1111	997.5	1047	940	693	6782.5
5	266.5	269	214.5	193.5	169.5	204	52	1369
6	236	188.5	254	211	156.5	213	76.5	1335.5
Totals	2571	2710	2270.5	2023	2234.5	1893.5	1977	15,679.5 gm (grand total)

Table 71. Op. 2007, Subop. 1, Biface Debitage Weights of Seven 20x20x20 cm Samples, Sorted by Sieves # 1-6 Only (Sieve 7 and fallout excluded).

Sieve	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Sieve Totals
1	0	0	85.5	0	0	0	644	729.5
2	168	0	182	0	274	188.5	322	1134.5
3	222	354	566.5	569.5	0	186	696.5	2594.5
4	1336	1409.5	1652	1693.5	1891	1849	893	10,724
5	301.5	351.5	377.5	480	573.5	475.5	277	2836.5
6	774	773.5	747	1016.5	1180	1269.5	520.5	6281
Totals	2801.5	2888.5	3610.5	3759.5	3918.5	3968.5	3353	24,300 gm (grand total)

is a ratio of about 1:1.5 for blade material versus biface debris. Certain early stage cortex flake removals were impossible to justify as preliminary to either blade or biface trajectories. These specimens were equally divided for quantification sorting. The biface debitage generally resembled that described by Shafer (1979:64-68) for a Late Preclassic biface workshop (Op. 2006). It is my impression that cortex flakes are more common in the Op. 2007 samples. A typical thinning flake has a multiple faceted platform, robust bulb of force, and expanding body. Seven biface fragments were present. The blade debitage's material is identical to that described previously for blades and bifaces. One blade core, seven core tablets, and 11 modified blades were present in the column sample. Ceramics are typically small, abraded redware sherds about 30 x 30 mm in size. Rubble was predominately limestone. Seven pieces were ca. 5-7 cm diameter, with the remainder being small limestone pebbles ca. 1-3 cm diameter. Shell was mainly Pomacea. Only one porous bone fragment about 5 mm in size was collected (Level 6). Occasionally a piece of debitage, rubble, or ceramic showed effects of fire. This was less common with depth from the modern surface.

Technological Insight

Below I describe the two major technological systems shown by the manufacturing debris at Op. 2007: oval biface and stemmed blade manufacturing. This discussion is aided by simple linear models for each system (Figures 48,49). As Rice (1981:238) discusses, a

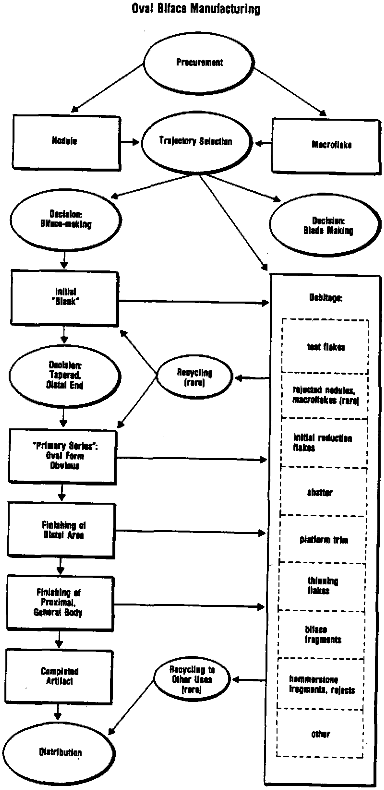


Figure 48. Flow chart for <u>oval biface</u> manufacturing at Op. 2007.

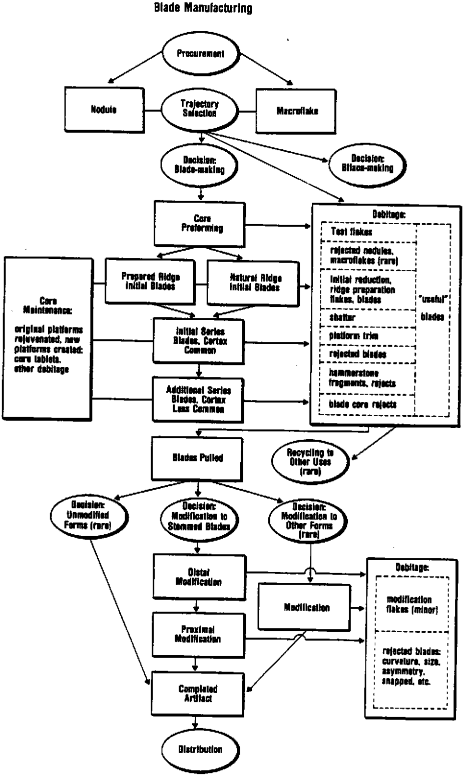


Figure 49. Flow chart for blade manufacturing at Op. 2007.

model is a heuristic device which makes some compromise to simplify reality.

Interpretations for idealized tool production are based on the presence of debitage, "Residual lithic material resulting from tool manufacture . . . Represents intentional and unintentional breakage of artifacts either through manufacture or function . . . " (Crabtree 1972:58). This is the essential subject material of technological analysis. I stress its value in light of the fact that the lithic deposit sampled at Op. 2007 is nearly pure debitage. Finished artifacts, as successful products, of both systems are absent. Minimal evidence of artifact use is present (see below). In other words, the models of tool production are based not so much on evidence of products as on the waste of production.

Both models theoretically occupy the manufacturing block of Figure 11. As earlier discussed, I realize there may be transition between adjacent processes (procurement, distribution, etc.). In discussion, I try to follow linear stages within the manufacturing models, although certain elements are redundant. Where possible, technological examples from the collection are identified to back up claims. Linear reduction models may give the impression that production occurred in distinct stages. This is true only in the general sense that qualitative shifts in technological behavior may be traced in lithic debitage (Sheets 1975:372). Stone tool manufacturing is a continuum of reduction. Adjustments for various problems (i.e. material flaws, abrupt terminations, etc.) and objectives require a variable and dynamic process. Despite the one-way reduction of mass, an option for novel techniques or recycling is sometimes possible. This should be recalled as I identify "stages" below.

Oval Biface Manufacturing

The oval biface manufacturing system here is largely that described by Shafer (1979:55-60) for a Preclassic workshop at Colha. However, there are slight differences. I incorporate unaltered nodules (or "cobbles") as potential raw material, and the gross morphology of Late Classic oval bifaces is slightly different (Shafer and Hester 1983:529). This later quality may relate to a slight reduction in product size, a somewhat cruder or more variable form, and other possibilities I am not presently investigating. Below I follow the flow chart (Figure 48) to explain what is basically a simple system.

Nodule/Macro-flake. Shafer (1979:58) indicates that Preclassic oval bifaces are made on macroflakes, "very large flakes, some in excess of 30 cm long". Certain biface fragments in the Op. 2007 collection show possible evidence of being made on macroflake "blanks". This is sometimes shown by the partial presence (on a biface) of a huge macro-flake's ventral scar, remnant platform, or bulb of force. In examining the collection as a whole, I only rarely see traces of these attributes. I cannot rule out this alternative, however, for two reasons: 1) a small number of tranchet-bit bifaces were apparently made at the workshop, and these tools require macroflake blanks for suitable working ends (Shafer 1979), and 2) it is possible that some biface fragments, even with just a few flakes removed, are difficult to assess. A close reexamination of the debitage sample would perhaps resolve this problem. On the other hand, numerous bifaces at Op. 2007 exhibit remnant forms of large cortex covered cobbles. The typical cobble size may be about 250 mm x 100 mm x 50 mm (cf. Figure 13c) or larger. About 40% (49) of the tapered proximal biface fragments have cortex on their ends, and most often this cortex has a rounded border and lack of any striking platform. Although these may not be considered finished tool fragments, this may be a portion of the bifaces where edge thinning (other than that incidental to transverse body thinning) was not strictly required.

Trajectory Selection. This is a decision point where the flintknapper chose how to use the nodule or macro-flake. Because the excavation of biface and blade-making evidence showed it to be well mixed, I believe that the raw material for both trajectories was the same. As I will discuss in Chapter VII, it cannot be said if a single worker was making this decision to follow through on it, or perhaps an overseer or aide made judgement. The first debitage possibly was produced here in the form of "test" flakes to reveal material quality. The collection includes total cortex flakes. Two nodules retrieved which have evidence of initial flake removals are more likely to have been potential blade cores (Figure 44f,g).

Initial "Blank". This refers to the very initial series of reduction flakes removed when a biface first takes form. The biface nodule of Figure 13c has no more than about 30 major flake scars. As depicted by deep bulbar scars and sinuous body edges, hard hammer percussion and little if any platform preparation took place. If a large blank specimen was broken in manufacturing, a suitable biface fragment might continue to recieve modification. I have no firm evidence for this although there is a slightly higher number of proximal than distal (recycled?) fragments in the collection (Table 6). Were large distal fragments occasionally retapered?

Selecting Tapered, Distal Ends. Bifaces at this point I consider to be "early stage". Most of the biface collection (fragments) may be grouped here rather than in the "late stage" described below (Table 72). Early stage bifaces tend to have 1) sinuous body edges (viewed both in outline and on edge), 2) large, bulbar scars, and 3) little platform preparation. I do not refine this into morphological terms although these bifaces are necessarily larger than those to follow.

At a time relatively early in production, one end of the biface was chosen for the oval (distal-bit) end with the opposite end to be tapered (proximal-hafted). Remnants of nodule cortex may remain present at either end and elsewhere on the biface (Figure 12b,c,h). About 40% of all proximal biface fragments had cortex on their ends while about 20% of the distal fragments did. This cortex frequently appears to be nodular remnants rather than macro-flake cortex platforms or ventral remnants. In terms of material, there may be a trend for finer grained chert (within mixed grained specimens) to be prefered at the distal ends. Platform preparation remained minimal if present. Rapid sequential percussion thinning may be seen along jagged biface edges (Figure 45h,i). Large flake scars (ca. 50 mm long) remain evident on bifaces.

Distal Area Finishing. Traits of "finishing" on a biface equate what I consider to be the "late stage" of production. These trends are: 1) the biface's body edges are relatively regular and straight (viewed as for "early stage" above), 2) slight platform preparation is

Table 72. Manufacturing Traits for Biface Forms at Op. 2007.

		MANUFACTURING TRAITS OBSERVED				
		Early Stage	Late Stage	Early and Late Stages		
		N	N	N	N	Percentage
BIFACE CLASS	BIFACE FORM					
Oval	Complete, Unused	12	17	2	31	10
	Complete, Used	3	11	2	16	5
	Proximal Frag.	79	33	15	127	42
	Medial Frag.		2	1	3	1
	Distal Frag.	62	35	9	106	35
Tranchet-bit	Complete, Unused	1	11	2	14	5
	Complete, Used		1		1	0
	Distal Frag.		1		1	0
Total		157	111	31	299	100

seen, and 3) body scars tend to be smaller and less deep. The platform preparation evidence consists of a minute edge beveling produced by light percussion trimming of the biface edge from a direction opposite that of the desired flake removal (cf. Shafer 1979:58). The result is a series of small step and feather termination flake scars ca. 1 mm x 1 mm. Occasionally handedness of the flintknapper is shown by beveled platforms on opposite faces of a biface's lateral edges. Traces of abrasion (edge grinding) may accompany this beveling. A possible switch occurred here from chert hammerstones to softer limestone percussors, but replication and more detailed flake analysis would be required to prove it.

Biface fragments in the collection indicate that the distal (oval) ends of the bifaces first underwent "finishing" as demonstrated by several fitting distal/proximal fragments (Figure 12a,e,f). It may be that the decrease in mass at the distal end temporarily balanced the artifact in terms of shock to its mass. That is, the tapered proximal end was not proportionate from the start, and further finishing of this area with a bulky distal counterpart more likely promoted lateral snap (defined below). However, the seperation I make here blends into the next category.

Proximal, General Finishing. As stated, this category is a close continuation of the finishing process. Biface breakage drops impressively by the "late stage". Care in reducing mass probably increased as flintknapping slowed down. Tapered portions of fragments and whole specimens indicate that the proximal ends generally have thickness retained with perhaps a bit more irregularity of body scars. The very proximal tip may or may not be truncated in appearance (ca. 10-20 mm wide), with a remnant flake scar facet or blunt cortex.

Completed Tools. Finished and acceptable oval bifaces are probably represented only by indistinguishable but final biface thinning flakes. Of the complete bifaces recovered in excavation, very few can be firmly interpreted as finished but not used. More importantly, I cannot suggest that freshly made tools of suitable form were tossed into the midden. I seperated the whole bifaces (N=49) into two groups: used and unused. Used bifaces (N=18) display blatant abrasion or battering along working or hafting portions. Unused bifaces (N=31) had edges not altered beyond modification assessed to manufacturing. The former group includes oval biface specimens which have been resharpened to reduced form (Figure 13e). The later bifaces may be rejected specimens which presented insurmountable problems of thickness or proportion (Figure 13f).

The morphology of an ideal oval biface can only be estimated subjectively from certain of the refitted or near complete bifaces that appear to have been rejected near completion (Figure 12f,13f). Completed oval bifaces may have averaged 150-200 mm in length, ca. 70 mm in width, and ca. 25 mm in thickness. The small biface of Figure 13d may be a minimal extreme at 135 mm length. This specimen was destroyed by severe percussion from either extreme misjudgement or perhaps an attempt to remove a protuberance.

Debitage. In reviewing the debitage, I will comment briefly on the sub-groups identified in the debitage block of Figure 48. First, although rejected nodules are listed, only two exist in the collection and they appear to be more likely related to blade production. Several possibilities exist to account for this paucity : 1) the raw material was presorted during procurement, and all material sent to the workshop was reduced, or 2) in the fieldwork we tabled-sorted away rejected cobbles. I favor the former interpretation because rubble of any kind was infrequent in the midden, it was often limestone, and most items were fairly scrutinized. Test flakes, as cortex covered flakes produced from inspecting cobble interiors, are indistinguishable from early reduction flakes. Those familiar with lithic analysis will note that I have not made the common division of total cortex, secondary (partial) cortex, and interior (no cortex) flakes (e.g. Shafer 1979:47). This is in part because I have not performed formal flake analysis. Also, the nature of the nodules and the reduction trajectory is such that primary cortex flakes might come from a <u>range</u> of blank and primary series bifaces. Op. 2007 flintknappers were not overly concerned with removing cortex as long as it did not interfere with basic form and functioning edges (Figure 15h). Shatter, "pieces having little or no regularity" (Crabtree 1972:90), is common in hard hammer percussion. It grades into what amounted to silica chipping dust in the final sieve fallout of the debitage sample analysis. The biface fragments were examined for fracture origins following the example of Shafer's (1979:32) work. Three major kinds were observed: <u>lateral snap</u>, <u>perverse</u>, and <u>material flaw</u> failures. Lateral snap is "a transverse, relatively straight fracture which, in a cross-section, displays an 'S' curve fracture face" (Johnson 1981:26). It is equivalent to Shafer's <u>snap</u> or <u>bending</u> fracture (Shafer 1979:32; see also Crabtree 1972:92). Lateral snap occurs when the tensile strength of an artifact is exceeded. In the situation of manufacturing (as opposed to use), this may result from reflexing vibrations started by percussion. The fracture often occurs at some distance from the point of percussion - a situation known as end shock (Crabtree 1972:60). A majority of the biface fragments (75%, 174) displayed this fracture (Figure 12c,h;13h). This trend is likely due to the large size of the bifaces under reduction. Next, 15% (35) of the fragments resulted due to identifiable material flaws (Figure 12g). Fossil imperfections, inclusions of coarse grain, and internal cracks were the culprits here. In some cases, the problem was obvious to the flintknappers from the start, while other faults were well concealed. Internal cracks were identified as both natural flaws and problems created during procurement or early stage reduction. Every extra tap of a hammerstone to a chert mass produces fracture, however minute and whether a desired reduction flake is released or not. With the rapid percussion evidenced on some bifaces, it is likely that blows were occasionally misguided to create internal fractures. A small number (6%, 13) of biface fragments may be classified as perverse fractures (Figure 12d). This is a "helical, spiral or twisting break initiated at the edge of an objective piece. Natural flaws, excessive force and mass to be removed add to the possibility of perverse fracture" (Crabtree 1972:82). Other fracture problems fill out the collection at 4% (10). For example, overshot termination (Crabtree 1972:80) ruined some bifaces where a thinning flake ran deep to remove the biface's opposite side (Figure 45g,h).

Finally, the hammerstones earlier described may all be considered exhausted or otherwise abandoned tools. The larger chert specimens were probably used in initial reduction while the biconical limestone hammers were possibly more often used in finishing reduction. One battered and abraded specimen earlier described (Figure 45c) is likely a biface platform abrader (H. J. Shafer, personal communication). In terms of debitage recycling, it is impressive that the Colha Maya apparently had little need to utilize the bulk of biface thinning flakes (except as structural fill). But with literally billions produced at Colha, an impromtu cutting tool was probably never far away (if not underfoot!). Four biface fragments show evidence of continued reduction directed lengthwise to suggest attempts at blade making or some other unknown purpose (Figure 15f;45k,l).

Stemmed Blade Manufacturing

The Late Classic stemmed blade manufacturing system has no previously detailed model. I use the term "stemmed blades" here rather than "blades" because I do not find evidence to suggest that unmodified blades were the major product sought.

Nodules/Macro-flake. This and the next of the flow chart duplicate that stage of oval biface manufacturing (Figure 49). Actually the vast majority of blade debitage indicates that nodules were procured for blade-making. The macro-flake category is retained here because it was possibly a rare option. Almost every blade core in the collection appears to have remnant nodular cortex but it is possible that a few exhausted macro-flakes (with cortex) are included here. The nodules suited to blade-making (rather than bifacing) were probably more angular and thicker except for the tabular shaped specimens that appear to have been too small for bifacing. This is indicated by rejected blade cores and two near complete nodules (Figure 44f,g). Based on one specimen (Figure 44g), the average amorphous nodule may have been about 180 mm x120 mm x 70 mm. Tabular nodules probably were smaller than this.

Trajectory Selection. This is the decision point where raw material was directed toward blade-making. As I indicated above, the shape and size of nodules probably dictated whether reduction would be directed toward bifacing or blade-making. I believe thin tabular nodules longer than ca. 200 mm were often directed toward bifacing, with more amorphous nodules and smaller tabular nodules encouraging the production of blades. The same natural angularity (or blockiness) that promotes removal of initial blades may be frustrating for biface production. I am arguing here that the same flintknapper(s) alternated between blades and bifaces because either technique (and all percussion shaping) requires skill in directing force along the surface morphology of the specimen reduced - be it biface or blade core. Modern replicators of bifaces usually can easily produce percussion blades.

Core Preforming. This is the process by which a nodule is shaped to establish a series of guiding surface ridges to direct blade fracture. The very first reduction possibly involved the removal of major unwanted protuberances, which do occur on some Colha nodules. The resulting flakes may be very obvious in form, but it is probable similar efforts preceded bifacing. As these "problems" were removed by percussion, each new facet defined potential platforms for the removal of blades at near right angles (actually, slightly acute to 90°). In other cases, the nodule was angular enough that a natural cortex platform aligned well over a desired blade removal area.

When appropriate "rough-out" of the nodule mass had occurred, or a suitable natural platform and direction of force was chosen, the guiding ridge of the first blade was considered. Two possibilities existed: 1) modify the proposed ridge area to refine or create its straightness and regularity, or 2) do nothing at all, hoping that the natural ridge would suffice. The modified, or prepared ridge blade category is complex. A very contrived ridge could be created by actually bifacing a guiding ridge edge (Figure 50d). Because of hard hammer percussion, this ridge can never be exactly straight. Only a few examples of this exist in the massive collection. Another technique to create a ridge was to remove large flakes (an an extension of the "roughing-out" described above) until two, or more, fracture planes intersected to form a useful ridge. In this case, the blade striking platform could be chosen or created by another flake removal. It is possible that a number of large angular flakes that were not collected in table-sorting pertained to this. The column sample material also supports this possibility although again, these specimens might relate to biface manufacturing. A third option, and one I think was effectively used, was to select a single large flake scar intersecting cortex (possibly among several that had been removed in different areas). If an elongate portion of that scar's edge could be aligned with a useful platform area, a cortex edged ridge blade could be removed. Unfortunately, the existence of large cortex flakes alone cannot prove this strategy. The second major possibility, natural ridge blades, may actually be a gradient form of such flakes. The true natural ridge blade is possible where the inherent

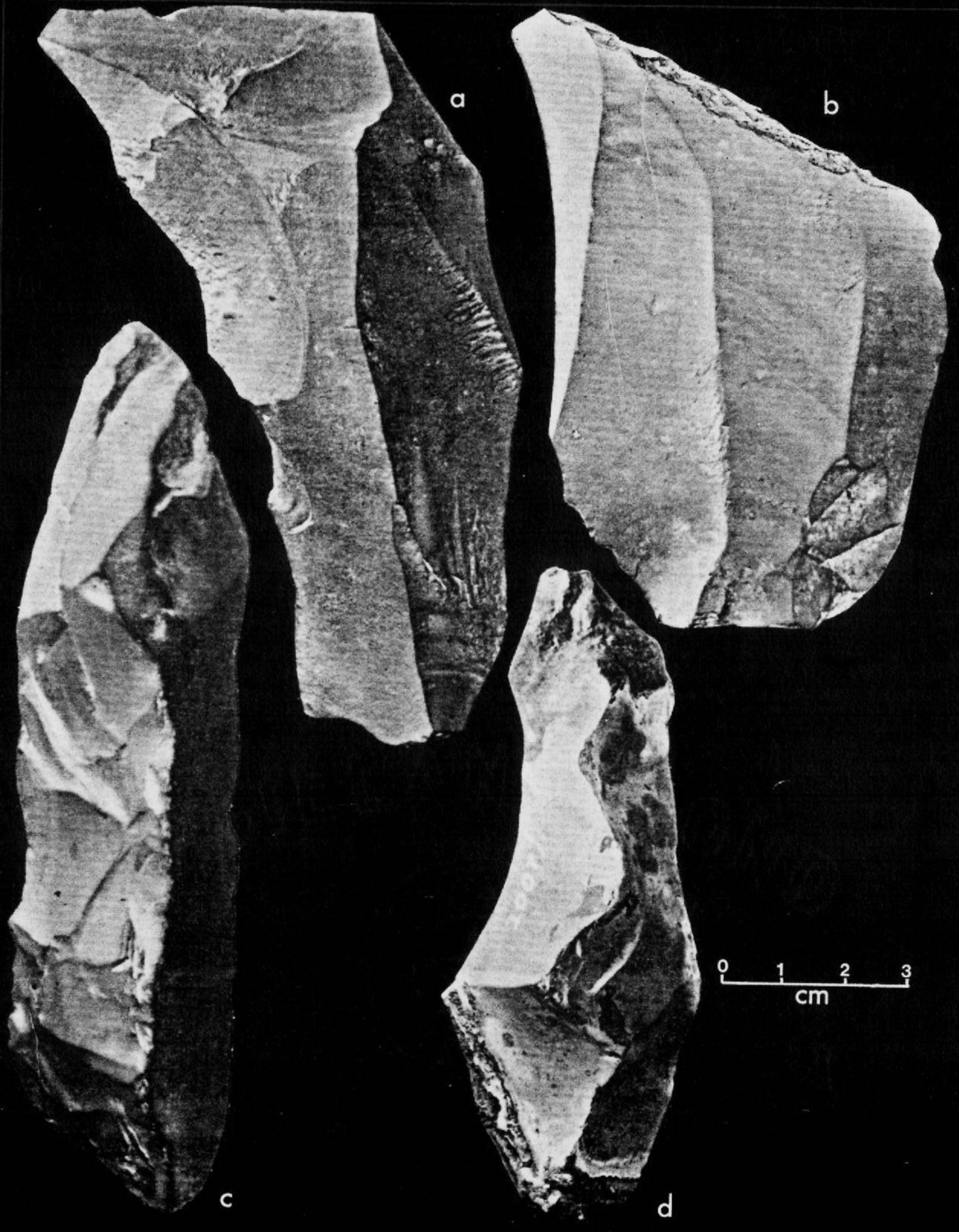


Figure 50. Initial blades: (a,b) typical specimens; (c) platform ridge (or unifacially trimmed) specimen; and (d) bifaced ridge specimen.

surface of a cortex covered stone permitted an elongate flake to be removed. This "flake-blade" creates the proper kind of scar to permit subsequent blade removals on one or both sides. A small but consistent number of collected specimens fits this role (Figures 51a,52b). The platforms on these flakes are both natural cortex and small flake facet surfaces. No evidence was observed for nodule splitting (or halving) of cobbles. The Colha nodules are generally irregular, and tabular nodules tend to be a bit short for splitting. Amorphous Colha nodules are difficult to consistently break on anvils or split by percussion, which may rapidly create internal fractures. Also, cortex on a number of blade cores' platform and distal portions indicates these were not halved cobbles. If the end of a nodule was truncated, I consider that flake removal as discussed above.

"Initial Series" Blades. These blades are those that usually have cortex borders along most of one edge, tend to be large (ca. 100-150 mm long), and tend to have large platforms either single or multi-faceted. They are very plentiful in the collection, representing the first series of blade removals across a nodule's surface (Figures 52a,c;53-57). As the platforms indicate, percussion continues with and without platform preparation, which if present takes the form of minute trimming scars which were directed into the platforms at an angle opposite to the blade removal. Detached platform areas are often so large (ca. 25 mm x 10 mm) that the percussor could act well away from overhang. The actual striking platform is frequently shown on larger single facet "platforms" as a ring crack initiation (Tsirk 1979) about 1 mm wide (Figure 34a, top view). These blades set up the ridges for additional

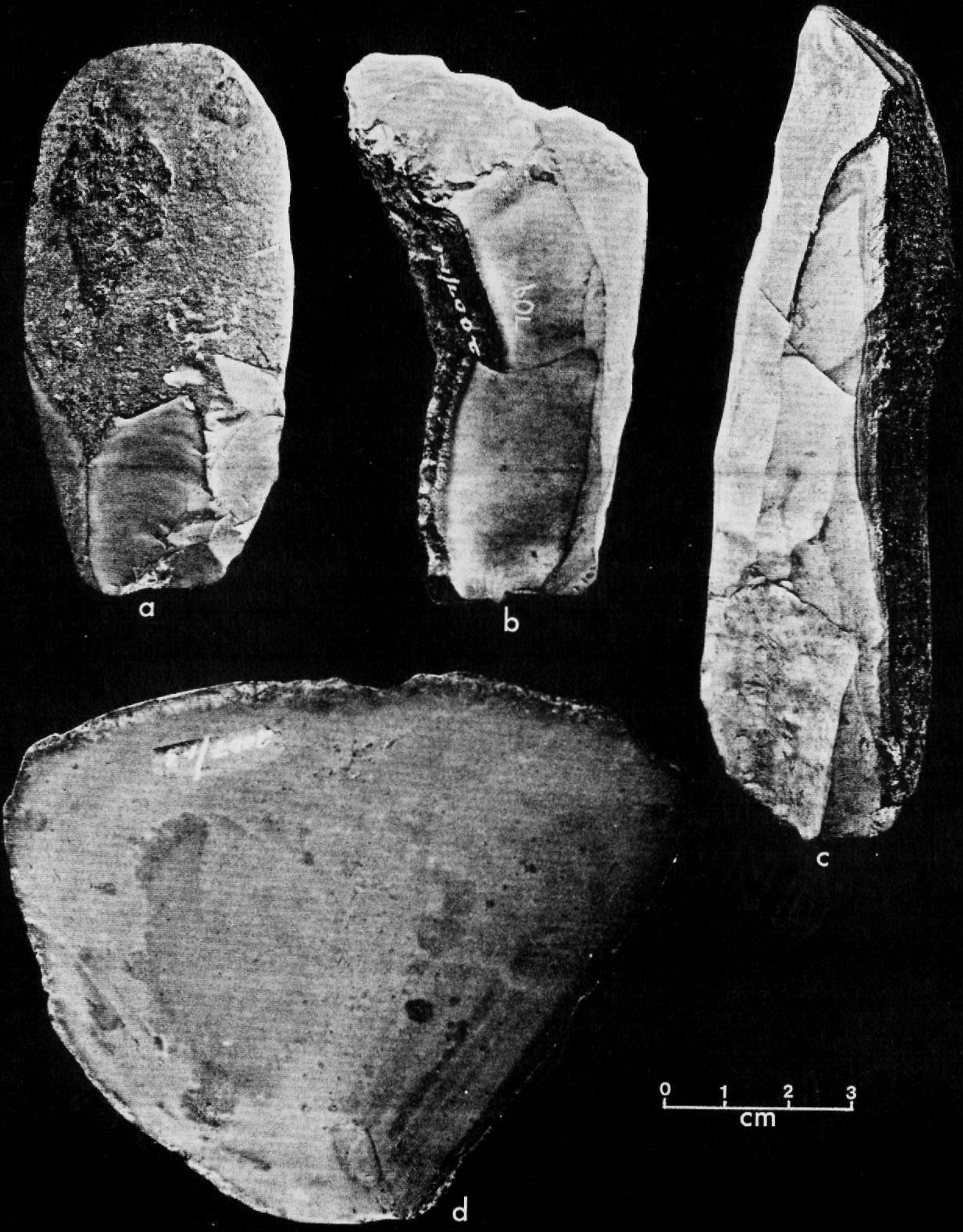


Figure 51. Initial removals: (a-c) examples of early stage blade detachment; and (d) ventral face of cortex flake.

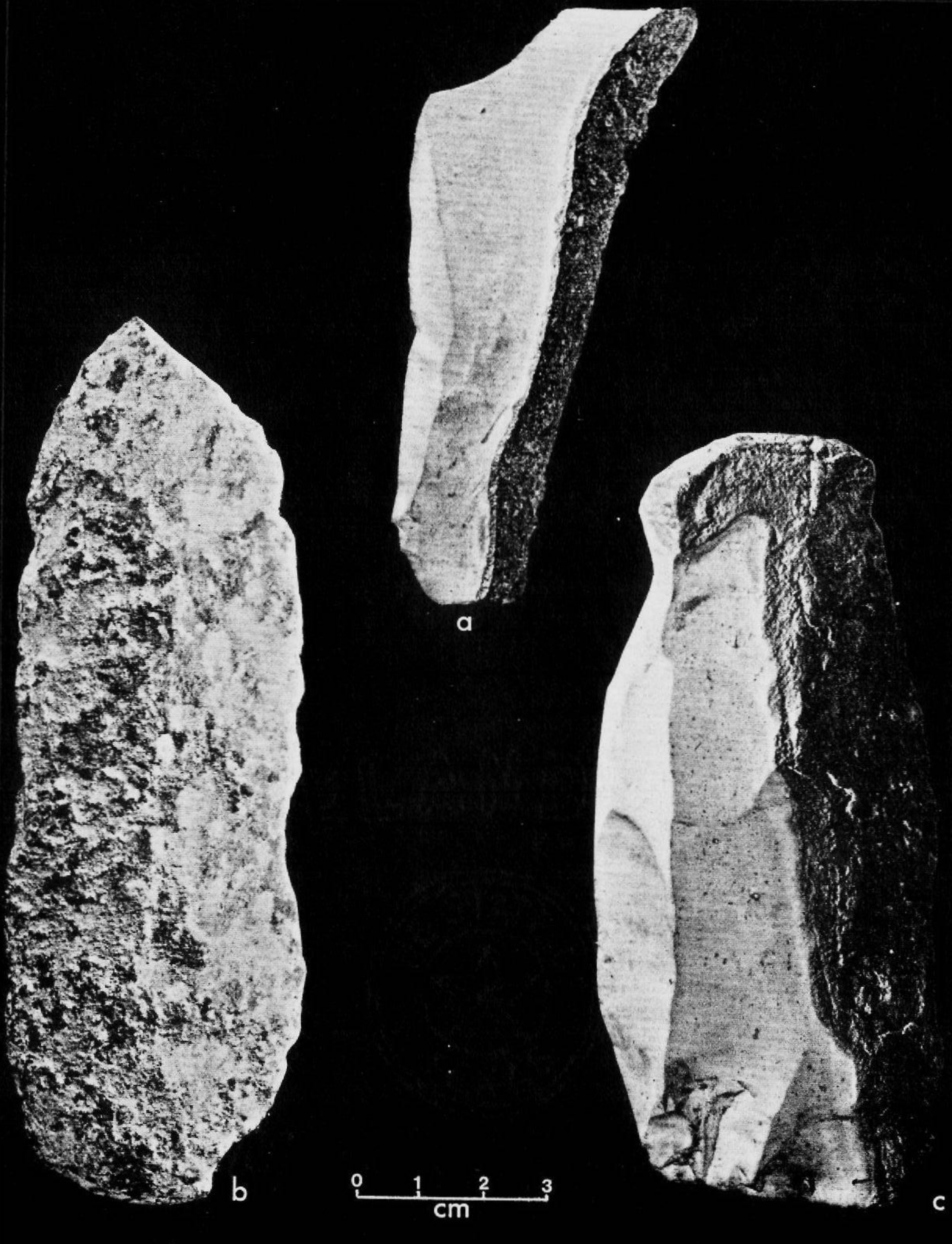


Figure 52. Initial blades: (a,c) typical cortex edged specimens; and (b) total cortex cover.

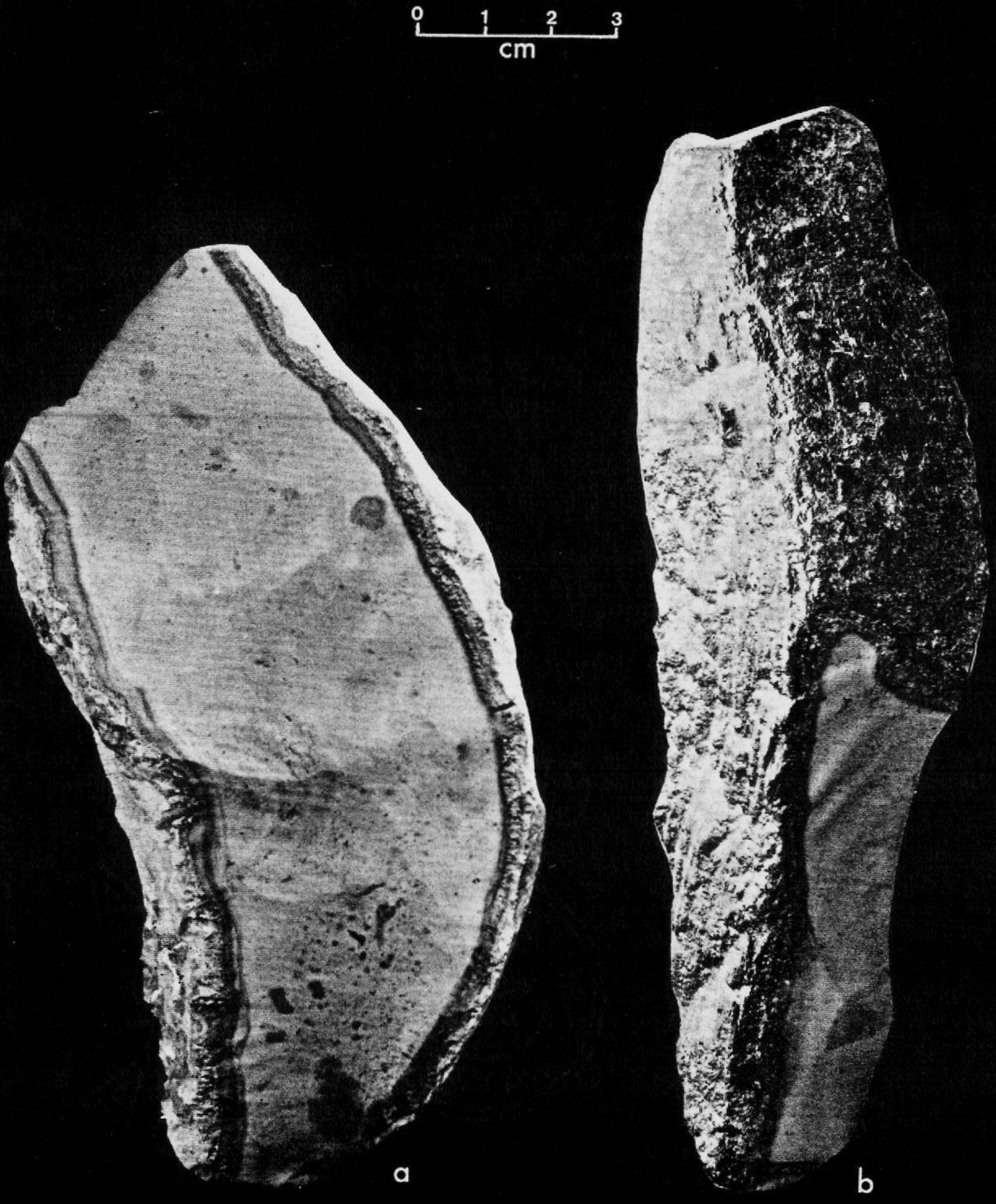


Figure 53. Initial blades: (a) unusual specimen that trimmed both sides of the cortex covered core; and (b) typical early removal.

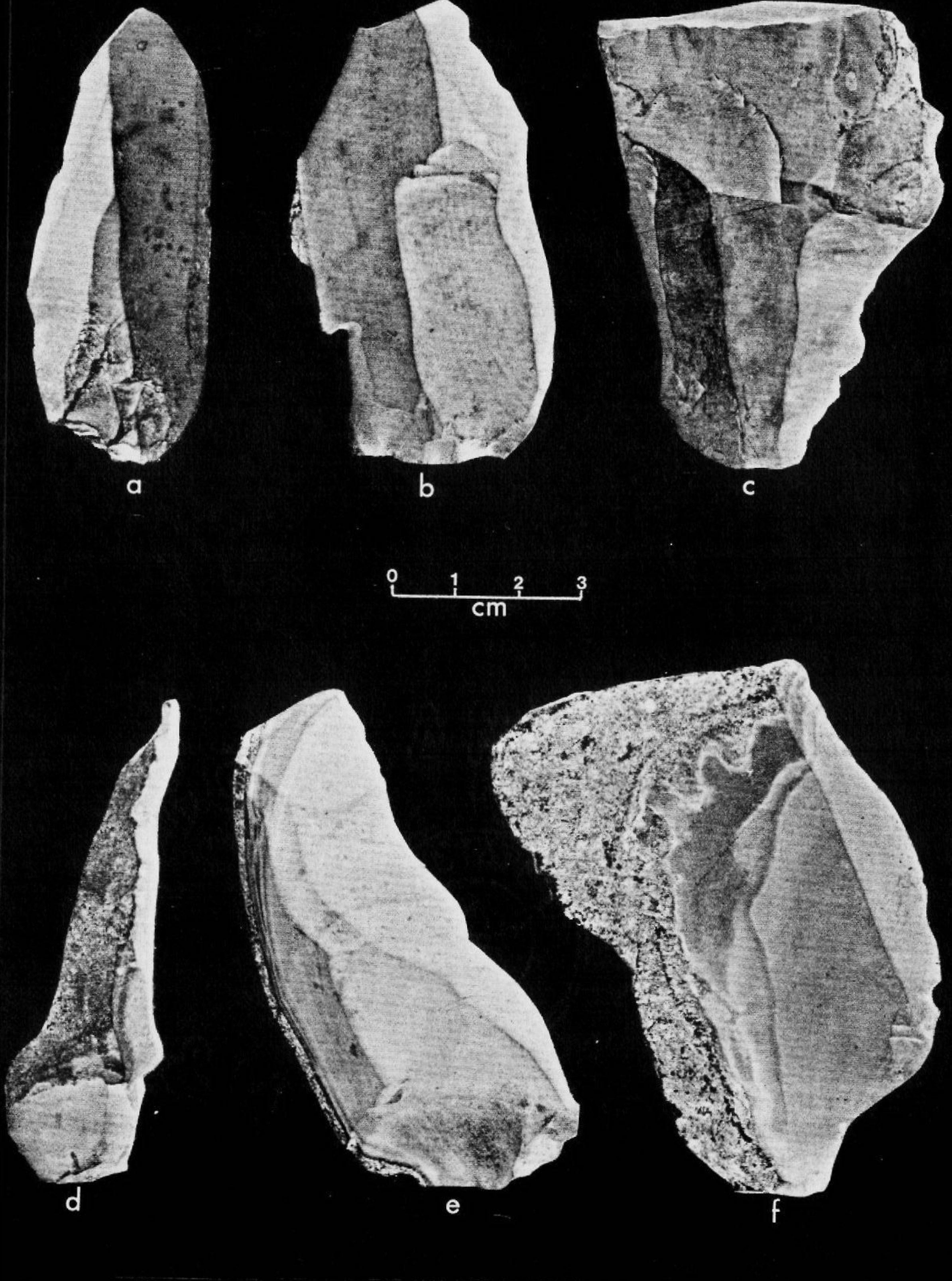


Figure 54. Unmodified blade debitage with cortex (a-f).

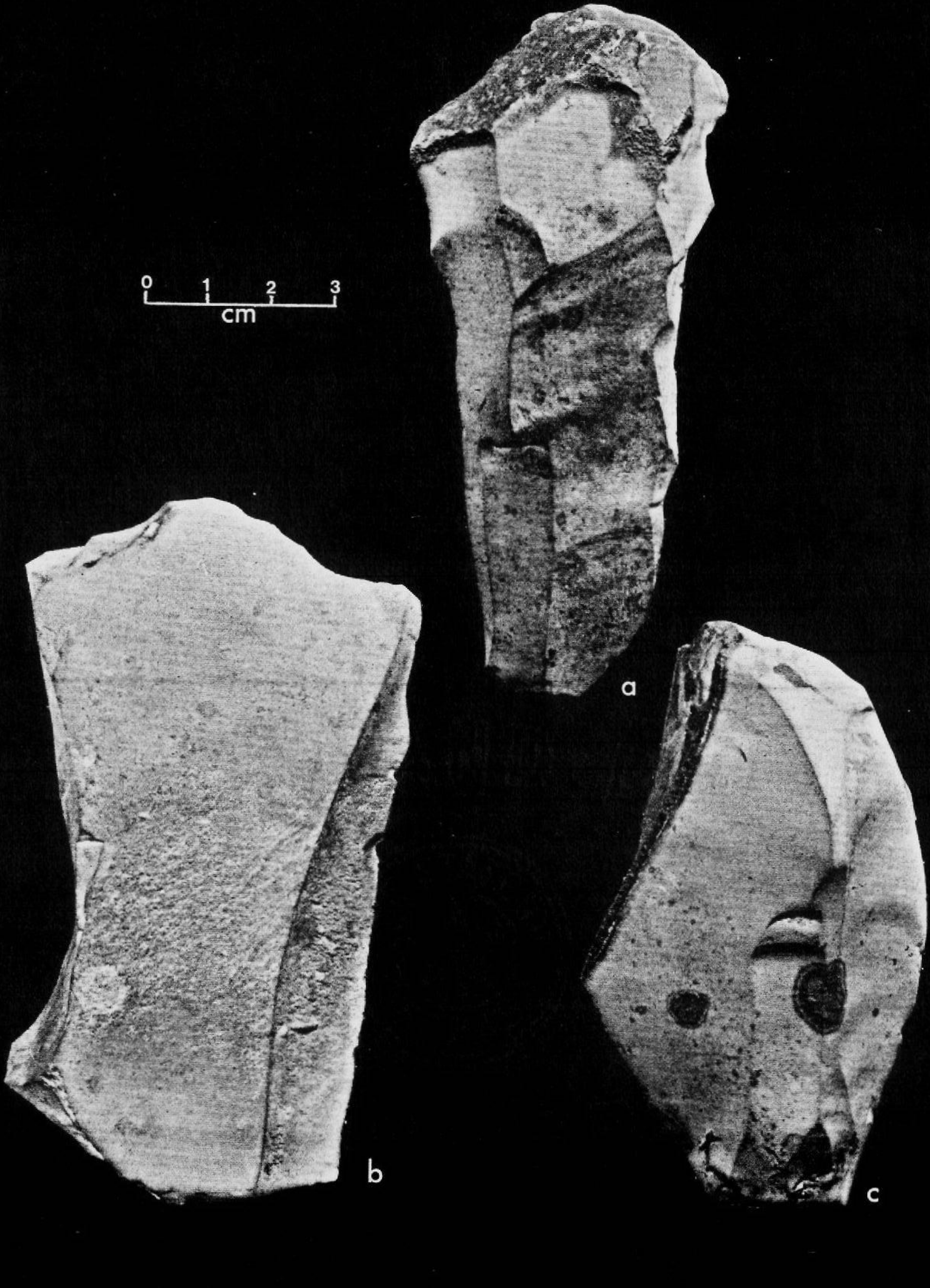


Figure 55. Examples of initial blades (a-c).

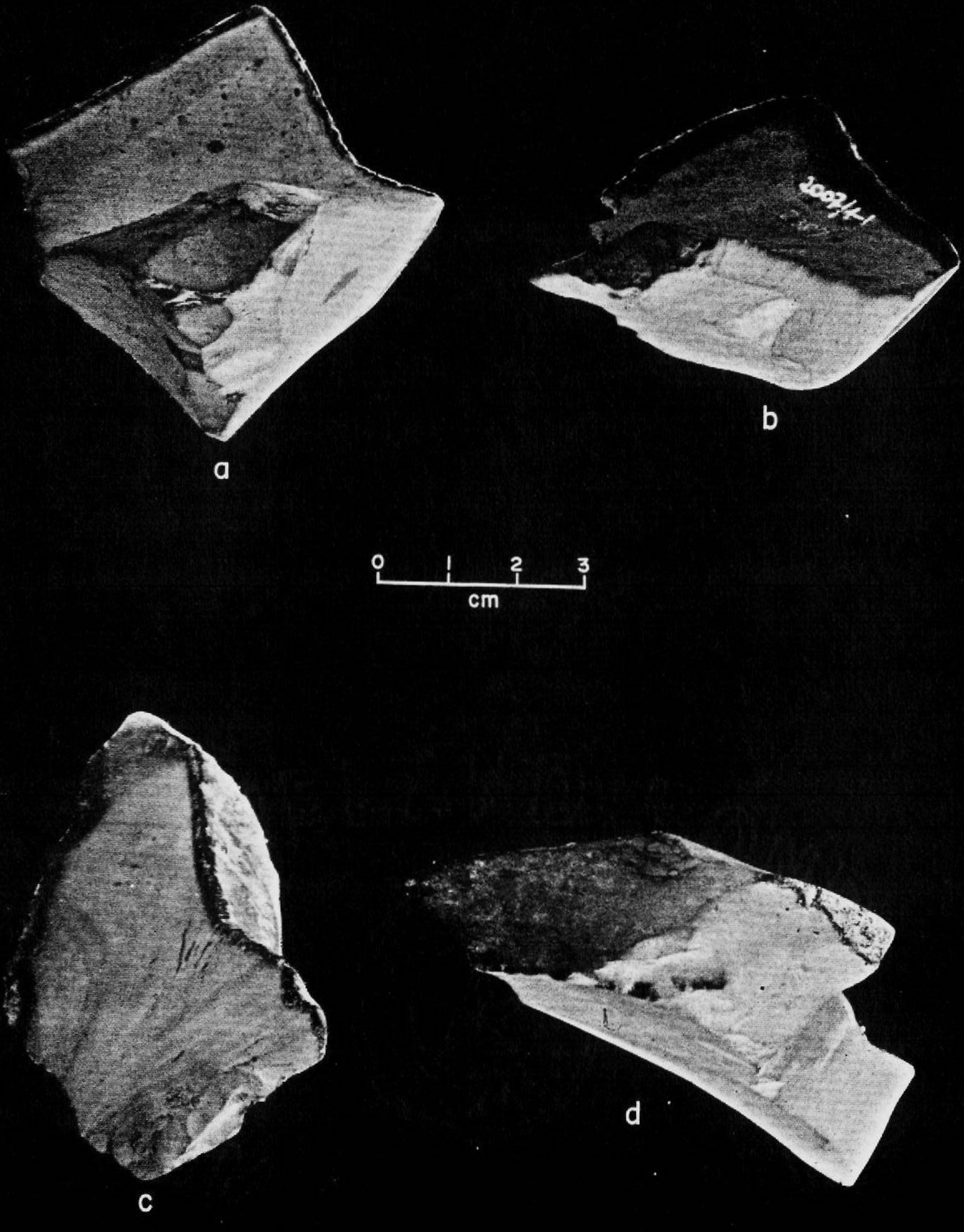


Figure 56. Platforms of large blades viewed: (a-b) overshot specimens; (c); and (d) large single facet platform with ring crack(s).

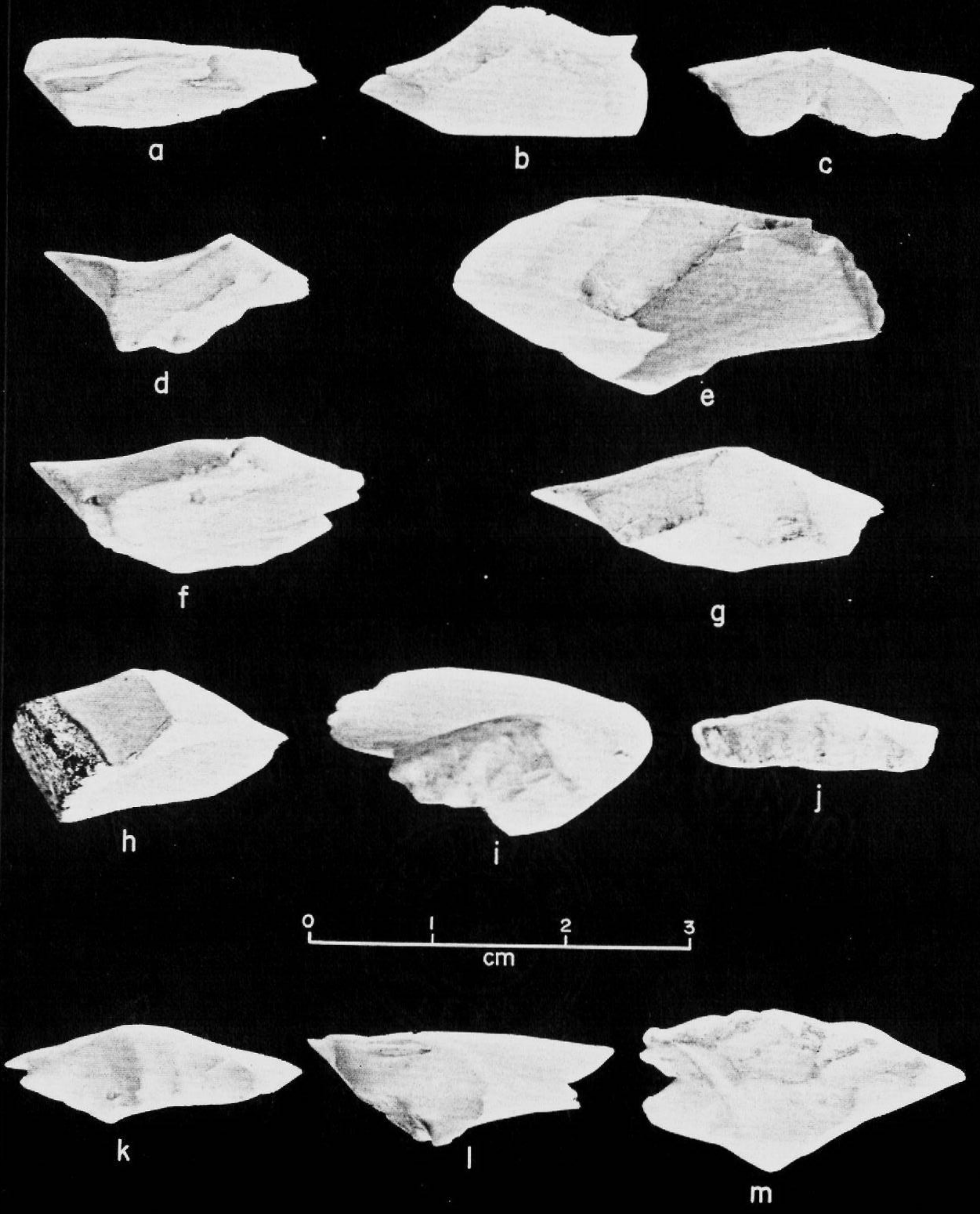


Figure 57. A variety of whole blades with views of platform ends (a-m).

series (see below). However, I have not segregated them formally because even exhausted cores might produce several cortex bordered blades, and cortex was permitted on specimens modified into near finished states (see below).

Core Maintenance. This category pertains to modification of the parent mass to insure that a maximum amount of blades may be removed. Problems can occur either in the platform area, where fracture intiation becomes difficult, or in lateral and distal terminations. The platform area could become exhausted (Figure 39a') or irregular, and platform angle might be poor. Termination problems often involved either hinge or other incomplete blade removals (Figure 58e-g), or overshot fractures (Figure 58a-c). The first (and continual) core maintenance was platform trimming, which prevented abrupt hinge fractures along ridges (Figure 37c). Some trimming also may have graded into the removal of short, thin flakes or blades to aid the major blade removal sequence (cf. Tunnell 1978:52-53). Major core maintenance involved several options. First, a new platform location on the nodule might be utilized to both escape an exhausted or unworkable platform and to remove or avoid problem blade terminations. Blade cores with two opposed platforms are an example of this (Figure 39). Second, a new platform might be regained in sequence to the previous one by removal of a core tablet (Figure 33a). These distinctive side-struck flakes permitted the previous blade series to be repeated, albeit slightly shorter in length. This is well shown by a core fragment that was refitted below a circular core tablet (Figure 42b). Certain platform ridged blades I interpret to be core tablets that

Figure 58. Rejected blade examples: (a-c) overshot; (d) great thickness; (e) hinge termination; (f) step termination; and (g) lack of force/short length.

removed only a portion of platform area (Figure 50c). They may be confused with prepared ridge blades (which in fact, they may be), or they may be core recycling debris of unknown function. Returning to definite core tablet effects, one blade core in the collection has a blade that refits it to indicate that the blade was derived from an earlier platform (Figure 42b). Thus it can be seen that core tablets are useful only when sufficient core length exists. Minor length types of blades may exist but I cannot determine them. When the mass and total platform area decreased and other irresolvable problems arose, blade cores were rejected to join debitage (Table 60; Figures 37b,c;38b,c). Five cores, however, are identified as recycled hammerstones which apparently reversed roles to become removers of blades.

"Additional Series" Blades. These are any blades removed after the "initial series" (Figures 17-19). Core maintenance continues. Cortex edged blades drop some in frequency, depending on core size. Platform preparation perhaps becomes a bit more common as platform and blade size decreases, although single facet examples remain most frequent (Table 20). The hard hammer became something of a liability at this stage. Smaller chert hammers like that of Figures 43d and 44e were possibly utilized. Crushed platforms and proximally snapped blades occur. The broken blades often have a distinctive "hangnail" fracture scar at the dorsal ridge that may relate to an 'S' curve fracture associated with lateral snap (Faulkner 1979:137). Two and even three ridges were sometimes used to guide blade removal, but most blades detached by following a single ridge selected for by hammerstone placement (Table 33; Figure 17h). Single and multiple ridge blades each relate to different platform outlines (Figure 21). For the later, the platform was much more likely to collaspe because the hammer struck between two ridges and over a concave depression (the bulb of force scar from a previous removal). Crushed platforms (Figure 57a,f,m) and poor terminations (Figure 58f) are associated with this platform shape, so it is little wonder why the shape was noted on only about 25% of the platforms (Table 21). The risk was taken probably because if a blade was successfully removed, it would be wider, thinner, and flatter (Figure 24g) than a single ridge specimen (Figure 24h). However, it is important to note that ridges in the general proximal area of a blade are being discussed. Single ridge platforms often led to multiple ridge intersections (Figures 20b,25h), and if the platform detachment was large enough, adjacent ridges were sometimes picked up near the initial platform break, well away from where the hammer struck.

Blade length appears to run from about 100+ mm to 30 mm. The smallest blades (Figure 19l-o). are probably ridge spall debitage un-intentionally produced by the hammerstones acting on platform overhang.

The bulk of product blades came from this "stage", which can be greatly extended depending on inital size and success in core maintenance. It is my impression that each exhausted core in the collection relates to more than two series of blade removals after the initial series. The core tablets and numerous cores with multiple platforms suggest this.

Main Debitage. The debitage here actually has some traits in common with biface-making debris. First, "test flakes" or flake-blades possibly were detached even before the final decision to preform a blade core. As I pointed out for bifaces, these items and other flakes are difficult to seperate from early blade core or biface preforming debris. Shatter and platform preparation debris is also present in both trajectories. Biface thinning flakes, however, are easily distinguished by: 1) irregular dorsal (previous) flake scars, 2) consistent curvature related to the biface body, and 3) a usually expanded flake outline. Platforms for small biface thinning flakes (ca. 50 mm length) are also generally prepared and small (e.g. 3 mm x 1 mm). The blade debitage tends to have: 1) an elongate outline associated with parallel (previous) dorsal scars, 2) a generally straight profile (at least in the proximal portion), and 3) a larger platform (often single faceted) at a more perpendicular angle to the flake face. The small ridge spalls earlier described for blade-making also maintain these traits. This impromtu dorsal thinning probably occurred most often on the untrimmed platforms of long blades requiring larger hammerstones and extra-forceful blows. Hammerstone fragments may have been more frequently produced in core preforming much as they were with initial biface reduction.

The remainder of blade debitage I sort into two categories: "rejected" and "useful". Rejected blades are assumed to constitute the bulk of the collection at hand - although both categories beg the question of function: rejected or useful for what? Based on the existence of numerous blades modified for proximal hafting, these stemmed blades were the prime objective of the manufacturing activity. Blades could be rejected at two points: immediately after detachment, or after modification (discussed below). In the former case, initial series blades - despite their large sizes, great length of cutting edges, and handy cortex-backed edges -

were very often discarded. Modified initial series blades have been collected but are rare (Figures 59,60). Unmodified blades were not coded for infered reasons of rejection. If the specimens were considered for stemmed modification, it is likely that curvature and great thickness were two major problems that could not be overcome. Length and asymmetry in outline (i.e. expanding termination) could be more easily modified if the blade was thin and straight. Abrupt (_hinge_ or _step_) and _overshot_ terminations existed on about 25% of all unmodified whole blades (Table 38). Table 45 indicates the expected: only a small percent of blades later modified had termination problems. Useful blades can only be speculated from the image of modified blade discards present (Figures 22-25;28b). Straight blades probably no thicker than ca. 8 mm at the bulb of force were desirable. Length varied, but perhaps 70 mm (Table 15) was an average "useful" size. It is important to visualize the blades, useful or not, as debitage. That is, reduction debris was continually screened for certain forms, but _all_ blades were of equal technological origin.

Blades Pulled. At some point the useful blades were sorted from the debris. It is probable that these blades were immediately set aside during the reduction of a single core and then reconsidered. Three possible decisions were then made.

Unmodified Specimens Sought. This is the first possibility, which I list only because it cannot be strictly disproven. Here unaltered blades would be considered finished products. I think this was a minor component because at least 50% of the whole unmodified blades had feather terminations (Table 38). It is further assumed all blades had cutting edges adequate for a variety of tasks. It is not good economic sense that these specimens were discarded unless some other formal kind of blade tool was desired (see below). For various mundane tasks, any certain unmodified blade form that might have been prefered could not function substantially better than pieces of the general debitage. It can only be speculated that aesthetically pleasing blades were rarely retained for symbolic use (i.e. blood-letting ceremonies, etc.).

Modified Stemmed Blades. The second possibility after pulling blades involved blade modification into stemmed forms. I think this was the main objective in blade-making at Op. 2007 because of the number of rejected stemmed specimens collected (N=114), plus an additional 102 modified blades that probably were abandoned before the stemming process (Figures 20,21). Modification was in the form of unifacially directed, delicate percussion trimming. Slight bifacing rarely occurred when alternate bevels overlapped. I base this partly on informal replicative experience. Colha chert is not easily pressure flaked, and abruptly beveled trimming apparently was acceptable, and perhaps desirable, for stem form. A small hard hammerstone such as one of the disc-shaped battered bifaces earlier described might have been used (Figure 45d-f). It would be important to have a percussor small enough that the stem edges could curve outward into a shoulder. A very precise hardwood or bone percussor might also have been applied, but micro-step fractures along modified edges suggest a more abrasive action - perhaps a combination of percussion and one-way grinding or crushing with a hammerstone. Formal replicative studies including microscopic analysis would resolve this. Excessive grinding of stem edges is not present.

Distal Modification. As Table 35 indicates, most whole modified blades are either distally modified or distally and proximally modified (with stems). This suggests that distal trimming was the first step in stemmed blade modification. It was probably done because termination problems resulted in excessive thickness or curvature which had to be resolved or abandoned before stemming could be worth the effort. Also, the blade body was thinner in the distal region. This is a more fragile area to rake with a small percussor - again, perhaps, an attempt to get the most risky step completed first. Only 16 whole stemmed blades had no substantial distal modification (e.g. Figure 21h,i). Distal portions of blades almost always had the unifacial retouch directed from the ventral to dorsal faces. This is a logical choice considering that the ventral faces are flat. Unifacial percussion directed from dorsal to ventral faces would more rapidly reduce these weak platforms and the general blade outline.

Proximal Modification. Proximal modification is where unifacial beveling may be opposed (in two directions) on both edges of the stem, or seen on both edges at either the dorsal or ventral stem face. As can be calculated from Table 34 55% of the stemmed blades (proximal fragments and complete) have unifacial bevels on both edges directed from the ventral to dorsal face. Only 8% have the opposite: two edges with bevel scars on the ventral face. The remaining 37% of the stems have alternate beveling. These stems are about evenly split between arbitrary labels I gave the stems in viewing the platform directly on end. From this perspective, "clockwise" beveling has ventral bevel scars on the left and dorsal on the right. "Anti-clockwise" has the opposite. The relevance of all this is simply that if the flintknappers(s) were right (or left) handed, they held the blades with proximal (stem) ends toward or against them about equal amounts of time. This is under the assumption that a flintknapper would flip the specimen over laterally and not end over end in trimming it. If the flintknapper(s) were generally right handed, a very slightly greater number of specimens were perhaps held with the distal tip towards the worker.

Modification to Other Forms. A small number of rejected modified blades take other forms (Figures 59-60). I consider this to be a minor technological component of the workshop deposit. First, about 10 modified macroblade fragments may be disregarded as recycled Preclassic tools (not all macroblades in the collection were encoded for tables). This leaves only a small number of modified blades which may all be considered informal artifacts. Four prepared ridge blades have had one end tapered, three of which are distal ends and one proximal (Figure 28a). One large "initial series" blade has unifacial modification on its sharp edge (Figure 59a). A large distal fragment of a natural ridge blade has been tapered (Figure 59b). A few blades have contrived serration (Figure 59c,d). Finally, a blade detached despite a severe knot appears to have been modified from sheer amusement for the accomplishment (Figure 27a).

Modification Debitage. Material here includes probably most (if not all) of the modified blades described plus microdebitage that would result from percussion trimming. These small flakes would be much like platform preparation debris. Table 47 shows an assessment made for possible reasons of rejection. I chose the single most outstanding trait (per specimen)

Figure 59. Modified blade debitage: (a) large, trimmed initial blade; (b) tapered cortex blade/flake; and (c-d) serrated "eccentric" cortex blades.

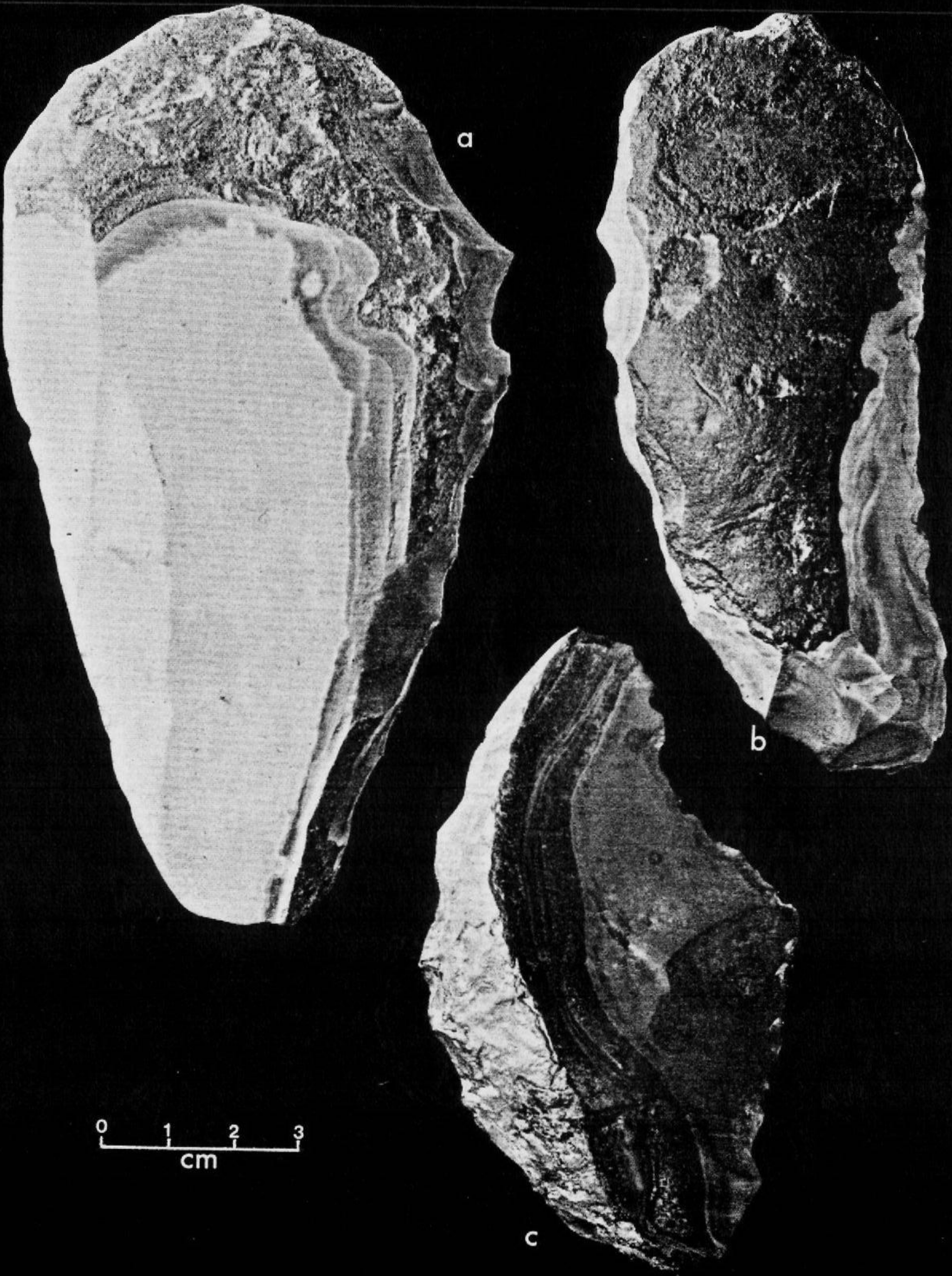


Figure 60. Modified blade debitage: (a-c) trimmed initial blades or early stage flakes.

that seemed to be a problem. Considering only the stemmed specimens or those assumed to be stemmed blade preforms (199 including fragments), 12% had no traits I could associate with rejection. Broken specimens (36%) are the greatest and most obvious reason for discard. Blades easily break under any transverse stress directed against their flat sides. With light percussion applied, these were primarily tensile breaks rather than vibrating shock such as bifaces encountered. In haste, improper support may have been given these specimens, the percussor may have slipped inward onto the blade face, or it may have gripped the edge suddenly (rather than "rake" it). Curvature appeared to be a major problem at 23%. Only severe curvature (e.g. Figure 27c) was considered here (see also Table 46). Inferred thickness or thinness of the blades next ranks at 14%. Usually this involved a thick bulb of force retained in stems (Figure 27b). Asymmetry (9%) refers to the blade face outline where ridges were discontinous or askew. The result was a mishapen outline that edge trimming could not correct (usually, because the stem would then be misaligned; Figure 26g). Size (6%) was a category I also used for outline to depict excessively great or small outline area with good symmetry, straightness, and so on. This accounted mainly for stemmed blades that I intuitively thought very small. The remaining 12% includes incongruous specimens with strikingly poor material or other ambiguous problems. Several rejected complete stemmed blades may indicate "quality control" after modification. One is an obvious bifacial thinning flake (Figure 21j), one is a modified thermal spall ("pot lid", Figure 26k), and the third is a thick prepared ridge blade (Figure 25b). Finally, two specimens had distinctive lateral fractures that appear as edge concavities on otherwise complete specimens

(Figure 26c,d). I could not determine the direction of impact these blades recieved.

The Completed Artifact. As for bifaces, examples of acceptable stemmed blades cannot directly be illustrated. Because modification for stemming did not greatly diminish "useful" blades, the discussion for ideal forms I earlier made continues here. The mean length and width for rejected whole stemmed blades is respectively about 70 mm x 24 mm (Tables 15,16). This may represent an accurate average. However, there is a chance that larger (or even smaller) items were considered ideal and are thus missing. Another way to check for minimal "useful" blade lengths is to consider the longest extant blade scars on rejected or exhausted cores. The mean dimension here is about 71 mm length x 21 mm width (Table 54). This closely matches the stemmed blade measurements above. Stems on complete blades average about 20 mm long and 14 mm wide (Table 32). Stem lengths of proximal fragments are 3.4 mm longer on the average (Table 32) - perhaps a sign that proportionately longer whole specimens are absent. Single ridge and two ridge dorsal faces occur about equally (Table 33). I cannot say if one type or the other possibly was being pulled more often, but platform types (earlier discussed) suggest that most completed blades were single ridge types. Comparing grain texture of unmodified to modified blades, the later has a better chance of being fine grained (Tables 25,44). Some bias here probably results from the fact that modified items are smaller, and thus more likely not to show mixed grain with coarse inclusions. Of interest the very finest grain for many Colha nodules is in a relatively thin layer just below the cortex. This may account for some modified blades having cortex (Figure 25g).

Concluding Remarks

In this final discussion I cover two topics. First, technological evidence apart from that of the oval biface and blade production systems is identified. Ten categories are briefly mentioned here. Technological processes other than manufacturing are often revealed by this evidence. Second, I review the oval biface and blade production systems to get them in broader perspective.

Tranchet-bit Bifaces (N=15). Enough tranchet-bit bifaces and tranchet flakes exist at Op. 2007 to suggest this was an occasional manufacturing pursuit. The production system has been aptly described by Shafer (1979:56,60-63). Basically, manufacturing follows five steps: 1) a large macroflake is procured, 2) the flake is preformed into an incipient oval biface, 3) the original platform end of the macroflake is unifacially trimmed to create a convex edge on the wide end of the biface, 4) a platform is isolated by notching one edge of the biface near the convex end, 5) the biface is side-struck to remove the trimmed edge - this tranchet flake is essentially a prepared ridge blade - to leave a convex, single facet working bit, and 6) the biface is further reduced (Shafer 1979:60-61,Figure 6). This procedure could have been added as an option to the scheme of Figure 48, with one exception. Macroflake blanks are essential because the working tranchet bits depend on the bulbar swell at the proximal flake end to form a slightly convex ventral face there (H. J. Shafer, personal communication). Note that this proximal (platform) end of the macroflake becomes the distal (working) end of the tranchet-bit biface.

Most of the tranchet-bit tools collected at Op.

2007 show signs of use and maintenance/recycling. As a group, they are short in length (under 100 mm) and often display microscars (both unifacial and bifacial) along the bit edge. One specimen (Figure 14n), under weak microscopic inspection, displays prominent edge rounding, sheen, and a few micro-striations. This particular tool appears to have been tranchet-flake retouched, possibly while in the haft (H. J. Shafer, personal communication). It was possibly used as an axe on relatively firm (i.e. woody) material (Shafer, personal communication). Other specimens indicate various attempts in the distal area at maintenance or recycling (Figure 14o,p) while only one appears to definitely be a manufacturing failure (Figure 14m). Bifacial thinning flakes in the collection sometimes retained part of the tranchet flake scars.

Although bifaces were reduced after the tranchet flake removal, comparing tranchet flake lengths to tranchet-bit widths (Table 13) shows a consistent difference to suggest that the bifaces were exhausted from bit retouching (and not production). At least six tranchet flakes have substantial modification of the edge which was detached along the dorsal face of the preform. Such recycling modification along with the distinctive, consistent artifact forms, is probably what led early researchers at Colha to falsely conclude that tranchet flakes were formal tools (Wilk 1976a).

In conclusion for the tranchet-bit tool system, other Late Classic workshops at Colha are now known to exemplify much greater quantities of tranchet-bit tool production than the Op. 2007 workshop (Op. 4029, for example). Also, some observed differences in the Late Classic tranchet-bit system compared to that of the Preclassic remain to be described (H. J. Shafer, personal communication).

Tapered Bifaces (N=10). This is a minor technological system assumed to have been present at the workshop. The only firm evidence is a collection of very thick artifacts each with a tapered point. A typical specimen is made from a nodule into a form ca. 120 mm long, 95 mm wide, 45 mm thick, and 325 gm in weight (Figure 61k). The tapered points end at from 10-15 mm rounded widths. At least one specimen actually has a triface of flaked planes along its point (Figure 61o). Proximal portions are globular, cortex covered remnants of the nodule. No manufacturing evidence has been identified for these specimens although it might well have been present. Use-wear analysis has not been performed for the tapered points. I speculate that at least some of the artifacts in my collection were never utilized. Shafer and Hester (1983:531) indicate that no functions have been assessed for this artifact class, and it appears to be associated with Early Postclassic rather than Late Classic times. At least some of the Op. 2007 specimens came from deep in the lithic midden.

"Cylindrical" Bifaces (N=5). These are a few bifaces which fall into a minor class of morphology which shows up from most time periods at Colha (T. R. Hester, personal communication). A typical specimen is a cylindrical biface ca. 90 mm long, 23 mm wide, and 18 mm thick. I submit that their technological significance stands as recycled artifacts - possibly Preclassic stemmed macroblade fragments (Figure 61d,e,g). One specimen (Figure 61f) also appears to be a Preclassic stemmed biface as depicted by Shafer and Hester 1983:Figure 5).

General Utility Bifaces (N=2). Only three bifacial tools at Op. 2007 fit this category, and at that they are poor matches for the celt form "characterized by a

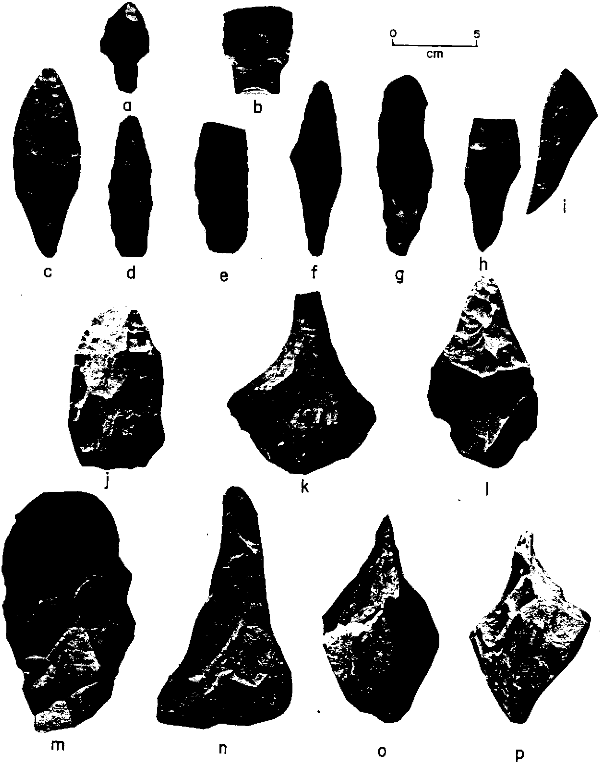


Figure 61. Various bifaces not related to the oval biface system: (a-c,f,h) stemmed specimens; (d,e,g) "cylindrical" specimens; (i) recurved fragment; (j,m) possible "general utility" forms; and (k,l,n-p) tapered specimens.

distinctive thick biconvex cross section, truncated poll end, and a distal edge that is rounded with a carefully fashioned bit angle" (Shafer and Hester 1983:531,Figure 8; Kidder 1947). The importance I see here is that these tools are considered typical of the Late Classic (in general and at Colha), and they were apparently not produced to any substantial degree at this workshop.

Other Bifaces. The technology of remaining bifaces in the collection is summarized below. A number of whole bifaces encoded as oval bifaces are probably maintained or recycled specimens (Figure 15). Two highly soil-polished resharpening flakes from biface bits were identified in the debitage. One is a near fit to a utilized oval biface (Figure 13e), and the significance is that at least some maintenance of used bifaces occurred at the workshop. As noted previously, at least 18 oval bifaces had macroscopic use-wear. Other small bifaces appear to be crudely worked flakes that have no connection to the oval biface system. These informal artifacts are of unknown function. Some were possilbly never utilized.

Five other small thin bifaces include stemmed specimens of various forms and unknown classification (Figure 61a-c,h). Of these, one appears to be a Late Classic form better known from the Belize River drainage to the south (Figure 61c). This thin, completely bifaced item is similar to those of Ponce's site near Tea Kettle village (H. J. Shafer, personal communication; notes of Department of Archaeology, Belmopan). The highly patinated chert of this artifact has fine viens (quartz?) not seen in Colha material. As such, it is an imported artifact at Op. 2007. The fifth biface is a fragment that indicates an unusual recurved outline (Figure 61i).

Perforators (N=5). Another informal and minor tool system at the workshop involves perforators, a term I use to describe small artifacts with at least one restricted "beak" assumed to have functioned as a penentration tool. The tapered bifaces described above would fit here but for their great size. Three of these specimens were made on nondescript flakes with cortex (Figure 62a,b,e). Of these, two have alternate scar beveling along their points (Figure 62b,e). The fourth specimen is a modified proximal fragment of what may have been a flake or blade removed from a blade core (Figure 62d). The point of this artifact is steeply beveled dorsally on both edges. The fifth specimen is a delicate blade which appears to have been recycled as a bi-pointed tool (Figure 62c). About 5 mm distance on either end has been beveled dorsally. Microscopic examination suggests it was used on a soft material (H.J. Shafer, personal communication).

Modified Flakes. This is a final group of chipped chert that represents an informal system for the recycling of debitage. The estimated number of specimens in the collection is ten or more. This covers flakes that are minimal bifaces, and others unifacially retouched. Two specimens (Figure 63) have what can be termed eccentric forms. I can assume them to be of only minor significance, technological or otherwise. Most of the other artifacts appear to have not been utilized. Formal use-wear analysis was not conducted. Several cortex flakes with incised (decorated) surfaces were encountered in excavation of the debitage. One is illustrated in Figure 64. Although it appears that the major number of incised marks is 13, additional incisions may be seen under close examination.

In recalling the massive blade/flake debitage, I stress three thoughts on flake modification: 1) most specimens have some minute edge modification which very

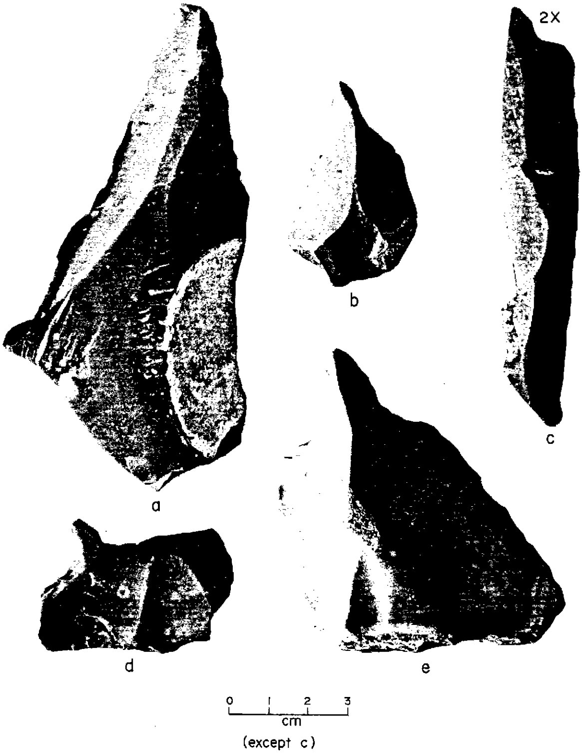


Figure 62. Perforators: (a,b) modified flakes; (c) bi-pointed tool made from blade - enlarged twice of scale shown; (d) modified proximal portion of blade; and (e) modified flake with battering on ridge

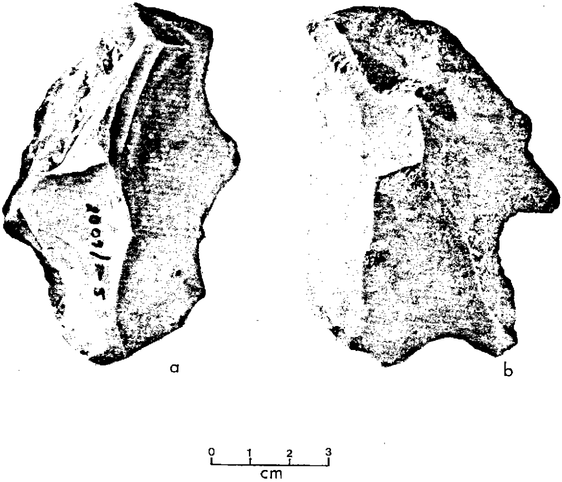


Figure 63. Flake eccentrics (a,b).

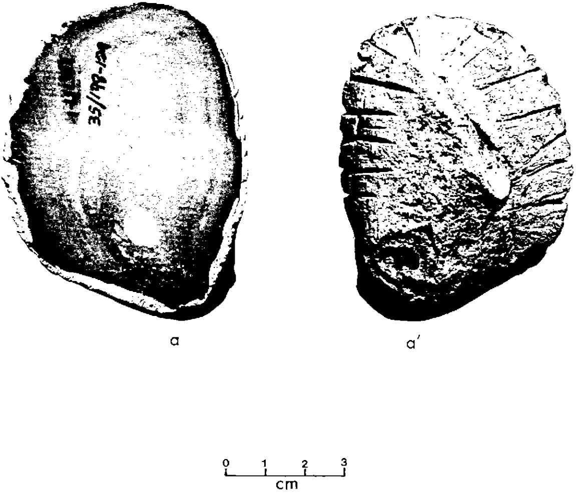


Figure 64. Incised cortex flake (two views).

likely is context derived (i.e. randomly placed edge chipping from the dumping, compacting, etc.), 2) it is actually remarkable that so little of the debitage is edge modified, considering its context, and 3) it is fair to say that some of this debitage might be interpreted as utilized by archaeologists if small amounts occurred in other contexts. The few specimens I identified above all have substantial modification beyond this kind of minute reduction.

Chert Metates (N=14 fragments). These items may represent recycling of chert grinding slabs manufactured at other Colha workshops. Alternatively, they may represent the domestic self-sufficiency of flintknappers. It is not known why these artifacts were being broken up although one (Figure 46c) shows possible use as a hammerstone. Because only a few of the small fragments were abraded, it seems reasonable that some metates were manufactured here and the fragments represent shattered debris from the pecking process. There is no corroborative technological debris to support the idea that these fragments represent anvils or some other device needed in manufacturing other stone tools. None display grooved abrasive surfaces. When present, wear is flat like that of a mano or matate.

Imported Metates (N=3). These artifacts represent the importation of finished tools. There is no evidence of any kind at the workshop that these specimens were modified beyond abrasive use. Food processing was one likely function for them.

Obsidian (N=25). This is another finished product imported for use at or near the Op. 2007 plazuela. As glass, obsidian is a fragile material with ultimate sharpness best suited for cutting soft material. Some of the obsidian present indicates that recycling of core material was taking place. In itself this is not surprising for such exotic and useful material. Most specimens appeared to have been well utilized (especially Figure 47m,n).

Review and Production Estimates for Oval Bifaces and Blades. Here I summarize these systems with a greater consideration of the processes of Figure 11. The procurement of chert at Colha is poorly known for all kinds of manufacturing (Shafer and Hester 1983:538). We know that chert was: 1) surface collected, 2) mined, and 3) directed toward both stone tool manufacturing and construction of architecture (Shafer and Hester 1983:521-522). Surface collecting was probably the easiest technique which had the side benefit of clearing areas for activities such as farming. With procurement in effect for several thousand years, it is little wonder no discrete collecting areas can be identified today at the site. The identification of concentrated procurement areas for macroflakes is also poorly known. Only relatively few boulders at Colha have been found to show rather opportunistic macroflake removals (H.J. Shafer, personal communication; Shafer and Hester 1983:538). The parent masses large enough to correspond to macroflake removals were probably too heavy to be easily moved (H.J. Shafer, personal communication). Distinctive chalky-white cortex is the best indication of debitage or tools from a mined source (cf. Shafer and Hester 1983:521). At Op. 2007, only about 10% of the biface or blade material displayed this cortex. Besides a few open pit quarries investigated at Colha (Shafer and Hester 1983:522), aquadas such as those near Op. 2007 may have been excavated for chert. The marl along the base of the structural platform described (Figure 6) also was apparently partially excavated. It is important to note that mined chert is moist upon immediate excavation. Some replicators believe mositure laden chert improves flintknapping qualities (Patterson and Sollberger 1979), while modern Lacandones of Chiapas dry flint to a degree for optimal reduction (Clark 1982b). Chert gathering was very possibly combined with the procurement of other materials, such as marl (Shafer and Hester 1983:522), and the chert may have been directed to several purposes including assemblage of building rubble. It is possible that in architectural remodeling, some rubble was re-procured for tool manufacturing. Procurement strategy probably changed through time. For example, higher quality chert may have been more plentiful in Preclassic times. However, there is no reason to believe that organization of procurement was ever haphazard.

The manufacturing of oval bifaces and blades at this workshop has been described in detail. As I explained, there is no evidence that these were not concurrent activities. The greatest seperation possible is that two different individuals or groups of flintknappers worked at the plazuela, sharing a common midden. The actual work area can be assumed to be in the excavated platform area or in other unprobed portions of the plazuela (Figure 3,7). The final production of tools is reflected by only a minimum of collected evidence. As stated, I have been forced to examine waste material and a few near finished and utilized artifacts to extrapolate the finished products.

Here I add a crucial estimation for the number of oval bifaces and blades produced. Only tranchet-bit bifaces, because of the distinctive tranchet flakes, can be readily estimated at Colha workshops (Shafer 1979). This trajectory is a minor one at best for the present collection. Instead, I can only estimate finished oval bifaces and stemmed blades from rough calculations involving idealized and actual weights of biface material, and examination of blade cores with conjectured "useful" blade counts. Both of these estimates are projected to relative debitage densities and volume. I must emphasize that the estimates below are crude ones - known and unknown biases exist. For example, my 20x20x20 cm debitage samples may be on the large side.

First, based on examination of the excavation plan (Figure 7) and field notes, I assume that 25 cubic meters is a conservative estimate of the volume of the debitage midden along and atop this northern portion of the plazuela (not counting the fill of the platform).

For oval bifaces, calculation was made between the weights of two idealized forms: blank nodules/macroflakes and finished specimens. I estimate the average nodule or macroflake to weigh one kilogram, based on the partly reduced biface of Figure 13c (at .908 kg). The "ideal" oval biface may have weighed about .325 kg (Figure 12f, .323 kg). This means that waste material would be .675 kg for this model artifact. To estimate the weight of an average biface broken in manufacturing, I split the difference between 1 kg and .325 kg (explained above) to give .65 kg for a typical specimen. If an average 20x20x20 cm sample of debitage weighs 7.7 kg, then 25 cubic meters is 24,062.5 kg in weight. As earlier discussed, biface debitage ran 1.5:1 with blade-making debris, so that three/fifths of debitage weight may be related to biface production, which would be 962.5 kg per cubic meter. A whopping 14,437.5 kg of biface-making debris exists in 25 cubic meters. Based on Table 6, about 100 broken bifaces and 10 rejected whole bifaces existed in Sub-operation 1, which excavated a 2x2x1.4 m volume of debitage (5.6

cubic meters). If this rate of biface production failure was maintained, about 500 rejected bifaces (most fragments, i.e 1,000 artifacts) should exist in 25 cubic meters of debitage. Estimating each of these specimens to weigh .65 kg, a total of 325 kg must be subtracted from the 14,437.5 kg to leave 14,112.5 kg biface debitage. If for every .675 kg of waste, a finished oval biface was produced, then 20,907 oval bifaces is my estimate for the production total.

For stemmed blades, I have performed what I consider to be a cruder and more conservative estimate. The best approach I can determine is to calculate a minimum number of "useful" blades per core, subtract for rejected modified blades, and extrapolate this based on core density in the midden. First, Table 53 indicates that about two useful scars per exhausted/rejected core exist. From examination of multiple platform cores and core tablets, I feel it is reasonable to assume that at least two series of blade removals followed the initial series and preceded the final series. Allowing for a difference in mass, it is reasonable to assume that four useful blades might come from the next to last series, and six useful blades from the series before that. This estimate, admittedly a speculation, gives 12 useful blades per core. Sub-operation 1 had 115 blade cores, which means about 245 useful blades per cubic meter, although about 12 of those blades were probably rejected based on 70 rejected modified blades found in the total 5.6 cubic meters (macroblades, etc. were not counted). Thus, if 1,310 useful blades became successful stemmed blades at Sop. 1 then 25 cubic meters of debitage (including the biface material) reflects 5,848 stemmed blades.

The economic distribution of the oval bifaces and stemmed blades is not much enlightened by the spatially concentrated exacavations of Op. 2007. No storage facilities were identified. Small amounts of the bifaces may have been locally distributed, based on the use-wear seen on some of the whole artifacts, and from the polished resharpening flakes. None of the stemmed blade fragments had modification other than that which could be attributed to manufacture. Based on Shafer's (1983) analysis of Pulltrouser Swamp material, there is a reasonable possibility that tools produced at this workshop were distributed over a wide area of northern Belize. The blades may have been transported to consumers in vegetable bark containers similar to those Maler (1901:Figure 12) illustrates for the Lacandones.

The _initial use_ of the bifaces and blades can only be conjectured to have occurred at a distance from the workshop. Shafer (1983) has good evidence that Colha-like _oval bifaces_ were sent to consumer areas for use as axes or adzes. There are no helpful use-wear studies of Late Classic stemmed blade chert tools that I am aware of. I can only assume these specimens were hafted for use as penetrating tools which performed a type of cutting action (i.e. dart points; cf. Odell 1981:206). Scenes depicted by ancient Maya artists indicate that stemmed blades were at least sometimes hafted on spears or fixed in clubs. Decorated ceramics indicate that _atlatls_ or throwing stick/spears may have been involved in ritual (Pohl and Pohl 1983:31-32) or hunting and warfare (Coe 1980:Figure 124; Pendergast 1969b:Plates 3,4,5).

Maintenance of the artifacts is minimal and was observed only for the bifaces. It is possible that some of the small whole _oval bifaces_ represent celts rehafted at the workshop. The several highly polished resharpening flakes indicate that at least a few times someone resharpened a well used biface at the workshop.

Abandonment is evident in the way that the upper platform came to be literally engulfed with lithic debris and no effort was made to keep the plaster floor clear. Based on a trace of ceramic evidence at Op. 2007 and known Postclassic occupation of Colha, Early Postclassic people may have had some activities upon the structure soon after the "collaspe" of the Classic period. Yet the uppermost debitage is Classic material inseperable from that of the deep midden. Little if any of the chert debitage on the surface of p. 2007's plazuela can be construed as Postclassic material, which belongs to a distinctive technological system (Shafer 1979).

CHAPTER VI

INTERPRETATIONS OF CRAFT SPECIALIZATION

> Too often, we ask how to measure something without raising the question of what we would do with the measurement if we had it (Kaplan 1970:608).

Introduction

This chapter synthesizes information from portions of the previous description of context, craft specialization, and lithic technology in order to formulate behavioral interpretation of craft specialization. As I state in Chapter I, the idea is not so much to prove craft specialization was present at the workshop but to refine knowledge of this phenomenon and see how particular evidence may be applied.

Below I focus on three aspects from my definition of craft specialization: the context of civilization, and standardization and efficiency of the manufacturing evidence. These are considered affirmative predicates under the general proposition that craft specialization was present at this Late Classic workshop. In other words, these are expectations about the data we may search for if craft specialization was present. I discuss each in terms of information selected from the known context and lithic data. Certain predicates may be criticized, but rejection (or failure to reject) does not take place in terms of hypothesis testing.

Context of Civilization or Urbanism

Predicate: the Op. 2007 workshop functioned within a context of civilization or urbanism.

Regional, local, and site-wide evidence indicates that this is a reasonable statement. It is a general condition that covers the activities of craft specialists and ancient Maya lifeways in the broadest sense. The various major sites I reviewed (e.g. Altun Ha, El Posito, Lamanai, Nolhmul, etc.) may all be argued to display evidence of most (if not all) of the traits I identified for the "state", symbolic communication, and discrete communities. It is redundant to list that evidence and add that Colha and the Op. 2007 plazuela fits within it. This is especially so because craft specialization has been noted to be a nomimal part of civilized contexts. At the site level, Colha is a distinctive community representing a concentration of human settlement (Eaton 1982). However, its degree of urbanism is not well defined apart from generalizations based on the nauture of its monumental center (cf. Hammond 1982a:68). Of the three main traits of civilization listed above, I believe that administrative power was the most important determinant for much of the technological evidence identified at the workshop.

Another way to check for the presence of a potentially civilized setting is to consider the potential of institutionalized craft specialization as Arnold (1984) defines it. Paraphrased, her five indicators are: 1) a high relative and absolute volume of production, 2) standardization in methods of production, 3) intensive, repetitive areas for craft workshops, 4) control over vital resources, and 5) craft specialist paraphernalia in burials (Arnold 1984:3). The first and third indicators can be accepted out of hand, based on specific and general knowledge of

Colha and the Op. 2007 workshop. The second indicator is discussed in this chapter (below). The fourth indicator may be accepted based on the knowledge that the community of Colha covered a substantial area. It seems reasonable to infer that, in view of the numerous active workshops in the Preclassic and Classic, visitors were not welcome to forge about for lithic resources. The final indicator, that of specialist trappings associated with burials, has generally not been evident in research at Colha, although special lithic artifacts (stemmed macroblades, eccentrics, etc.) rather than manufacturing tools have turned up.

As should be clear from my earlier discussion of civilization, cultural behavior under the influence of civilization does not necessarily point to a single kind of technological evidence. In other words, the material technology of a civilized group may be similar to that of primitive contexts - abstract factors of general organization appear most important. However, we may yet ask what traits of lithic technology can be expected in a civilized context. The remaining predicates of craft specialization may be considered the answer to this question.

Standardization

> Predicate: the flintknappers at Op. 2007 worked in a standardized manner to produce standardized tools.

Here, standardization of manufacturing behavior is assumed to result in standardized tool morphology. A third possibility, standardized tool use, will not be addressed. The key element for identifying or testing standardization is that some explicit standard - real or provisional - must exist for the researcher. Archaeologists should not refer to "standardized" behavior or standardized material without regard to some criterion.

This condition is complex because standardization can be interpreted on several levels. The most appropriate level for the present collection is examination of the manufacturing debitage. Standardization in the sense of restriction is shown well by the evidence that only two major tool classes dominated the production effort: oval bifaces and stemmed blades. This formality of production is thus one kind of standardization.

A number of specific attributes measured in the Op. 2007 biface and blade debitage might be considered standardized. For example, the mean platform angle of whole, unmodified blades (N=790; Table 18) is 100.4°, with a standard deviation of 8.4°. Bifaces and blades were consistently first modified to finished states in their distal portions, and so on. This kind of descriptive inference-making has been used to verify standardization at Late Preclassic Colha workshops (Shafer 1982b:33-34). However, it can be improved with two theoretical extensions. First, variables of technology can be viewed as norms of behavior - "mental template[s] from which the craftsman makes the object (Deetz 1967:45)." These "customary patterns (Spaulding 1960:76)" of morphology may serve as standards. If a single artifact can be measured in any way the resultant value in itself can be considered a potential "mean" of behavior for its respective artifact class. More importantly, statistical measurement from a number of these artifacts (a sample) should portray an even more accurate behavioral "mean". This approach has been explicitly used in theory building for tool classification:

> The basic presumption I make in defining the expected shape of a frequency distribution is that normative values play the role of population parameters and that measurements over artifacts play the role of sample values. ... a mean length, angle, or whatever measure would seem to be normatively prescribable in that an estimate for that parameter is expressable on a single artifact. In contrast, the standard deviation is a population property and is a consequence of (a) the degree of control of the artisan(s) in repeatedly manufacturing the same artifact, and (b) the extent to which variation from the normative (mean) value is acceptable (Read 1982:71).

In this fashion, many of the tables of descriptive statistics in Chapter V can be viewed as potential measurements of such behavior.

The second theoretical claim involves an extension of the first. Read (1982:71) also notes that a "range in normative prescription from none to considerable" existed, "depending on the context of artifact use". This is important because boundaries for a given normative standard must be established. In other words, what is the cut-off point for the transition away from a consistent standard into more variable standards? I submit that comparative studies may provide the additional "standards" of greater variation for this purpose.

Below I describe a few brief, informal trials of comparison. The selection of data primarily is due to the availability of the sources. I purposely included coefficients of variation in most descriptive tables of Chapter V to aid in this approach. The coefficient of variation is simply a measurement's standard deviation multiplied by 100 and divided by the mean - in other words, standard deviation expressed as a percentage of the mean (Sokal and Rohlf 1969:62-63). It is a helpful measurement because variations in populations with different means can be fairly compared. For example, wing length variation of parakeets might be compared to that of chickenhawks. Or, oval biface length variation along the Rio Hondo might be fairly compared to macroblade length variation at Colha. The lower the coefficient of variation, the less variability between the two samples. The CV values of artifacts made by craft specialists should be smaller than the CV values of non-craft specialists.

One trial examination comes from the work of Wilmsen (1967). Here, I offer statistics from a small part of his data base: the collection of whole flake tools from the Folsom strata of Lindenmeier, a Paleoindian site in Colorado (Wilmsen 1967:34-35, 50-51). It is assumed that these whole, modified flakes are a discrete product reflective of hunter-gatherer technological norms, which should be more variable than those of the Colha Maya. For example, simple band societies would not be expected have specialists largely at work for consumers beyond their immediate group, a centralized political or economic power to control the training and placement of craftsworkers, and so on (e.g. Arnold 1984). The Lindenmeier data I have selected is:

all flakes*, platform angle-
N=597 X=69.9° s=10.2 CV=14.6%
flake tools, length-
N=158 X=43.07 mm s=17.38 CV=40.4%
flake tools, width-
N=158 X=31.67 mm s=10.67 CV=33.7%
flake tools, thickness-
N=158 X=7.89 mm s=2.97 CV=37.6%
(*no standard deviation provided; Wilmsen 1967:65,

74-76). To this I compare the modified blades of Op. 2007 (Tables 19,15,16,17), with coeficients of variation of 6.9% (stemmed only), 27.9%, 34.1%, and 46.7% respectively for platform angle, length, width, and thickness. It is apparent that for length and platform angle there is a slight trend for the Op. 2007 material be more standardized.

Again, I stress that many unknowns exist and I cannot justify various differences solely to craft specialization. For example, in any social context, greater standardization may be technologically inherent for striking platform angles in blade-making compared to flake-making. The same is true for blade length versus flake length. To attempt a further check on this I examined some blade data from a cache found in western Texas (Tunnell 1978). This is a collection of 72 large, trimmed chert blades probably made by a single flintknapper. The blades were produced in a manner similar to that of the Colha specimens (Tunnell 1978:52). I calculated coefficients of variation from the depictive figures for length, width, and thickness. The CV values are: length, 16%; width, 12.3%; and thickness, 17.3%. This indicates less variation than any of the Op. 2007 blade <u>debitage</u> possesses for those values. However, these are <u>finished</u> products (or preforms) which have been slightly trimmed. A more appropriate comparison for length and width comes from examination of the longest blade scars on the Op. 2007 blade cores - these might better represent "useful" products (Table 54). The CV values here for all cores are 16.5% for length and 26.5% for width. These figures are more in line with what would be expected: a single skilled hunter-gatherer blademaker's products should equate those of a Maya workshop. It would be informative to know the CV values for a group of blade caches created by a number of different hunter-gatherers.

This is the present limit of my investigation of standardization. I have not been able to obtain good comparative data on bifaces. I believe it would only be fair to compare a large collection of manufacturing fragments. The whole bifaces of Op. 2007 are not representative of the ideal finished form.

Efficiency

> Predicate: the Op. 2007 flintknappers were efficient in their manufacturing behavior.

As I discussed earlier in Chapter IV, I consider efficiency to be the maximization of utility, and the minimization of effort and waste. Zipf (1949:3) and Christenson (1982) have pointed to the contradiction involved in the simultaneous "minimizing and maximizing" of any one variable. In consideration of this, maximization of utility encompasses the qualities of the "minimum" stated above. This is because: 1) minimizing effort may be a universal condition of humans coming to terms with the external world (cf. White 1949:373), and 2) minimizing waste in production of stone tools was possibly not an overriding concern at chert-plentiful Colha. In general technological sense, blade production may be considered efficient because it promotes a maximum production of total cutting edge from a given mass (Sheets and Muto 1972).

Maximization of utility may be viewed in several ways. Like standardization, it may be sought in the technological evidence of manufacturing behavior, the finished tool form, and initial tool use. Here I only consider the former-most aspect. The gross inference I make from the context and collection of Op. 2007 is that the flintknapper(s) were seeking to quickly reduce large quantities of chert into standardized tool forms. Mistakes made in manufacturing were avoided only in balance to achieving this goal of maximizing production quantity.

The speedy reduction of chert is shown in both the biface and blade-making debitage. As discussed, platform preparation was minor for large portions of both trajectories. Numerous examples of extra ring crack initiations exist on the platforms of blades, blade cores, and some bifaces. These percussion marks do not support the idea of flintknapping done in a leisurely fashion at the plazuela. The bifaces, at least in early reduction, often exhibit sequential flake removals without much platform preparation (or extra consideration) before each percussion blow. This contrasts to the way most modern replicators of bifaces carefully (and often slowly) consider the removal of each thinning flake. Another sign of haste in blade manufacturing is the number of overshot blades. As Faulkner (1972) has shown, this is a termination problem (or choice) definitely related to placement of the percussor (or pressure) instrument too far in from the platform edge. This is a likely event in rapid blade-making where the flintknapper over-reacted to the chance that percussion would be too near the edge of an unprepared or slightly prepared platform. A crushed or poorly terminated fracture from this later behavior is more difficult to recover from. In other words, an overshot blade at least produces a long blade scar with guiding ridges retained and a clean break at the platform.

The above discussion is not an argument that the Op. 2007 flintknappers were unskilled. For example, overshot blades are not in excessive proportion in the collection (Table 38), and in some cases they were probably deliberately struck to remove problem areas on a core's surface (i.e. hinge termination scars). Also, modern replicators are often frustrated in using only hammerstone percussion to thin large bifaces. They usually switch to large, soft billet hammers like those of elk horn. This requires a different kind of platform preparation which takes more time. The platform types associated with this approach are seldom seen in the debitage. The Colha flintknappers were definitely skilled in thinning oval bifaces through use of the percussion (hard hammer) techniques in evidence (Don E. Crabtree, personal communication).

There is a balance between speedy reduction, problems in reduction, and final production output. The hasty production techniques were described above. Problems in reduction not necessarily associated with this include categories like material quality. My general impression of the Op. 2007 chert is that much of it is not what modern replicators consider good chipping quality. What I coded as fine grain often was not as vitreous as excellent North American chert (like Central Texas Georgetown material) or the Colha chert often found at Preclassic workshops. Indeed, it could be that readily obtainable quality grain chert was somewhat scarce by Classic times at Colha. At any rate, it would be more efficient if all chert procured including the poorer grades could be reduced for consumer products. The fact that this was done and could technically be done indicates efficiency on the part of the Op. 2007 worker(s). In terms of final production output, I can provide some evidence that the flintknappers were both skillful and efficient. First, based on calculations from 70 rejected modified blades and 115 blade cores recovered from the 5.6 cubic meters of Sub-operation 1, about ten successful blades (at least) were produced from each core. I interpret this from my earlier estimate of 12 "useful" blades per core (Chapter V) and a ratio of _two_ rejected modified blades for each core of the test unit. I cannot see any way to fairly judge "small quantities of waste" and a "minimum amount of raw material" to be shown per core (cf. Torrance 1981; Shafer 1982b:32-33). Second, if 20,907 _oval bifaces_ were produced from 25 cubic meters of debitage, with 500 rejected bifaces (Chapter V), then for every failed biface, 42 were successful. This seems an indication of both skill and efficiency. It compares well to data Shafer (1982b:32) offers from a Preclassic workshop, where 24 tranchet-bit bifaces failed in production compared to an estimated 1,000 finished tools. Remarkably, this is also a ratio of 42 to one.

Summary

Three major parts of my definition of craft specialization (Chapter IV) have been emphasized to interpret the behavior represented by the evidence described for Op. 2007. Predicates of civilization, standardization, and efficiency have been discussed. Support has been provided to suggest that the Op. 2007 production was standardized, efficient, and took place under a context of civilization. Other topics remain undressed and many questions have probably been raised for the reader. The next and final chapter attempts to deal with some of these issues. This present interpretation has been more generalized (or inferential) than I would prefer. I could not well resolve the transformation of generalities of craft specialist behavior (Chapter IV) into specific, fair test measurements utilizing lithic technology (Chapter V). Some explanation for this is also discussed in the concluding chapter.

CHAPTER VII

CONCLUSION

> One does not try to explain something unless one thinks it has occurred (Scriven 1962:220).

Introduction

Concluding discussion is in three parts. First, the study efforts of my thesis are reviewed. Next, a reconstruction is offered for the behavioral events depicted by the evidence. This discussion was not placed in the preceding chapter because I wish to segregate it as a more speculative part of my study. Finally, I document certain problems I have experienced in conducting this thesis. By identifying these difficulties I am indicating new directions for research.

Review of the Study

In 1980, excavations took place at one portion of a small Late Classic plazuela at Colha. Testing was done to sample an area of lithic debitage where distinctive blade-making debitage was evident. The initial test pit penentrated about 1.5 m of flintknapping debitage to reveal the lower retaining wall of an architectural platform. A tremendous amount of chipped stone manufacturing debris formed a primary refuse deposit along and above the platform. The core fill of the platform also consisted of debitage. This material may have been an earlier deposit which was modified to become the platform core (with the additional bulk accruing along its edge). Or, the platform's core debitage may have been redeposition of material from nearby. The upper floor of the platform was a hard plaster surface nearly exposed at the modern surface. An alignment of stone across this floor probably represented the basal trim or footing of a perished superstructure, or some less formal use of the cobbles. The platform abutted a higher, more rounded mound with a rubble core (Sub-op. 2). Throughout the deep lithic midden and the thin veneer over the platform, the manufacturing debris was consistently of Late Classic technology and chronology. Small amounts of ceramics, basically no bone, and only recently developed humus existed in the debitage.

In examining the manufacturing debitage, two major trajectories were obvious: oval bifaces and stemmed chert blades. A complete sequence of manufacturing evidence was present in the midden: rejected nodules, exhausted hammerstones and blade cores, all stages of biface thinning and blade production debitage, and bifaces rejected in production. Flintknapping was directed in small amounts toward other goals such as making tranchet-bit tools. A very small amount of consumed exotic stone artifacts were present.

The collection was described largely in terms of morphology, but with an aim to use those descriptions to support a technological analysis. Almost all of the material examined may be considered debitage. Inferences based on it permitted the construction of schematic models of manufacturing process.

The problem of craft specialization was the foremost theme behind interpretations of the context and collection. An extensive amount of study was required to define this kind of work behavior. Three predicates of craft specialization were selected for closer scrutiny. Of these, one - the context of civilization - was fairly abstract, while standardization and efficiency were better suited for application to the evidence. All of the predicates were supported to some degree by inferences based on the general context and technological evidence.

Reconstruction of Events

Sometime after about A.D. 700, a small plazuela was constructed not far southwest of the major precinct of the community now called Colha. Part of the plazuela was possibly constructed over a mound of chipping debris which had been dumped by artisans working at an adjacent platform. Domestic activities in the area slightly but steadily contributed other refuse to mix in with the debitage. A number of people, possibly a family unit, either lived and worked at the plazuela, or commuted to work there from a nearby location. Superstructures similar to modern Maya thatched huts or _jacal_-style sun shades were erected over the plaster floored platforms.

Massive quantities of _oval_ _bifaces_ and stemmed blades were produced from local chert which was both mined and surface collected. The flintknapping occurred very near the debitage midden, probably on the adjacent platform. Immediate reduction may have taken place over cloth or hide tarps which were occasionally gathered to cast off the debitage. Work effort was not necessarily of great duration, but the manufacturing was relatively fast paced when it occurred. The work procedures were generally efficient. It is possible that only a few flintknappers were present at any time. The finished artifacts were relatively standardized in form. They were distributed in local and regional exchange systems that were likely formal and well supervised. A complex, dynamic marketing system was probably also a part of this. The oval bifaces were probably used in land clearing and cultivation, while the stemmed blade projectiles were useful components for hunting and warfare. Although the flintknappers, as craft specialists, are assumed to have been substantially compensated for their efforts, they may have also been partly self-sufficient (i.e. seasonal farmers, etc.). Rare imported consumer items included obsidian and groundstone tools. About A.D. 900, the resident Maya at Colha suffered a major social catastrophe. It is probable that northern Yucatec Maya successfully invaded the site (Hammond 1982a:69). The production of stemmed blades at this workshop may have been part of an arms build-up preceding this event. The Postclassic inhabitants of Colha made only minimal use of the abandoned plazuela. Much of the old superstructures' material possibly was recycled for use elsewhere. Apparently the site was basically abandoned by the Late Postclassic and European times.

Problems of Analysis

Rather than have a section of recommendations for future work, the topics below indicate areas in need of more study. There are three categories to be considered: 1) the complexity of craft specialization, 2) the analytical power of lithic analysis, and 3) comparative needs. This section is not intended to be overly negative, but if only a minor part of it causes one student to rethink a research plan and save a bit of time, it is worth stating.

Craft Specialization

The difficulty in studying craft specialization at Colha lies in refining (or redefining) the kinds of evidence we need to demonstrate the presence and degree of this phenomenon in the archaeological record. We need highly specific definitions of the material evidence distinctive to this activity. Craft specialization is especially complex because it is part of an ancient continuum that retains meaning for very recent (and modern) industries. Graduations of craft specialization (including its absence) must be defined. Unless it is put into the broadest of terms, no widely accepted theoretical statement exists for craft specialization. This is probably because no one definition can account for it. In short, I am saying that craft specialization is more complex than many assume, and it is in need of theoretical resolution. Because it has recently become a popular topic, I hope to see important new statements. The real problem will be in closing the gap from abstract classification of social behavior to predict mundane but distinctive material evidence.

Lithic Analysis

The major weakness of this thesis has been my inability to devise meaningful measurements of attributes from the chipped stone manufacturing debris. The problem is not new nor is it unique to this material category. Callahan (1979:4) notes that there is little agreement which technological attributes are determined by mechanical fracture versus those sensitive to human action. Subconscious action on the flintknapper's part is known to exist (Crabtree 1968:476). The variable properties of raw materials and an analyst's error of measurement (Fish 1978) compound these factors. The notion of precision versus accuracy in analysis comes into play (cf. Bowers et al. 1983:569).

Setting up the traits of craft specialization into testable propositions measured by aspects of lithic terminology is not difficult, but choosing meaningful technological attributes and scales of descriptive measurement is. As Payson Sheets (personal communication) asks, what would be the thresholds for positive, negative, and neutral test results? Apparently in good company, I have not resolved this question. Results from a major archaeological dissertation on craft specialization "were only suggestive because there is no definitive scale along which to measure specialization in terms of chosen variables" (Torrance 1981:434).

A second problem I have encountered involves the methodology required to use a technological analysis of lithic material in questioning aspects of craft specialization behavior. Technological analysis for lithic studies is largely inferential. That is, the analyst examines large amounts of debitage, describes the material, and then selects details from it to reconstruct broad technological models. A good way to fairly test the behavior of craft specialists is to set up a positivist-deductive framework of formal hypotheses. This requires an abrupt, though not incompatible, switch in theoretical perspective. Careful reasoning would be required to avoid a type of ad hoc hypothesis generating that could be biased from the judgemental inferences that preceded it. At any rate, I did not attempt this approach for two more basic reasons. First, as stated previously, the behavioral traits of craft specialization I have identified are relatively abstract and not easily quantified. Second, and more important, I have failed to justify certain technological attributes of the collection to be sensitive measurements of craft specialist behavior.

Another more technical problem of analysis that must be mentioned is the fact that an extraordinary volume of chipped stone debris must be examined in even the smallest of samples retrieved from Colha lithic middens. Unless sampling strategy is well thought out, field and laboratory work may suffer great expenditures of time, money, and energy. I believe that most of the technological information in a midden can be learned by careful examination of a single test pit's content. Much of the excavation after the initial 2x2 m test at Op. 2007 was stereotyped structure "chasing". It also has now become the practice at Colha that an experienced analyst can record many attributes on artifacts without collecting them. The column samples, however, are essential controls for abundant technological data, some of which we are probably unable to utilize properly today. The value of computer encoding, even for basic cateloguing, should be obvious. In fact, the data base now assembled for Op. 2007 measurements is a very positive note to end on. This information may come to have great utility for establishing the very criteria we need for standards of craft specialization. It also provides new dimensions for comparative studies, my final topic of discussion.

Comparative Needs

As was apparent in my grappling with notions of efficiency and standardization, a good background for measurement was sorely lacking. This is a problem that evolved during the later part of my research. Comparative information is required from two sources. First, the more I have learned about craft specialization, I suspect that the cultural factors and human organization of a particular craft specialist endeavor are more distinctive (and crucial) than the technological evidence viewed in isolation. Yet, as my "reconstruction of events" reflects, we really do not know the specifics of social organization at Colha or for the ancient Maya in general. Much ethnographic information exists, but of the handfull of scholars who can synthesize it, only a few at best may also understand the utility lithic artifacts offer. The greatest mistake for a researcher at my level would be to draw impromtu ethnographic analogues to hastily generate hypotheses. I am also not convinced that the early chronicles provide the kind of detailed, unbiased information needed for craft specialization studies, but certainly it is worth a try. The same goes for looking at modern peasant activities. The appropriateness of projecting such analogues past a thousand years I will not debate.

The second comparative need I see is in the region of lithic replication (experimental studies). This is one of the best ways to link material effects with controled work behavior. Replication such as that Ahler (1971:53,81-87) performed for projectile point functions shows that lithic analysts can be secure in assumptions of attribute correlations when they are well reasoned. But again the problem returns to the cultural effects of social obligations in work at Colha. Can the <u>group</u> activity of craft specialists be accurately replicated, for example, to determine what constitutes full-time effort, much less efficient manufacturing?

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Appendix 1. Biface Coding Format.

Column	Variable Name and Description	Value
1-5	UNIQNUM, unique number of artifact	"1-800" block in use at TAMU
(6-7)*	SITE	
(8-11)*	OPERATN	
12-13	SUB_OP, suboperation	1-11
14-15	LEVEL, excavation level	1-9
16-17*	CLASS, tool class	1=oval biface 2=tranchet-bit biface (3-11, Shafer codes) 12=miscellaneous biface not definitely related to oval biface system
18-19*	FORM, tool form	1=complete, unused 2=complete, evidence of use 4=proximal fragment 5=medial fragment 6=distal fragment (3,7-8, Shafer codes)
20-21	BRK_TYPE, type of break	1=lateral snap 2=perverse 3=material flaw 4=overshot 5=other

(22-23)*	STAGE	
(24-25)*	MATERIAL	
26-28	MAX_LEN, maximum length	(mm)
29-31	MAX_WID, maximum width	(mm)
32-34	BRK_WID, width of break on biface (if applicable)	(mm)
35-37	MAX_THK, maximum thickness	(mm)
38-40	BRK_THK, thickness of break on biface	(mm)
(41-43)*	EDGE_ANG, edge angle	
44	CORT_PLT, cortex noted on proximal end of biface, not necessarily a cortex platform	0=absent 1=present
45	CRTXTYPE, cortex presence and type	0=none 1=surface origin 2="mined" origin
46	EARLYSTG, "early" manufacturing traits displayed on biface	0=absent 1=present
47	LATE_STG, "late" manufacturing traits displayed on biface	0=absent 1=present
48	GRAIN, biface grain	1=fine 2=coarse 3=mixed, fine and coarse

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* These columns and variables are related to Colha biface analysis conducted by Dr. Harry Shafer (TAMU). They may be excluded or only partially used in this study. If excluded completely, parentheses enclose the column numbers.

Appendix 2. Blade Coding Format.

Column	Variable Name and Description	Value
1-4	UNIQNUM, unique number of artifact	"1-2500" Op. 2007 block
5-6	SUB_OP, suboperation	1-11
7	LEVEL, excavation level	1-9
8	TYPE, blade form	1=whole, unmodified 2=proximal fragment, unmodified 3=distal fragment, unmodified 4=medial fragment, unmodified 5=whole, modified 6=proximal fragment, modified 7=distal fragment, modified 8=medial fragment, modified
9-10	MAX_WID, maximum blade width	(mm)
11-13	MAX_LEN, maximum blade length, whole or fragmentary	(mm)
14-15	MAX_THK, maximum blade thickness	(mm)
16	CRTXTYPE, cortex present and type	1=none 2=surface origin 3="mined" origin

17	CRTXPROX, cortex on proximal end of blade (platform *or* general proximal region	0=absent 1=present
18	CRTXDIST, cortex on distal portion of blade	0=absent 1=present
19	CRTXRGHT, cortex on right edge of blade (viewing dorsal face with platform down)	0=absent 1=present
20	CRTXLEFT, cortex on left edge of blade (viewing dorsal face with platform down)	0=absent 1=present
21	CRTXTOTL, cortex totally across dorsal face of blade	0=absent 1=present
22	PLT_TYPE, striking platform types	1=multiple 2=single facet 3=missing or crushed
23-24	PLT_WID, platform width	(mm)
25-26	PLT_DEP, platform depth (transverse to width)	(mm)
27	PLT_SHP, platform shape	1="single ridge type" 2="two ridge type"
28-30	PLT_ANG, platform angle	in degrees, goniometer to ventral face of blade
31	BLD_OTLN, blade body outline	1=parallel lateral edges 2=contracting lateral edges (extreme-beyond normal blade termination) 3=expanding lateral edges
32	BLD_CURV, blade curvature	1=slight 2=pronounced

33	RIDG_NUM, major dorsal ridges on blade	(count)
34	BLD_TERM, blade termination	1=feather (normal) 2=hinge 3=step 4=overshot
35	GRAIN, blade grain	1=fine 2=coarse 3=mixed, fine and coarse
36	MOD_BLD, type of modified blade	1=stemmed 2=not stemmed but inferred to be related 3=miscellaneous modified blade
37	MOD_AREA, area of modification on blade	1=proximal 2=distal 3=proximal and distal
38	MOD_TYPE, type of modification	1=soley unifacial 2=unifacial with bifacial (if alternate unifacial beveling without bifacial overlap, code "1")
39	STEM_LOC, stem location on blade body	1=proximal 2=distal (rare)
40	STEM_TRT, stem beveling treatment (viewed from proximal end); no significant bifacing noted on any stems	1=beveled "clockwise"

40 con't		2=beveled anti-clockwise 3=unifacial on ventral side 3=unifacial on ventral side only 4=unifacial on dorsal side only
41-42	STEM_WID, stem width	(mm)
43-44	STEM_LEN, stem length	(mm)
45-46	STEM_THK, stem thickness	(mm)
47	REJ_CAUS, inferred cause of modified blade's rejection	1=not apparent 2=extreme curvature 3=too thick 4=size; width or length too small or great 5=material flaw 6=asymmetry in form 7=artifact broken during modification 8=too thin 9=other (comment on coding sheet)
48	STEMFORM, stem outline	1=parallel edges 2=expanding edges 3=contracting edges

Appendix 3. Blade Core Coding Format.

Column	Variable Name and Description	Value
1-2	SUB_OP, suboperation	1-11
3	LEVEL, excavation level	1-9
4-6	UNIQNUM, unique number of artifact	"300-431"
7	CR_SHAPE, shape of core	1=tabular 2=polyhedral 3=other
8-10	MAX_LEN, maximum length of core	(mm)
11-13	MAX_WID, maximum width of core	(mm)
14-16	MX_DEPTH, maximum depth of core (perpendicular to width)	(mm)
17	ORIG_MSS, original mass configuration	1=definitely recognized as a cobble (not a macroflake) 0=other or not known
18	CRTXTYPE, cortex presence and type	0=not present 1=surface origin 2="mined" origin
19	GRAIN, core grain	1=fine 2=coarse 3=mixed (fine and coarse)
20-23	WEIGHT, core weight	(gm)

24-25	PLT_AREA, effective platform area	count of cm^2 rounded to nearest centimeter
26	PLT_HANG, platform overhang	0=absent or very minimal 1=present
27	PLT_TRM, platform trimming	0=absent or very minimal 1=present
28	PLT_CRSH, platform crushing	0=absent 1=present
29	UNOP_M_P, unopposed multiple platforms	0=absent 1=present
30	OP_M_PLT, opposed multiple platforms	0=absent 1=present
31-32	SCAR_NUM, total number of major scars on core	count of all scars larger than ca. 2x3 cm
33-34	USE_SCAR, total number of "useful" scars on core	count of blade scars inferred to represent final blades removed that were "useful"

35-37	LONG_S_L, length of longest blade scar on core	(mm)
38-39	LONG_S_W, width of above scar	(mm)
40-42	PLTANG_S, platform angle of above scar	(°) goniometer read to match the blade platform of the absent blade(s)
43	FEATHR_T, feather (normal) terminations represented on the core's blade scars	0=absent 1=present
44	HINGE_T, hinge terminations (as above)	0=absent 1=present
45	STEP_T, step terminations (as above)	0=absent 1=present
46	OVERSHT, overshot terminations (as above)	0=absent 1=present
47	REJ_MASS, reduced mass possible cause of core rejection	0=absent 1=present
48	REJ_PLT, platform problems possible cause of core rejection	0=absent 1=present
49	REJ_TERM, termination problems possible cause of core rejection	0=absent 1=present
50	REJ_UNKN, cause of core rejection unknown	0=absent 1=present
51	RING_CRK, ring crack initiation on core platform	0=absent 1=present

52	BATTERED, extreme battering at core platform or elsewhere	0=absent 1=present
53	EARLYREJ, core possibly rejected very early in reduction	1=present 0=absent
54	UNDET_BL, undetached (initiated) blade noted on core	0=absent 1=present
55	REJ_RIDG, cause of core rejection possibly due to a lack of properly aligned ridges	0=absent 1=present

VITA

Erwin Roemer, Jr., was born in Austin, Texas on 20 December 1952. Raised in Elgin, Texas, he attended the University of Texas at Austin and recieved a B.A. in Geography in January 1975. From that time he worked for a variety of projects related to public service archaeology in New Mexico and southern Texas for The University of Texas at Austin and The University of Texas at San Antonio. He also has been employed by the Museum of the American Indian, Heye Foundation (New York). Since late 1978 Roemer has been involved with the Colha Project in Belize (again under the auspices of UTSA). Roemer enrolled in Texas A&M University's master of anthropology program in 1980. Since 1982 he has been employed at the TAMU Archeological Research Laboratory. His permanent address is P.O. Box 2, Elgin, Texas 78621.